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Graduation Rates of URM Students in STEM Disciplines: An Examination of Institutional Differences at Selected Four Year Campuses within a Large System of Public Higher Education

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Abstract
Graduating well educated students in STEM disciplines has become a national priority, particularly as the nation looks to maintain its global competitiveness in light of continuing racial and ethnic disparities affecting graduation rates. This correlational study examined the differences in institutional success in raising the graduation rates of underrepresented minority students (URMs) in STEM disciplines at 20 selected institutions within a large system of public higher education. The study used secondary data available from both the system's Office of Institutional Research and the Federal IPEDS reports. Results of the study identified selected institutions that performed the highest at graduating URMs in STEM. The study also revealed that several institutional factors (Pell Grant Aid, faculty salaries, expenditures and average student age) were not significantly associated with URMs graduation rates. A positive correlation was found between SAT scores, high school GPA and URM STEM graduation rates. These precollege student achievement factors were most prevalent at the highly selected institutions in the study which also had the highest URM STEM graduation rates.

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Graduation Rates of URM Students in STEM Disciplines: An Examination of Institutional Differences at Selected Four Year Campuses within a Large System of Public Higher Education

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Dedication

I'm reminded of the old African proverb that "it takes a village to raise a child," as such, it has taken an entire community of family, close friends, and colleagues in seeing me through this journey. Without their unequivocal level of support, encouragement, and understanding, I would have never succeeded. To my mother who has always believed in me and not having a formal education beyond grade school, has been proud to live vicariously through my successes. To my loving uncle Rico, who unexpectedly passed away during this journey, and always supported my never-ending desire to take on new challenges. I will never forget his warm smile and words of encouragement. To my wife Connie for always being there and my two wonderful sons, Justin and Camilo, wise beyond their years, thanks for your confidence, inspiration and trust in me – I achieve because of you.

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They never showed boredom or frustration when I needed to bounce ideas off of them while having conversations around my research topic and overall issues centered on URM student success.

Biographical Sketch

Carlos N. Medina is currently the Chief Diversity Officer and Senior Associate Vice Chancellor for Diversity, Equity and Inclusion at The State University of New York (SUNY). Prior to coming to SUNY System Administration, Mr. Medina worked at SUNY's Research Foundation and the New York State Education Department. Mr. Carlos N. Medina attended SUNY College at Cortland from 1973 to 1978 and graduated with a Bachelor of Science degree in Physical Education. He attended Cornell University in Ithaca, New York and graduated with a Master of Professional Studies with a focus on Human Services Administration in 1989. He came to St. John Fisher College in the spring of 2012 and began doctoral studies in the Ed.D. Program in Executive Leadership. Mr. Carlos N. Medina pursued his research on the graduation rates of underrepresented students in Science, Technology, Engineering, and Mathematics (STEM) disciplines under the direction of Dr. Guillermo Montes and Dr. Richard DeJesus-Rueff and received the Ed.D. degree in 2015.

Abstract

Graduating well educated students in STEM disciplines has become a national priority, particularly as the nation looks to maintain its global competitiveness in light of continuing racial and ethnic disparities affecting graduation rates. This correlational study examined the differences in institutional success in raising the graduation rates of underrepresented minority students (URMs) in STEM disciplines at 20 selected institutions within a large system of public higher education. The study used secondary data available from both the system's Office of Institutional Research and the Federal IPEDS reports. Results of the study identified selected institutions that performed the highest at graduating URMs in STEM. The study also revealed that several institutional factors (Pell Grant Aid, faculty salaries, expenditures and average student age) were not significantly associated with URMs graduation rates. A positive correlation was found between SAT scores, high school GPA and URM STEM graduation rates. These pre-college student achievement factors were most prevalent at the highly selected institutions in the study which also had the highest URM STEM graduation rates.

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Chapter 1: Introduction

Introduction

As a nation, the goal of fortifying college success in Science, Technology Engineering and Mathematics (STEM) has intensified in the United States due to the ever increasing demand for a highly skilled labor force needed to sustain a global competitive position (Carnevale, Smith, & Melton, 2011). The President's Council of Advisors on Science and Technology (PCAST) has indicated that our nation's economic forecasts point to a need to produce one million college graduates in STEM fields to maintain America's economic advantage. The discussion of STEM as a national imperative, a priority deserving both state and federal support, has focused both on the need to educate many more thousands of graduates in professions from traditional disciplines, as well as those in evolving and allied disciplines. New York State regions mirror the national predictions that STEM occupations will grow faster than non-STEM occupations between 2010 and 2020 and face the knowledge that 26% of all degree holders in the science and engineering labor force are age 50 or over, and by age 62, half of all bachelor's degree holders in science and engineering are expected to leave full-time employment (National Science Foundation (NSF), 2008). This impending decline in the STEM workforce has contributed to the looming crisis the country and its industry is currently experiencing (Fifolt & Searby, 2010).

The President's Council of Advisors on Science and Technology in a special report to the White House, has espoused the need for skilled workers in STEM fields is expected to require some one million new workers, some facts in this regard include that there has been a nearly 8% increase in STEM-related employment opportunities compared with 2.6% of non-stem related employment (2012). The U.S. Department of Commerce projects that between 2010 and 2018 there will be a 17% growth in STEM-related professions compared with only 9.8% of non-STEM professions; that STEM workers earn 26% more than their non-STEM counterparts (White House Fact Sheet, 2010). Yet, there aren't enough domestic educated workers to take advantage of these opportunities. Clearly, the need for more students pursuing and graduating with degrees in STEM disciplines has never been as great, particularly for those from underrepresented populations. Dr. Donna J. Nelson, Associate Professor, University of Oklahoma said it succinctly:

> under-represented minorities are projected to constitute almost 32% of the American population by 2020, outnumbering white males (30.1%). Therefore, proactive steps should be taken now in order to insure the proportionate inclusion of such a large part of the U.S. population in science and engineering, throughout all levels of academia. (Nelson & Brammer, 2010, p.2)

At the NSF 2012 conference in Chicago, Illinois, another well-known scholar and keynote, Dr. Richard Tapia, from Rice University, spoke eloquently on the need to educate more students in STEM, saying:

> We need to combat the loss of the precious few underrepresented minority students pursuing STEM. It is a simple matter of the nation's survival…to make the country healthy. The rate at which the minority population is

growing is outpacing the rate at which we are improving our effectiveness in educating these students (Zverina, 2012, p.1).

General Background

One purpose of STEM education is to provide opportunities to develop decision-making skills to understand situations and make informed decisions (National Research Council, 1996). Diverse populations have not been adequately represented in reforms that would increase the numbers of scientifically literate citizens. Between 2001 and 2010, the underrepresented minorities' (URMs) share of science and engineering bachelor's degrees has been rising modestly from about 10.5% to 18% (NSF, 2013b). Retooling the teaching and learning framework for STEM and science education is both a cultural and economic necessity. One researcher states, there was one crucial shortcoming in the art and practice of math and science instruction as developed throughout the 1960s saying, the science classroom needs to incorporate the conceptual opportunities to build explanations for the inquiry and interpretive frameworks guiding experimentation (Carey, 2009). That is to say, that creative pedagogical approaches in the teaching of STEM disciplines would benefit a more diverse student population.

The implementation of STEM programs became a logical extension of the past two decades of STEM education reform efforts. The publication *Science for All Americans,* published by the Association for the Advancement of Science (AAAS) (1989), was designed to guide educational reform through 2061, but underscored the critical importance of addressing the inherent connections among science, mathematics, and technology. *Benchmarks for Science Literacy* (AAAS, 1993) rewrote those ideas in terms that provide the fundamental rationale for integrative STEM education:

> "*The basic point is that the ideas and practice of science, mathematics, and technology are so closely intertwined that we do not see how education in anyone of them can be undertaken well in isolation from the others*". These ideas led to the "Science and Technology" standard in the *National Science Education Standards* (NRC, 1996), which very clearly stipulates that "abilities of technological design" be included in the curriculum (AAAS, 1993, p.107).

Today, we have reached a new plateau with the Next Generation Science Standards, in recognition of the diversity of students and the need to engage students in collaborative interdisciplinary inquiry. Through substantial funding from federal agencies and coordinated, collaborative statewide programs, many higher education institutions have recruited undergraduate students to STEM programs in a systematic attempt to broaden participation overall and especially for underrepresented minorities, this effort has not satisfied the needs of an innovation or knowledge economy. Whereas the United States Department of Education reported that 12.9% of all students (2,994,667) received bachelors and other degrees in STEM in 2001, by 2008-2009, that percent of the total degrees awarded declined to 10.7%. While the number of STEM bachelor's degrees and certificates actually increased (433,742), their numbers do not keep pace with overall increase in degrees awarded (4,057,501). According to the National Center for Education Statistics (NCES) (2011), the percent growth for all degrees 2001-2008, was 35.5% whereas the STEM fields showed a net change limited to 12.4%. Part of the dilemma in raising the rate of STEM graduates is underscored by the barriers faced by women and minority participation in STEM disciplines. Though enrollment has grown, many pressures and barriers erode the graduation rates of underserved populations compared to the graduation rates nationally within STEM disciplines. Questions of student departure and institutional response continue to be disconcerting, even in the midst of many supportive interventions. Providing an environment that offers the optimal amount of challenge and support has been the basis of many interventions, focused on themes of affirmation including the creation of positive expectations, respect and equity, identity clarification and motivational reinforcement.

Although it is reported that 75% of all students hope to enter college right after high school, with many having already identified their area of interest, the level of attrition from first to second year transitions shows that many depart from STEM fields including those from underrepresented or minority backgrounds. The Higher Education Research Institute (2010) survey of 200,000 students revealed that of those starting in STEM disciplines, only 40% of Latino students, 31% of Black students and 37% of Native American students go on to complete degrees in any major within five years. In New York, the completion of a four year degree in the traditional four year period is significantly lower for African American and Latino students, 22% and 17% respectively, while Native Americans in New York do slightly better at 30% (NCES, 2009). Nationally, the five year completion rate for students from the 2005 cohort in public higher education rose to 57% (NCES, 2013). Information from the State University of New York (SUNY) Institutional Research Office shows that in select SUNY four-year institutions, graduation rates have risen to 62%, with even higher graduation rates for

Asians. Overall, a six-year completion rate in the United States for Caucasians at four-year institutions rose to 60.2%. At historically black colleges and universities (HBCUs), the degrees conferred to African-Americans in STEM disciplines, ranged from 22%, 21.4%, 21.2%, and 20.3% from 2005 to 2008 (NSF, 2013b). The significant departure from STEM, even in the supportive HBCU environment where attrition is notably less than in other types of institutions, such as the public higher education sector, continues to impact a future labor force.

The vast underrepresentation in STEM by African Americans, Hispanics, Native Americans, and Pacific Islanders has become a central focus for the administration of President Barack Obama and a priority in its educational policy. Despite aspirations and interests, Blacks, Hispanics, American Indian/Native Americans, and women of all ethnic, economic and racial backgrounds are less likely to continue in advanced level science courses in STEM fields. Several researchers have reflected on the limited exposure to science achievement and inquiry skills, due to inadequate learning environments, which is echoed in reports dealing with the under-preparation and lack of STEM familiarity (Lee & Luyks, 2006). The lack of equitable education opportunity also increases the lack of genuine understanding of STEM careers is also deemed responsible for the early departure from STEM programs. Beyond this problem, which masks gender and race inequities in the American classroom, the question of SAT scores and academic preparation, both seen as major indicators for success in science and STEM overall impact students' college choice and program of study (George, 2013). Another significant and well-studied phenomena hinges on providing curriculum experiences that incorporate aspects of relevant life experiences that are specific to the underrepresented minority student (Warren, Ballenger, Ogonowski, Roseberry, & Hudicourt-Barnes, 2001).

Despite interventions, minority populations choosing STEM disciplines as a college choice remain low and the transfer rate from STEM disciplines to non-STEM further erodes the graduation rate in these fields. Data comparing enrollment graduation rates in STEM between 1996 and 2001 from the National Center of Educational Statistics (NCES, 2009) offers a point-in-time reference illustrating the depth of the discrepancy in graduation rates among underrepresented students in STEM. During this period, of the 21% of African Americans enrolled, only 3% earned a bachelor's degree; and of the 23% Hispanic student enrollment, 4% persisted to earn a bachelor's degree in STEM. In data representing all bachelor's degrees for 2010 as reported by NCES, 36% of all Asian/Pacific Islander students earned a bachelor's degree in a STEM field, compared with 25% of White, 23% of American Indian/Alaska Native, 21% of Black, and 20% of Hispanic students.

The first-time enrollment of underrepresented populations has increased, reflecting the demographic changes in the country. In New York State between 2006 and 2020, the Latino population is expected to grow by 21%, the African American population by 8% and the Native American population growth is estimated at 5%, totaling a 34% increase in students ages 5-24 in these categories (NCES, 2009). In some instances, persistence and completion rates have improved but substantial gaps remain as do many issues surrounding enrollment and retention in science, technology, engineering and mathematics (STEM) career path.

Historically, creating access to higher education has long been a priority of many state and federal initiatives, and more recently STEM initiatives. President John F. Kennedy implemented the National Defense Education Act, the National Defense Student Loan and the TRIO Programs to provide gateways to higher education to encourage minority participation. Additionally, with the passage of the Higher Education Act in 1965 and President Lyndon B. Johnson's War on Poverty, the nation began to act on the need to provide equal access to higher education by providing financial aid to minority students. As the population is moving toward a minority majority, the success of this population in completing college has become a national issue. This daunting admission captures the problem: "The demand for skilled workers in STEM fields will be difficult, if not impossible to meet, if the nation's future mathematicians, scientists, engineers, information technologists, computer programmers, and health care workers do not reflect the diversity of the population" (Crisp & Nora, 2012, p. 2). In this analysis, representation by Hispanics, the fastest-growing and youngest group in the United States is critical as Hispanics will comprise 30% of the U.S. population by 2040 and will be the majority group in several states (U.S. Census Bureau, 2008).

Moreover, of the minority students entering college with intended STEM majors - their persistence in STEM is eroded from the first to second year at significant rates and losses continue through to their last or senior year. In evaluating the erosion, a recent study indicates that only 31% of minority students initially planning to major in a STEM field remain by senior year, while 43% of non-minority students persist to this point (Griffith, 2010).

This reality has implications on many levels and the exploration of systematic outreach and retention efforts within the State University of New York as a 64-campus enterprise. Failing to successfully develop the emerging college-going student population as the next-generation workforce in traditional and nascent STEM disciplines is an ongoing concern and responsibility. The issue is not one of enrollment, but of retention and persistence to graduation within these critically needed areas of study.

The capacity of the educational system in the United States to create a diverse and competitive workforce for the STEM marketplace must be questioned, especially in light of the looming change in the demographic shift, suggesting that many of our current and certainly our future students will be comprised of underserved and underrepresented minority populations.

Nationally, Some 40% of the K-12 student population today has a minority heritage, but only 9% of today's college-educated workforce from these backgrounds have earned a degree in a STEM field (Hrabowski, 2012). With the exploding growth of the Hispanic population, now New York's largest minority group, advancing educational attainment is critical in light of the need for a STEM workforce to fulfill the needs of an innovation society as well as burgeoning technical enterprises throughout the country. Talent is especially needed for regional technology hubs in New York State. Another group of learners, those with immigrant parents, many of whom are known as first-generation college students, are also less likely than other students to have earned a bachelor's degree (13% compared to 33%) after five years (NCES, 2011). This too represents a challenge and dilemma for STEM educators as they embrace inclusion and address cultural barriers to success. Relative to the global educational attainment, the

United States has slipped to 15th place (The National Center for Public Policy and Higher Education, 2008), creating even greater alarm regarding its ability to compete in a global marketplace (Palmer, Moore, Davis & Hilton, 2010). China and India both have tremendous human capital, with some 16 million and 9 million students enrolled in higher education and are producing far more STEM graduates to further their economic output through this pipeline of highly skilled graduates (The National Center for Public Policy and Higher Education, 2008). The National Center for Public Policy and Higher Education also notes that some 20% of India's students, aged 25-34, are enrolled in STEM disciplines. While the overall graduation rate for minority populations in the United States and in the State University of New York comprehensive colleges has been slowly improving – there is a growing recognition that workforce development for highly skilled occupations in the United States requires greater intervention to prevent student departure and that the gaps in STEM participation for all students as well as underrepresented minorities will have significant impact on the country's ability to be competitive.

Problem Statement

The United States is faced with a demographic projection suggesting that 85% of new entrants to the workforce in the country will be members of minority groups, and women will make up more than half of the United States population by 2050 (U.S. Census, 2010). Despite the growing demand for highly skilled workers, engineers, and those with technology expertise, the academy has not been able to rectify the lower participation and still lower graduation rates for URMs in STEM fields. Over the next two decades, 70 million baby boomers—most of whom are Caucasian—are expected to retire and exit the U.S. workforce. Currently, only 5% of the general U.S. population works in STEM-related jobs such as nursing, dentistry, and electrical work (Myers, 2013). This short supply of available skilled workers further exacerbates the problem of the need to fill an ever increasing demand for new employment in STEM, expected to need one million new workers within the next decade.

Who might replace these workers? According to the National Action Council for Minorities in Engineering (NACME), Latinos in America in 2006 reached a new plateau of 44.3 million people, accounting for almost 15% of the total U.S. population (NACME, 2008), but a mere 2% of those 44 million Latinos living in the United States have worked in STEM-related fields. According to the U.S. Census the Hispanic population is projected to grow from 53.3 million today to 128.8 million—or one in every three people—by 2060. In New York State, changing the equation of who attends college and graduates in STEM is a critical concern for SUNY as a large university system and educational leaders across the country.

After several decades of intervention and federal support for STEM education initiatives, and numerous reports on the ability of the United States to produce a workforce able to compete with that of other countries, the issue of maintaining economic advantage has once again become a focus of government's efforts to overhaul the educational programs for student participation and educational attainment. Despite great effort, toil, and interest, educators are not producing adequate numbers of graduates for a STEM-proficient workforce (Sanders, 2009). The legislative approval of the America Competes Act and new Broadening Participation funding by the National Science

Foundation are two examples, among many others, of major investments in STEM arenas by the Gates Foundation, the Lumina Foundation, and the Albert Sloan Foundation.

President Barack Obama, during his first speech to a Joint Session of Congress on February 24, 2009 announced that by the year 2020 the US should have the highest proportion of college graduates in the world (Williams, 2013). In the same Joint Session of Congress, President Obama went on to say,

> In a global economy, where the most valuable skill you can sell is your knowledge, a good education is no longer just a pathway to opportunity. It is a prerequisite. Right now, three-quarters of the fastest-growing occupations require more than a high school diploma, and yet just over half of our citizens have that level of education. We have one of the highest high school dropout rates of any industrialized nation, and half of the students who begin college never finish. This is a prescription for economic decline, because we know the countries that out-teach us today will out-compete us tomorrow (Obama, 2009, para.60).

As mentioned earlier, after several decades of intervention and federal support for STEM education initiatives and numerous reports on the condition of the ability of the United States to produce a workforce able to compete with that of other countries, the issue of maintaining economic advantage has once again become a focus of government's efforts to overhaul the educational programs for student participation and educational attainment. Along these lines a large public university system can benefit by better understanding what successful institutions are doing to successfully graduate more URM students in STEM and assist the state and nation with producing more highly skilled workers.

Theoretical Rationale

Many predictive factors for student success have been studied extensively, and varied teaching and learning practices have been adopted to help students overcome barriers that are purely academic, the most prevalent being inadequate mathematics competencies and underdeveloped study skills. The participation of underrepresented racial subgroups in STEM programs presents an imbalanced picture of students who fail to complete their undergraduate degree or complete it in a non-STEM field. Hispanic men are shown to have one of the highest rates of non-completion and low educational attainment at age 25 and older (NCES, 2011). The cause of the departure of African Americans from college STEM programs has been identified in numerous studies as the lack of math proficiency and low test scores as compared to Caucasian students in math competencies. While this gap showed signs of narrowing during the 1970s and 1980s, studies indicate it has subsequently been broadening (Campbell, Hombo, & Mazzeo, 2000) and remains an issue in the literature surrounding grade sensitivity in STEM subjects and preparatory studies prior to college.

Concerns of cultural difference barring acceptance in the college environment have also been developed as the social integration research of many scholars. Vincent Tinto's early studies suggest that students who became engaged in the social milieu of their college could garner enough support to proceed to graduation. Broadly drawn, Tinto (1993) argues that individual departure from institutions can be viewed as a result of the interactions in several systems within the college environment. The lower the social and academic integration a student experiences, the greater is the likelihood of departure. Institutional factors preventing social acceptance (integration) and academic achievement have also been studied by many other scholars and are seen as central to student persistence (Braxton, 2000). More recent investigation of the relationship between STEM learning and students' perceived sense of community (SOC) has also demonstrated that affinity groups and campus programs such as summer bridging activities, pre-college orientations, undergraduate research and establishing learning communities also prevented students from leaving their STEM discipline. Today, both at the undergraduate and graduate levels, many barriers persist despite the many strategies that have been implemented. However, interventions such as summer bridge programs, faculty mentoring, intrusive advising and research opportunities, when combined, have been shown to alter the isolation and stereotype threat and a poor climate for diverse students in higher education programs (Hurtado, 2007). Intensive analysis of the research on successful intervention protocols demonstrates their value in varied model programs.

A sampling of the many university systems that have implemented strategies to overcome the prevalent barriers to graduation in a STEM-related degree would include the California State Colleges and the University of California. At Cal Tech, a concerted retention strategy for women was implemented leading to a net increase in the completion rates for females as well as males, resulting in baseline retention rates of 76% and 77% for women and men respectively across eight colleges. Chief among them were campus faculty trainings focusing on teaching to female learning styles and integrating female students in the classroom. Revision of the curricula to include more contextual examples for women, more collaborative projects and equal time spent on lab projects were contributory. Outreach and retention strategies later introduced at a number of targeted colleges with a project goal of increasing retention showed impact within a year or less (Milgram, 2009). Similarly, the State of Georgia University system has significantly revamped its STEM and engineering curricula, with the goal of removing structural impediments to success. Over and above the student-centered interventions affecting retention in STEM disciplines, institutional adaptation and pedagogical reform are viewed as additional factors impacting teaching quality, which contribute to a positive view of STEM disciplines and increased persistence by minority and underrepresented populations (Gloria, 1997; Nora, 2004; Pascarella, 1978; Seymour & Hewitt, 1997). The attrition of students, even those with high test scores and aptitude in math and science, has been identified as a systemic issue, based on the narrow teaching of content; without regard for the overarching goal of creating students with scientific literacy and academic excellence as primary goals (Tobias, 1996).

Over time, institutions across the country have implemented model programs which have had demonstrated success using an array of strategies to combat the loss of potential graduates with interests in STEM disciplines. The programs all draw on strategies identified in the report by BEST (Building Engineering & Science Talent, 2004), with specific core areas: institutional leadership, targeted recruitment, engaged faculty, personal attention, peer support, enriched research experiences, bridging opportunities, and continuous evaluation. Top among them are the Meyerhoff Scholars Program, the Minority Engineering Program, and the Mathematics Workshop Program. The Meyerhoff Scholars Program, located at the University of Maryland, Baltimore County, addressed four critical areas which are known to inhibit minority success—financial support (with minimum grade average of B or better), monitoring, advising, skills and knowledge building, including summer research experiences, and mentoring by scientific or STEM professionals, including family and faculty involvement (Summers & Hrabowski, 2006).

The Mathematics Engineering Science Achievement (MESA) model helps elementary, high school, community college, and college students in their aspirations to succeed in STEM studies at the postsecondary level. This model evolved from the development of 100 Minority Engineering Programs (MEP) refined over 40 years as a result of the leadership of engineering professor Ray Landis (2005), author of *Retention by Design*. Well over 800 California educational institutional partners participate in the extension of his learning community/outreach model which has been replicated in 10 other states at all levels of the educational pipeline with extensive support from industrial partners and associations with professional affinity groups representing diverse perspectives in STEM disciplines in engineering, science, math, and computer science. Their success rate in helping students transition to, and persist in STEM programs, has helped diverse populations, and become part of their vision to act as advocates of STEM education. This approach serves to provide access and equity to impact diverse populations to contribute to a competitive global workplace.

A third approach in the form of a mathematics workshop model concentrated on the formation of peer study groups to provide students opportunities for "self-correction and an environment in which they could safely make public their understandings." (Garland, 1993, p.14). Theory supporting interventions such as these were posited by Vincent Tinto (1975, 1993) as activities influencing student departure and provide evidence that "continued institutional commitment will impact academic and social integration" (Garland, 1993, p. 17). Early landmark efforts such as these provided evidence that a framework including a peer network, peer tutoring, mentoring, and early intervention with counseling and advising support helped all students. Underrepresented minority students excelled at rates equal to or better than majority students in content acquisition and mastery within the study undertaken by Uri Treisman, in his implementation of these strategies in teaching calculus (Garland, 1993).

Statement of Purpose

This study examines differences in institutional success measured by the graduation rates of underrepresented minority (URM) students in STEM disciplines at 20 comprehensive four-year colleges and doctoral-granting university centers within the State University of New York. The study will be limited to African American, Hispanic, and Native American students (including Pacific Islanders).

Research Questions

Specifically, the study has been designed to explore the following research questions:

1. Are there differences in STEM URM completion rates among the selected four-year SUNY institutions?
2. If so, is the variability among graduation rates explained by institutional characteristics of the institution? To what extent?

Significance of the Study

The study identifies the highest performing institutions at graduating URMs in STEM within the SUNY system. It examined the differences in success among the 20 doctoral serving institutions and comprehensive colleges selected in supporting underrepresented students seeking a STEM degree.

Underrepresented Students in STEM Fields

A broad range of programs and student-centered supports have helped underrepresented students in colleges throughout the country, although the enrollment rate in STEM and graduation rates for bachelor's degrees in STEM still do not generate enough growth to meet the demand or satisfy the need for a highly-skilled and diverse workforce for professions designated as critical STEM industries. University systems of public higher education in California, Maryland, Georgia, Texas, Florida, and New York are striving to close the graduation gap for minority students. The rate of STEM participation by underrepresented students enrolling in colleges suggest the need for more targeted enrollment from secondary to postsecondary education. Focusing on the transitions students need to make at different stages of their postsecondary education is a critical component of the State University of New York's Replications Project, which seeks collaborative relationships between community colleges and comprehensive colleges and/or university centers which provide post-graduate education programs. University systems have addressed a host of intractable problems through a broad range of strategies to ensure that the pattern of attrition is narrowed and thereby help to close the graduation gap and reframe the graduation rate of unerrepresented and low-income students. As a historical perspective, there were 977 institutions of higher learning in the United States at the turn of the century, enrolling approximately 240,000 students, or approximately 2.3% of the population. By 1994, 63.7% of the college-age population enrolled in some form of higher education, (Braxton, 2000, p.239). Despite the popularity of attending college, Tinto reported:

> Of the nearly 2.4 million students who in 1993 entered higher education for the first time, over 1.5 million will leave their institutions without ever completing a degree. Of those, 1.1 million will leave education altogether, without ever completing either a two- or a four-year degree program. (Tinto, 1993, p.1)

In this review of participation in undergraduate STEM disciplines, the Higher Education Research Institute (HERI, 2010) reported that minority students intending to enter a STEM discipline has increased to 34.1%, comparable to the rates for Caucasian and Asian students, yet completion rates for minority students reflect an alarming fall-off. The findings of the study showed that White and Asian American students who started as STEM majors had four-year completion rates of 24.5% and 32.4% respectively. Underrepresented minorities who initially began college as a STEM major had four-year STEM degree completion rates of 15.9% for Latinos, 13.2% for African Americans, and 14% for Native Americans. When considering the five-year completion rates for all five cohorts, the differences in rates were even more pronounced. White students were found to complete their STEM degrees in five years at the rate of 33% and Asian Americans at 42%. The rates for Latinos, African Americans, and Native Americans were 22.1%, 18.4%, and 18.8%, respectively. The graduation rate at the six year mark, which is used as a standard nationally, was not computed. Some of the disparities in STEM achievement and persistence by underrepresented minorities may be based simply on life choices, but the responsibility of an institution to create an environment for student success is nonetheless a critical factor. According to 2010 data from the National Science Foundation (NSF) (2013a) and the U.S. Census Bureau, underrepresented minorities earned 18.6% of total undergraduate degrees from four-year colleges, but only 16.4% of the degrees in science fields and less than 13% of degrees in physical sciences and engineering (NSF, 2013a). With changing demographics increasing the representation of currently underrepresented students in the college-going population, low representation of Hispanics, African Americans, and Native Americans/Pacific Islanders in physical sciences, engineering and life sciences, and computing, provides institutions with a stark realization that the demographics of those succeeding is not keeping pace with those attending, even though college enrollment reached a record high of 12.6 million students in 2011, a 3% gain from 2010 (PEW, 2012). For the first time, the number of 18- to 24-year-old Hispanics enrolled in college exceeded 2 million and reached a record 16.5% share of all college enrollments. Hispanics are the largest minority group on the nation's college campuses, a milestone first achieved in 2011 (Fry, 2012). Data supporting this trend reveals that 33% of Hispanic students ages 18-24 are enrolled in school compared with 42% of all young adults, though only 13% of Latinos in all age groups have a bachelor's degree, and only 4% have a graduate or professional degree (White House Fact Sheet, 2011). Yet, Hispanic college enrollment growth has accounted for 74% of the growth in college student enrollments in 2011 (PEW, 2012).

Even as their growth among all college-age students continues to outpace other groups, Hispanics are now, for the first time, the largest minority group among the nation's four-year college and university students, where graduation rates overall for this population are not representative of their share of the population. For the first time, Hispanics made up one-quarter (25.2%) of students aged 18 to 24, enrolled in two-year colleges and received 13.2% of all associate degrees in 2010. And Hispanics earning bachelor's degree reached a record 140,000 recipients, according to data published by the

National Center for Education (PEW, 2012; Snyder & Dillow, 2012). In both cases, Hispanic students comprise a growing share of all degree recipients. Despite these gains, Hispanic representation among degree recipients of two-year programs was reported at 21.7% and at four year colleges and universities; the Hispanic students totaled 11.7% of the graduates in 2010. (Snyder & Dillow, 2012). Of the 1.7 million bachelor's degrees conferred in 2010, approximately 8% of all recipients were Hispanic, 10% were African-American, and 7% were Asian/Pacific Islander. (NCES, 2011). Drilling down further, Hispanic populations throughout the United States attaining a bachelor's degree in a STEM area has been computed by the National Center for Educational Statistics. For 2010, 18,613 of 246,732 or 8% of bachelor's degrees in STEM were conferred to Hispanic students. The Bureau of Labor Statistics projects that Hispanics will become 19% of the civilian work force between 2010 and 2020, yet their graduation rates will preclude many from opportunities in STEM endeavors.

African-American college students provide another example of attrition and departure from the STEM majors they had intended to pursue upon high school graduation. In 2001, 13% of freshman starting college were African American, but only 9% persisted to graduation by 2005. By comparison, white students reportedly comprised 74.8% of the total population of incoming freshmen, with graduation rates in 2005 approaching 70% overall and some 67.3% in STEM (Sasso, 2008). Dr. Carlos Rodriguez, principal research scientist at the American Institute for Research, has advocated for legislative intervention as "there's been a very narrow band [of minorities] graduating, between 13% and 16 % of all STEM degrees that has pretty much stayed constant since 1992," (U.S. News STEM Solutions 2012 – A Leadership Summit, 2012) and has not allowed the workforce to diversify or become more representative of demographic make-up of society. In 2009 the National Science Foundation reported that the type of institution that African American students attended constituted a factor of degree completion. Some 40% of minority students utilize community colleges as a stepping stone to begin their degree studies and then go on to utilize a comprehensive college to attain their baccalaureate degree. In the two-year institutions, persistence to graduation is also a major concern, as low graduation rates in this sector impact future attendance and graduation from a four-year degree program. The institutional pathways that a university system provides are factors in this progression, as well as other important conditions such as geographical proximity, the level of research undertaken at a college, and financial aid.

Other factors, such as the lack of mentors of color or those with a similar racial heritage, reflect the fact that role models are not evident for aspiring students. Even as more African American women are completing STEM doctorates, their presence on faculty is still low, a subject taken up in the report by Nelson and Brammer (2010): *A National Analysis of Minorities in Science and Engineering Facilities at Research Universities.* Institutional collaboration with major affinity groups has become a more focused approach to build a STEM workforce poised to fill the one million anticipated opportunities in all the engineering, computing, technology, math, and health and science sectors. Although the Hispanic share of the overall workforce held by Hispanics as reported has increased significantly from 3% in 1970 to15% in 2011, Hispanics represented 7% of the STEM workforce in 2011. African Americans comprised 11% of the overall workforce, with slow growth to 6% in STEM jobs, up from 2% in 1970 (Landivar, 2013).

As an example of collaborative efforts, NACME (the National Action Council for Minorities in Engineering) has partnered with 50 colleges providing $124 million in scholarship and support to significant work with colleges throughout the country. Their strategies incorporate a continuum of programs and activities from middle school to high school through workforce entry as well as research to shape a national STEM workforce development policy at all levels of the educational spectrum. Measures to reduce the systematic barriers and preparation deficits limiting educational access and college completion in STEM fields are subject to funding and leadership priorities within colleges. The significant factors that impact the institutional ability to sustain growth and college completion in the STEM sectors requires a careful analysis of many variables. Identifying the strengths and weakness throughout a university system may posit useful information on success factors for potential enrollment, particularly for the production of STEM graduates.

Research Context

The State University of New York, established in 1948, has grown to become the largest public university system in the nation with 64 geographically dispersed, state-operated, statutory and community college campuses. Some 422,582 undergraduate students are currently enrolled, and more than 3.3 million degrees have been awarded (SUNY, 2013). Four university centers and 13 comprehensive colleges granting baccalaureate degrees help the university system fulfill its role as an economic workforce development leader in the state, which is fully constituted by 64 campuses and one distance learning program with many global extensions. The University system is a complex amalgam of land grant universities, technical colleges with roots in agricultural development, and an array of liberal arts colleges. Throughout its history, access and inclusion have been primary drivers in creating New York's higher education system. The flavor of diversity is captured in this description:

> If we compare SUNY to a fleet at sea, its university colleges and colleges of technology would be battleships: rough and ready, purposeful, adroit in responding to crises, and indispensable for the vitality and integrity of the entire fleet. Its community colleges would be like ships of varying size harbored throughout the SUNY sea, essential in providing fundamental services and able to meet specific, localized needs; its specialized campuses would correspond to the flotilla's uniquely-tasked ships, each one with its own special focus; and SUNY's university centers would be like aircraft carriers, dwarfing the other vessels and receiving a proportionally greater share of the resources because of their paramount, complex missions. All must sail the same political waters, face the same economic storms, and have the same common purpose on behalf of the state's citizens. (Skopp, 2010, p.39)

Diverse students in SUNY have been steadily growing, with a total minority enrollment (121,319) standing at 26.2%. Black and Hispanic students are represented by 9.9% and 9.4% of this population. Asian and Pacific Islanders and American Natives represent 5.1% and 0.4% of the population respectively.

In a review of underrepresented graduation rates for students entering from 1990-2004, against that of all graduates, there are promising indicators with regard to educational persistence within SUNY. The graduation rate in each minority cohort has trended up for all groups except Native Americans, which dipped from 46.50% to 37.30% during this timeframe: from 43.4% in 1990, to 57.8% in 2004 for Black non-Hispanic students; from 51.4% to 55.8% for Hispanic students; from 63.8% to 68.6% for Asians. Overall, the graduation rate for all graduates rose 2.5% to 63.5%. A subset of this population enrolled in the Educational Opportunity Program (2006 cohort) has achieved a 56.2% graduation rate. The success of the Educational Opportunity Program first created through legislation in 1967-1968 and similar programs within the State University of New York have steadily assisted underrepresented populations gain access and persist to graduation.

This study reviews the facets of undergraduate enrollment, retention and retention strategies in place at the colleges within the university system and the success of STEM students at the comprehensive colleges and university centers to discover and analyze underrepresented minority graduation rates and their production of STEM graduates.

Definitions of Terms

The following are definitions of terms that are used throughout this study:

URMs – the term stands for Underrepresented Minority Students signifying several historically underrepresented groups in higher education; African American, Hispanic/Latino, Native American and Southeast Asian.

SUNY – refers to the State University of New York and is the comprehensive system of higher education which consists of 64 campuses throughout the State of New York.

STEM – this term refers to Science, Technology, Engineering and Mathematics used widely in higher education to mean the type of programs that fit the Science, Technology, Engineering, and Mathematics fields and what makes a discipline a legitimate part of STEM. It is important to note that there are STEM classification systems posited by both the Department of Homeland Security and the National Science Foundation, providing different ways to identify the disciplines included in STEM. The Department of Homeland Security (DHS) has the broadest STEM definition with 424 programs distributed across 21 disciplines. In comparison, the National Science Foundation (NSF) includes 224 programs in 12 disciplines. See Appendix A for both classifications systems by the types of disciplines included.

Persistence – "the rate at which a student begins his/her education at a given point in time and continue to degree completion" (Tinto, 2012, p.127).

Retention and Graduation – refers to the rate at which an institution retains and graduates a student (Tinto, 2012).

Success – the term refers to progress towards graduation.

Student Attrition – "the rate at which students terminate college without completing a degree" (Tinto, 2012, p. 128).

Chapter Summary

The nation's ability to maintain its global leadership in research, innovation, and economic competitiveness is directly tied to its ability to produce high-quality STEM graduates who can produce new innovations critical to success of our knowledge economy. As discussed in this chapter the demand for graduates in STEM-related fields continues to grow; state and federal investments in STEM while good need to be increased; achievement in STEM is key to state economies and US prominence, and efforts to engage more females and minorities in STEM remain priorities. While college degree attainment throughout the world has increased, the US rate of completion for 25-34 year old students has dropped, and the country now ranks 12th in this category (Carnevale, Smith, & Strohl, 2010). In conjunction with the demographic shifts that are increasing the numbers of minorities in the nation, it is clear that the fastest growing segment of the population is not realizing its potential relative to persisting and graduating in STEM related disciplines.

This chapter has discussed several programs, institutional strategies, and other practices that have been shown to combat the loss of potential graduates particularly those from underrepresented student populations. The scholarly work from highly regarded researchers like Vincent Tinto and his student integration theory was highlighted along with other models that describe some of the factors pertinent to student persistence and graduation. Yet, the problem still prevails and the need to continue to assess this phenomenon has never been quite as critical. The context for this study was 20 institutions of a large system of higher education in the northeast and graduation rates were examined as well as the differences between the institutions were examined.

Chapter 2: Review of the Literature

Introduction and Purpose

Raising achievement, persistence, and degree completion in disciplines that require a high degree of commitment, identity as a researcher or scholar, skills in mathematics, and a desire to pursue a career in a STEM-related field combines many facets of education. Increasingly, colleges and universities are drawing from the growing minority populations as well as international students, part-time students, disabled students, and mature students, including returning veterans. These types of students increase the non-traditional and diverse populations attending public higher education. Another population that needs the assistance of institutional support through multiple forms of cultural inclusion would be the first-generation student. Traditionally, this population, largely underrepresented minorities, has been shown less likely to pursue a STEM major due to lack of knowledge regarding the subject, lack of encouragement and support (Lam, Srivatsan, Doverspike, Vesalo, & Mawasha, 2005). Each of these groups, whether a racial or other subset, is at risk of failure or non-completion in the pursuit of an undergraduate degree, based on research framing participation and student success. Student persistence is a complex phenomenon affected by influences from student backgrounds, institutional factors, and student choice. Examining intrinsic and external factors for student success includes motivational factors such as mastery, self-determination, belongingness, and social responsibility inside and outside the classroom.

Among this student group, literacy becomes a significant determinant of participation and success (Dean & D'Agostino, 2007).

The institution's leadership, its faculty's response and its students' engagement number are among the critical factors that help create and support a culturally diverse and vibrant STEM community within higher education. Several institutional-dependent variables are in play, each hinging on the effort to broaden participation in STEM for culturally diverse students through a concerted program of motivation, engagement, academic challenge, scholarship or financial opportunity, cultural inclusion programs, faculty diversity, and interactions with a faculty mentor. Improving recruitment and timely graduation rates in STEM programs may not only enhance the student success factor so important to each individual pursuing a degree, it can help the nation overcome the shortage of STEM graduates and raise the institutional awareness of needed retention strategies (George, 2001).

As a system, the State University of New York, through its many colleges and programs, provides an opportunity to study which institutional factors are significant in meeting the challenge of better educating underrepresented college students as the global need for capable STEM graduates increases. Removing the barriers or social disabilities preventing underrepresented minority students from attaining the same rate of graduation as their majority counterparts will enable the system to improve its institutional profile, but also will serve the economic future of the state in addressing a national educational priority. The variables chosen for this study reflect the frameworks for student retention and departure as developed by Van Gannep's (1960*) Rites of Passage*, Tinto's (1988)

Model of Institutional Departure, and Bridges' (2003) *Managing Transitions: Making the Most of Change*.

This study examines the rates of degree completion at the baccalaureate level of URMs having attended one of the twenty selected colleges and universities pursuing degrees in STEM disciplines. These campuses represent a cross-section of all the institutions within SUNY and include geographical variation consistent with the populations across the state. Though the increasing rate of graduation for URM students has increased modestly within the University system, the rate of participation in STEM disciplines and the graduation rates for underrepresented minorities in these fields has not kept pace with the increasing enrollment or overall graduation rates.

The literature in degree persistence in STEM fields cites many individual variables that have a role in student success, apart from racial identification. For those who enter as underrepresented minorities, student variables may be even more determinate in realizing a STEM-related undergraduate degree and are significant factors in the research on attainment. The prominent variables are:

- Information seeking patterns for college enrollment
- High school GPA
- Entering choice of STEM discipline as major – "science identity"
- Parental education
- First-generation college status
- Financial support/scholarship
- Experience of stereotype threat or perceived as a "chilly" environment

Alternatively, within the United States, many positive outcomes have been associated with programs that coordinate the academic experiences both in and beyond the classroom. These institutional variables have all been extensively studied in the literature. They are:

- Learning communities within STEM disciplines, including residential experiences
- Intrusive advising/remediation
- Early research experiences
- Bridging pre-college transitions including dual enrollment, middle and early college and summer camps (skill-building) experiences
- Opportunity programs such as Equal Opportunity Program (EOP), Higher Education Opportunity Program (HEOP), Search Education Elevation Knowledge (SEEK, New York State)
- Pell or TAP or other financial incentives
- Role model/mentor

Background and Context

The transition and success of underrepresented students entering a college has been widely explored in many transition framework studies, (including Terenzini et al., 1993 and Tinto, 1975). In Tinto's work, the social and integrative experience of college is explored as a factor of persistence. Drawing on the work of Van Gennep (1960) in anthropology and Durkheim (1997) in sociology, Tinto (1993) developed one of the first longitudinal models of institutional departure. His model suggests that student behaviors of leaving or staying at an institution arise out of a process of interactions between the individual student and other members of the institution's academic and social systems. Tinto suggests that a student's background sets the stage for interaction with institutional systems, but it is the individual's subsequent interaction with the systems that has the largest effect on persistence. Tinto's model predicts that students who have more positive academic and social experiences become more integrated into institutional academic and social systems, and are less likely to depart. As Tinto suggests, "the most important condition for student success is involvement, or what is now commonly referred to as engagement" (Tinto, 2012, p. 7). In Bridges' (2003) studies, the role of counseling and advising are framed as factors in the transition and success that students experience. Many studies have reviewed mentorship as a catalyst for student success. Involved faculty serving as role models and mentors supported the development of a learning community, not unlike the idea of the old African proverb creating "a village to raise a child."

Student aspiration, despite intent and interest, may be overwhelmed by the pace and rigor of a STEM curriculum, (Lara, 1992) due to problems of under-preparation in math and reading stemming from the elementary or secondary education programs attended. A study conducted at Binghamton University within the SUNY system underscored math competencies as an ongoing concern in persistence of students initially entering a STEM field (Kokkelenberg & Sinha, 2010). An achievement gap, years in forming, may not be remediated even with the benefit of a mentor, another area the literature explores in depth (Obleton, 2011; Thompson & Bolin, 2011). Degree attainment is further explored by Rendon (1994), who reviewed how students are validated by faculty and others, in or out of the classroom, to develop the persistence to excel and overcome academic deficits or other factors influencing departure. The validation construct argues that belief in a student's ability to succeed as expressed by recognition, respect, and appreciation could create a sufficient degree of acceptance to allow students to become engaged in the community. Tinto (1993) described this integration as "competent membership" (p. 208) within the academic culture.

As a factor in departure, campus environment has been explored widely, not only for student diversity but also in the context of faculty diversity. Campus environmental factors and the influence on racial and ethnic minority student success has been shown to play a critical role particularly at Predominantly White Institutions (PWIs). Both campus climate and culture, two different aspects of environment, have been a source of substantial interest in retention literature for underrepresented populations. (Museus, Palmer, Davis, & Maramba, 2011). According to Kuh and Whitt (1988) campus culture supports a "collective" atmosphere, mutually shaping patterns of norms, values, practices, beliefs, and assumptions that guide the behavior of individuals and groups...and provide a frame of reference within which to interpret the meaning of events and actions on and off campus. Additionally, culture is seen as a manifestation of experiences and expressions acquired through daily practices and interactions as well as common symbols and traditions (Kuh & Love, 2000). While campus culture is seen as a set of deeply held beliefs, values, and norms, a definition of campus climate is "current perceptions, attitudes, and expectations that define the institution and its members" (Museus et al., 2011, p. 22). Based on the two definitions, the overall culture of a campus is deeply embedded in the landscape of an institution's history and operational structure which is more fixed and difficult to change, whereas campus climate is based on current perceptions which can be seen as more dynamic and malleable over time (Museus et al., 2011). Building programs of inclusion to foster undergraduate transitions to a new environment, and campus culture can mitigate the isolation and stereotype threat expressed by students in campus life.

Researchers who have examined the role of campus climate in the experiences of URMs in STEM have found that those students report chilly and hostile climates, and that such environments can be associated with feelings of discouragement (Fries-Britt, Younger, & Hall, 2010). Several studies described by Yi, (2008) also demonstrate that less supportive educational environments have led to URMs students' departure from the STEM disciplines. Students withdraw voluntarily due to proximal or personal reasons, such as insufficient financial aid, attenuated motivation, and lack of a sense of belonging. Others withdraw because the institution they attend is perceived as failing to foster a "supportive" environment. The complexity is exacerbated by personal factors, such as life circumstances, emotions, and self-perceptions. As previously noted, college completion in the United States now lags behind that of many other developed nations (U.S. Department of Commerce, 2011). Degree completion has again become a centerpiece of national policy. Within the State University of New York, enrollment is on the rise; graduation rates too, are increasing. However, attainment in STEM disciplines does not mirror these gains for URM students. Institutional factors, such as the presence of role models, campus climate, or affiliation or engaging in an ethnic or professionally-focused community organization also shape the retention experience (Braxton, 2000; Parkin & Baldwin, 2009). In reviewing the literature, many studies address the programs that are in place within a given institution, but the SUNY system provides a rich source of data on persistence and educational attainment across a broad population in a range of colleges, providing more tangible evidence of the relevance of personal goals, preparation, support, and many other facets of institutional response in the enrollment and graduation of STEM students within the State University of New York. Many forces are at play in this context, but public higher education institutions can implement a number of different and coordinated services, ranging from financial aid options, to academic strategies, and even affirmative action, to improve minority student degree completion. In this study, we reflect on the predictors of college admission and preparation as determinants of persistence in STEM and interventions designed to influence student growth and degree attainment (Perna, 2013). Moreover, the role of a racially diverse campus environment can be an area of institutional growth and leadership to foster educational attainment.

A qualitative study conducted by Fries-Britt et al. (2010) examined the academic, social, and racial experiences of URM students who were succeeding in physics. They developed a conceptual framework for the study based on a range of well-known theories and bodies of research. The authors relied on theoretical work (Astin, 1993; Pascarella, 1980; & Tinto, 1993) which served as background for understanding the most salient factors related to student success in higher education. Of significance was Astin's (1993) input-environments-outcome (I-E-O) model which served as a basis for understanding the academic environment. The study by Fries-Britt et al. (2010) was conducted over a five year period with the National Society of Black Physicists (NSBP) and the National Society of Hispanic Physicists (NSHP). Students selected for the study were required to be in good academic standing and persisting toward degree completion. There were 110 students selected, 35% were women and 65% men. The participants came from a variety of colleges and universities: private, public, predominantly White, historically Black and Hispanic serving institutions from throughout the country. The researchers developed five key questions to guide the study:

> (1) What factors are important to racial minority student success in the literature (for example, faculty, peers, familial, and financial) applied to the experiences of students of color majoring in physics? (2) In what ways did racial minority students in physics characterize their experiences? (3) What perceptions did students have about their interactions with faculty inside and outside the classroom? (4) Did race contribute to their motivation to succeed? (5) How did their academic experiences shape their overall sense of self? (Fries-Britt et al., 2010, p. 77)

The data was collected at annual meetings of the NSBP and NSHP conferences. A combination of individual interviews, small focus groups, and document analysis was used to gather information. Additionally, key staff persons were interviewed. Individual interviews and focus groups were audiotaped and transcribed verbatim. Data was coded using the NVivo software program. Results from the study centered around three environmental type factors: faculty interactions, the role of peers, and the proving process URM students felt they were put through before being accepted. Students in the study had both positive and negative experiences with faculty interaction. The participants felt that the tone used by faculty to address them and the body language displayed determined approachability or a more distant interaction. Ultimately, students perceived these faculty behaviors as conveying what a given instructor thought about the quality of their work and ability to do science. On a more positive level of interaction, findings reflected students describing professors who acknowledged their work and sought them out for involvement in research projects confirming that they had a talent for physics. Students also found that some professors shared their own struggles and fears, this made participants feel more inspired as a result. What was revealing about these findings is that students expressed that professors who tended to share their own experiences were faculty of color and/or women. However, the researchers did indicate finding that good faculty mentors did not have to be from the same race and/or ethnicity as the students to be effective, more important was the genuine interest in the students' overall success.

With regard to the role of peers, it was found that support in this area was a major influence in student persistence in science. Students interviewed were found to have an excellent level of peer interaction and relationship building within their academic programs. Many of the students reported that if it wasn't for peer support they would not have made it in their STEM major. Interviews with students from Historically Black Colleges and Universities (HBCUs) were found to create a family-type environment among peers and faculty. There were fewer students from predominately white institutions (PWIs) that reported the same level of allegiances. Some of the participants who came from institutions and departments where there was an intense level of competition indicated they did not feel as close to their peers as described earlier.

The last critical factor addressed by this study centered on participants feeling that there was a never ending process of having to prove themselves. No matter how long they persisted in physics they felt they had to prove themselves in every class taken with a new professor and peer group. Students also expressed frustration with having to prove that they were capable of being admitted to more competitive type programs.

The findings in this study relative to faculty interaction and peer influence were consistent with other studies and the scholarly research in higher education. Another study on the factors promoting retention and persistence of students of color in STEM, found that support for students of color include role models of color, knowledge and lesson sharing from advanced students of similar ethnic groups, and relationships with staff of color (Palmer, Maramba & Dancy II, 2011). The authors go on to mention that the support that URM students receive from peers, mentors, and faculty are critical to success in STEM. Additionally, the empirical research in this area shows that URMs find membership in cultural enclaves (subcultures) that support and protect them from the chilly or less than friendly environments of campus help promote their success in college (Giuffrida, 2003).

Social/Cultural Capital

Social/Cultural capital as a concept was first developed by anthropologist/sociologist Pierre Bourdieu over 20 years ago. Bourdieu examined the privileged elite and how they used culture to maintain their influence and status in society (Ovink & Veazey, 2010). As described by the researchers, Bourdieu's (1986) view of culture is a resource that could be monopolized and used to access scarce rewards as well as be passed from one generation to the next. Bourdieu also referred to the term *habitus,* as a system of class-specific dispositions that can shape the action of an individual in an attempt to reproduce and perpetuate existing systems of hierarchy. Bourdieu (1990) postulated that the amount and type of capital people possess, especially cultural capital, is a function of the habitus developed in one's class of origin. Relating this conceptual understanding to class or socio-economic status, elites' socialization experiences reflect the use of cultural capital for the realization of their high expectations. Non-elites on the other hand, "are socialized in ways that not only limit their expectations and aspirations, but this limited habitus fails to transmit the cultural capital necessary to navigate the institutions of the dominant class" (Ovink & Veazey, 2010, p. 374).

Scholars who have examined differential outcomes by race/ethnicity have found that underrepresented minority students are at a disadvantage in comparison with white students' level of social capital and the impact on educational attainment, typically due to low income or family financial status, or their being first-generation college students. They have to sacrifice more in order to acquire the economic capital and cultural capital to attain a postsecondary education. The more privileged students are in a position to benefit due to inheritance (Martin & Spenner, 2009). Consequently, upon entering, college students bring what they have in cultural/social capital, and the experience in higher education has been found to increase this important asset (Pascarella, Pierson, Wolniak, & Terenzini, 2004).

In the study conducted by Starobin, Laanan, & Russell, (2013) at selected community colleges on the topic of social capital and its influence on STEM majors, the authors describe social capital as referring to "the intangible resources found within the context of relationships that individuals form with other people, including family members and individuals within social organizations" (2013, p. 1). The study examined community college students who indicated that they wish to pursue a STEM education upon transfer to a four-year institution. More specifically, the study focused on social capital relative to gender and math attainment in the context of STEM education. Data was gathered from students at five community colleges within the state of Iowa. A survey was administered to students who registered in at least one STEM identified course during the fall semester of 2012. Only 10% of the 5,445 students chose to participate and 275 students responded to all of the questions. Since the response rate ultimately ended up being low, the researchers utilized the entire sample population from all five colleges in the survey. Data was analyzed using descriptive statistics, the Pearson correlation and an independent samples t-test.

The researchers ran three sets of Pearson correlation tests to determine the variables of social capital and degree aspirations, math attainment, and the amount of parental education and degree aspirations. Additionally, comparative analyses were completed between males and females using two separate independent *t*-tests. Results from the correlation analysis indicated that the relationship between social capital and degree aspirations were found to be statistically significant to the $<.01$ level. There was a variance of 19%-39% relative to social capital and higher degree aspiration. Positive correlations for each question indicated that the higher the student's degree aspirations, the higher the level of social capital. In the second correlation between math attainment and degree aspirations, the researchers found a positive outcome indicating that the more mathematics a student takes the higher his/her degree aspirations. A third and final correlation was calculated between highest level of parental education and degree aspirations. Parental education accounted for 35% of the variance in academic degree aspirations. Since the results were a positive correlation they indicated that higher levels of parental education are associated with higher levels of student degree aspiration.

On examining gender differences, the mean for males (*M* = 5.72) was almost identical to the mean for females (*M* = 5.71), showing no statistical significance. The second *t*-test, between math intensity and gender to determine if there was a significant relationship between males and females and the number of math courses taken, indicated a slightly lower mean for males of (*M* = 2.18) than for females (*M* = 2.28). There was no statistical significance since the difference fell within the standard error. The overall results for the comparative data indicated that no significant relationships were found between any of the variables and gender. This may have been as a result of a very small data sample, unlike other studies with much larger data sets.

Overall, this study found that the higher the level of education of the parents, the higher the level of degree aspiration of the children. Additionally, number of math courses taken and degree aspirations are closely correlated. These findings reveal that social capital, math attainment, and level of education of parents all correlate to student degree aspiration. This is critical to students pursuing STEM disciplines, particularly for URMs who tend to have less in social/cultural capital.

In another study that examined factors that affect the academic performance of Latino students in STEM majors, researchers looked at cultural congruity in the academic major and the impact on academic performance. The basic assumptions that shaped the study centered around cultural capital gained prior to students' college enrollment, the premise that the higher level of cultural capital the higher level of cultural congruity, and perceptions of campus climate could offer interpretations of students' cultural congruity by examining their college experiences and related impact on academic performance

(Cole & Espinoza, 2008). Essentially, this study developed its framework for examination of cultural capital on the basis of the level of parental education obtained.

A random sample from freshmen survey data collected from the Cooperative Institutional Research Program (CIRP) (1999) along with follow-up data from CIRP (2003) was used in the study. The freshman survey (Student Information Form; SIF) was administered and a total of 146 students responded with majors in STEM. Out of the participants who responded 60.3% had GPAs of A- or better, 73.8% had parents with at least some college education and the overwhelming majority, 82.9% lived on campus. There were a number of variables used in the study within broad categories such as peer involvement, diversity-related activities, student-faculty interactions and basic demographic (institutional type, gender, parental education, and high school grade point average GPA). Analysis consisted of descriptive statistics, factor, and regression analysis.

The results of the study indicated the regression model represented 42.3% (adj R^2 = .357) of the variance for the GPA of Latino students in STEM majors. Institutional type was not found to have statistical significance to Latino students' academic performance. This could be a result of the level of academic preparedness in students surveyed. With regard to student background variables the only significant finding was gender, which was positively related to students' GPA (p <.05). This is not surprising since this is consistent with much of the research. Cole & Espinoza, (2008) briefly discussed the results of other studies that support the finding, in that female students, while not well represented in the fields of science and engineering compared to their male counterparts for those who do apply, tend to be well prepared. The parents' level of education was found not to have a significant impact on the students' GPA in college. This is surprising given that research has shown that parental education is a significant factor on students' educational attainment and aspiration due to higher levels of cultural capital as discussed earlier. However, in this study the researchers point out the fact that most parents had some college education (73.8%) which may explain why this variable was not as significant.

One of the most significant findings in the study given the largest beta weight of all the variables in the regression model ($\beta = 0.365$, $p < .001$) was the high school GPA having a positive influence on students' college GPA. This finding is not out of the ordinary as it is in alignment with much of the research in this area which shows that high school preparation is highly correlated with the persistence and retention in STEM disciplines. Cole and Espinoza (2008) espouse that "this finding also supports the theoretical assumption that students' academic performance in college is influenced by the cultural capital they bring to college; as long as high school GPA is considered a measure of cultural capital" (p. 294). Lastly, out of the 10 variables in the three environmental categories in the study, the only significant ones were (a) studied with other students, (b) attending diversity functions, (c) time spent on studying/homework, and, (d) faculty support and encouragement. The findings in these categories indicated that studying with another student and attending diversity functions negatively affected Latino students' GPA. Researchers such as Astin (1993) have found that time away from studying can negatively impact grades. The amount of time spent on studying and faculty interaction relative to being supported and encouraged were positively related to GPA, as other studies discussed have shown.

The researchers found that the most salient independent variable explaining Latino students' GPA after four years in college was high school GPA. Given what is known about the gaps that exist between URMs, White, and Asian students in persisting and completing STEM degrees, a greater emphasis needs to be placed on targeting and providing supportive services for low achieving students who are interested in STEM. These services could be part of well-designed enrichment programs that focus on math and science preparation prior to enrolling in college. According to the literature, there are a number of summer bridge programs that do a stellar job in preparing URMs for their first year in college and beyond. They focus on "affording students the opportunity to build their social and cultural capital and facilitate access to and participation in STEM" (Stolle-McAllister, 2011, p. 13).

Academic Engagement

Academic engagement has been extensively studied in the research literature. Tinto and other highly respected scholars in higher education have referred to engagement as one of the most salient factors in the retention of students (Tinto, 2006). Tinto goes on to state that "Involvement, or what is increasingly being referred to as engagement, matters and it matters most during the critical first year of college" (p. 4). This statement couldn't be truer given the rigorous curriculum associated with STEM disciplines; academic engagement early on particularly for URM students is of paramount importance, as increasingly the focus on persistence and completion of STEM degrees has gotten much attention nationally.

A mixed method study conducted on student academic engagement in introductory STEM courses examined this important factor. Quantitative survey data was drawn from 2,873 students within 73 introductory science, technology engineering, and mathematics courses across 15 institutions, and qualitative data were collected from 41 student focus groups at eight of the institutions (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). The researchers sought to examine the predictive power of specific learning strategies and classroom environments that relate to students' academic engagement in STEM. The campuses selected for the study varied by institutional control, size, selectivity, minority-serving status (Historically Black Colleges and Universities and Hispanic Serving Institutions), geographic region, and classification.

The survey was administered at the beginning of the academic term and requested information on pre-college preparation, pre-college experiences, background characteristics, and educational and career plans. A follow-up survey was given toward the end of the term which inquired about students' experiences relative to the context of their introductory courses. The majority of students identified as white (52%) and 61% of students were women. Approximately, 75% of the students reported majoring in a STEM discipline. On the qualitative side, the student sample included 14% African American, 54% White, 8% Latino/a, 21% Asian American, and 3% Native American. Female students were the majority at 62%; 42% were freshmen, 33% sophomores, 18% juniors, and 1% seniors. Gasiewski et al. (2012) organized focus groups consisting of students enrolled in introductory STEM courses or by students who had completed the courses and participated in the quantitative data collection. Focus interviews ranged from 60 to 90 minutes in duration conducted with two to 10 participants per session, and averaged five focus groups per campus.

The overall results of this multi-contextual mixed methods study from the quantitative data gathered provided information about the relationship between student learning strategies, faculty attitudes and characteristics, pedagogical techniques, and student level engagement in introductory STEM courses. The qualitative findings provided more detail about student perspectives about their own behavior and that of faculty. More specifically, among the student-level variables Gasiewski et al. (2012) found no significant difference between White and URM students in the reported level of academic engagement in introductory STEM courses. There were also no significant differences across gender lines. Only one of the pre-college preparation variables remained significant. This variable was the high school chemistry grade. Those students who reported receiving high grades in high school chemistry also reported having high levels of academic engagement. The more interesting finding was that the high school biology grade, SAT score, and earning college math credits did not significantly predict students' academic engagement in introductory STEM courses. This is probably due to individual student motivation levels and their interest around involvement. The findings also indicated that freshmen reported much higher levels of academic engagement in introductory courses than other students who were upper classmen. Overall, it was found that engagement in introductory STEM courses for those students who felt excited about learning new concepts, tended to report much higher levels of academic engagement. An excellent observation made by the researchers based on the findings is this:

> Even if we significantly raised the level of student preparation in high school science, it may not necessarily improve STEM degree completion unless we also address engagement in college introductory courses. Such academic engagement

> has as much to do with the engagement behaviors and attitudes of faculty who teach these courses as it does with motivated, resourceful, and engaged students themselves (Gasiewski et al., 2011, p. 250).

Lastly, the study also considered psychological traits of engaged students. They found that students' behavior, emotions, and cognition were important factors in predicting the level of academic engagement.

Another study by Hernandez, Schultz, Estrada, Woodcock, and Chance (2012) examined academic engagement and looked at a large sample of high-achieving African American and Latino undergraduates in STEM disciplines attending 38 colleges and universities in the country. The study followed URM science students through the academic pipeline. The focus of the study is on the goal orientations of African American and Latino students majoring in a STEM discipline over the course of three years. As brief background to the underpinnings of the study is the inference how environmental and person type factors affect performance and persistence in STEM fields. The study is aligned with the concept of goal theory which focuses on the reasons why students pursue achievements in a scholastic context. As part of the study, the researchers also examined motivation as part of goal theory. They define "motivation in terms of the goals that give purpose, meaning, and direction to achievement-related behaviors: consistent with the general cognitive approach, goals are characterized as internal events that draw individuals toward an activity" (Hernandez et al., 2012, p. 91).

The sample of participants consisted of 1,046 African American (n=594) and Latino (n=452) undergraduate students. The African American students were majority female (77%), in their early 20s (M = 20.96, SD + 3.06), and were completing their junior or senior year in college (58%). Additionally, 16% of the African American population were first generation college-going; 9% did not know their parents' educational attainment. A larger proportion of the African American students had at least one parent who attended college (some college = 21%), had an associate's degree (10%), baccalaureate (22%), or graduate or professional degree (22%). With regard to the Latino population of students, they consisted of majority female as well (67%), were in their twenties (*M* = 21.61, *SD* = 3.78), and were completing their junior or senior year in college (73%). In terms of first generation status, they made up 23% or did not know their parents' educational attainment (6%), and a larger proportion had at least one parent that had attended college (some college = 18%, associate's degree = 8%, baccalaureate degree = 21%, graduate or professional degree = 18%).

Based on the researchers' utilization of the Structural Equation Model (SEM) - based parallel process latent growth curve modeling, the overall results of this study were interesting in that they reflected both environmental and person type factors dealing with the regulation of task, performance-approach, and performance-avoidance goal orientations of URM students. Hernandez et al. (2012) reported that the findings were indicative of both African American and Latino students interpreted items and used the response scales in the same way, both across groups and within groups over time. A significant finding was in the area of academic engagement in undergraduate research which was found to be the only factor that buffered URM students against an increase in performance-avoidance goals over time. There were several other findings that were significant: student growth in scientific self-identity reflected a strong positive effect on developing task and performance-approach goals; only task goals were found to positively influence cumulative GPA over baseline GPA; and performance avoidance goals predicted student attrition from the STEM pipeline.

The statistical models used in the study revealed that the background characteristics of baseline GPA and African American status predicted intercepts of the achievement goals; this also revealed that research experience was the only contextual factor that predicted the achievement goals. Another salient finding was that African American students exhibited higher initial performance-avoidance goals than did their Latino counterparts. Overall, the findings were indicative that African American students in STEM may be at a relatively higher risk of experiencing the negative cognitive, emotional, and behavioral consequences that come with holding performance-avoidance goals.

Hernandez et al. (2012) derived the predicted probability of persistence for students with relatively high, average, and relatively low initial performance-avoidance goals (e.g., ±1 *SD* performance-avoidance goals), controlling for other factors in the model. Those students who expressed average performance-avoidance goals had an 86% probability of persisting in their initial STEM major, those expressing higher avoidance goals had a 79% probability of persisting, and the students who demonstrated lower avoidance goals had a higher probability of persisting at 89%. With regard to leaving STEM for students with relatively high average and low initial performance-avoidance goals, the predicted probability was calculated as well. Students expressing average performance-avoidance goals had a 93% probability of persisting in a STEM discipline; those with higher levels of avoidance goals had an 89% probability of persisting, and finally those with lower avoidance goals had a 96% probability of persisting. The researchers integrated the results and found that contextual factors such as research experiences and individual differences (scientific self-identity) impact on individuals' achievement goals.

Furthermore, Hernandez et al. (2012) indicated that even after controlling for background characteristics and prior achievement, achievement goals were found to have a lasting influence on student achievement and persistence in STEM education. Consequently, those students with lower engagement in research experience reflected higher performance-avoidance goals and those with higher performance-avoidance goals were more inclined to leave their STEM majors.

The findings of this study are indicative of the importance of expanding opportunities for URMs in access to research activities early on in their academic career, as well as promoting activities that minimize the influence of performance avoidance goals. These recommended approaches may have implications for expanding the STEM pipeline as a result of increased exposure resulting in higher levels of motivation, performance task goals, and overall academic engagement. With regard to the limitations of the study, the researchers cautioned readers of the potential for overgeneralization of the findings. Mainly due to the sample of URMs that was selected, most students were high achievers and were enrolled in training programs aimed at broadening participation in STEM. Essentially, there was very little difference if any, between the URM sample and "high achieving majority students than to low-achieving minority students" (Hernandez et al., 2012, p. 103).

Review of Methods

The studies and general background information for understanding the overall factors that promote and/or influence persistence in STEM included empirical studies that were quantitative, qualitative, as well as mixed methods studies. Data analyses and projections illustrated by some of the studies highlighted in this section, utilized data from the National Center for Education Statistics and the National Science Foundation.

The research studies discussed highlighted the importance of STEM in keeping the U.S competitive in a global economy. Several studies addressed the need to expand STEM education by strengthening the education pipeline particularly for URM students. The recognition that URM student populations are those that are projected to grow significantly in the next 30 years, coupled with the current reality that these same students today are not well represented in STEM fields, is a major concern.

All of the studies were collected utilizing data that dealt with the multiple factors that affect access, persistence, and completion rates in STEM. The studies selected focused on environmental factors, social and cultural capital, and academic engagement. Within these broad categories there were other important factors which impacted on student success in STEM that the studies brought to light, such as the impact of faculty interactions, role of peer influence, early scientific research and goal theory.

The studies presented in this literature review utilized a broad range of measures and techniques. They ran the range of quantitative, qualitative, and mixed-methods. Several of them used large data bases like the Higher Education Research Institute (HERI) which houses the Cooperative Institutional Research Program (CIRP). Studies reflected both quantitative longitudinal approaches in studying the factors that influence students in the pursuit of STEM degrees and others were qualitative with small sample groups.

Research Gaps and Recommendations for Further Study

There are many lessons that can be learned from studying institutional factors that impact, in particular, URMs in STEM disciplines. However, much of the research that has been conducted is focused on individual student factors. A recommendation by Museus and Liverman (2010) is that "researchers studying URMs in STEM have much to glean from the examination of post-secondary high-performing institutions" (p.24).

Several of the studies reviewed focused on the importance of campus environment/culture. As one illustration, in the qualitative study conducted by Fries-Britt et al. (2010) environmental factors such as faculty interactions, the role of peers, and the process of proving oneself were examined. This study gave a better understanding of the importance of the above-mentioned factors; however, more research can be done on peer interactions and the subcultures that are developed within STEM departments and the impact on student persistence. Additionally, the role of the faculty member and other agents within the institution in helping URMs facilitate better connections to the campus environments could benefit from further study. It is important to mention that in the studies reviewed that examined social and cultural capital the understanding of one's cultural background, status and even class, has been shown to influence students' aspirations and expectations while in college. More needs to be explored as to efforts that can reduce the gaps that exist between URM students and majority students who tend to have more social capital. The study conducted by Ovink and Veazey (2010) looked at many of the cultural and social factors that impact URM persistence in STEM. Of particular interest was the role of habitus as posited by Pierre Bourdieu. Research that can explore how habitus may be enhanced and therefore increase cultural capital amongst URMs is important. Also, research of successful programs that provide supplemental instruction and other supportive services including cultural experiences, may lead to a better understanding about how to ameliorate the gaps that exist.

The majority of the studies reviewed had a common limitation due to sample size and other measures; the caveat of not generalizing the findings to all students and institutions outside of the sample that was used, was common. Perhaps by disaggregating the data and looking closer at the different racial and ethnic groups could play a more critical role in developing a better understanding of different groups relative to persistence and graduation in STEM. From a qualitative perspective looking at the heterogeneity of URMs can help understand the contextual experiences of different subgroups experiences in the educational environment. This approach would help account for variables such as socioeconomic diversity, citizenship, and other factors germane to long term persistence.

A gap in the literature is a better understanding of how campus type affects URMs in STEM. For example, what aspects of the environment of a campus are most influential predictors of URM success? With regard to academic engagement the literature focuses on factors that influence increases in student participation, however, there is room for more research in the area of faculty student interaction. During the first year of college, URM students pursuing STEM majors are faced with having to take the complement of gatekeeper type courses (calculus, chemistry, physics, etc.) that are rigorous and determine their success in STEM fields. Examining the approaches that supportive faculty take in their classrooms, as well as outside the classroom environment, can help illuminate the strategies that determine why students may become more engaged. Along these lines examining new ways to engage students and enhance learning environments is important and can add to the literature. There also seems to be a gap in examining high level administrators' leadership and their commitment to URMs in STEM. High level administrators are responsible for setting policy and influencing the culture of an institution. The role that administrators may play with regard to supporting a culture of student success and the strategies they use to support programs, use data and assessment to ensure retention and degree completion is critically important.

Summary

Expanding the pool of students who enter and graduate in STEM disciplines has become a major concern for the nation. The population of school age persons (0-24 years) projected to grow the most in the next 30 years are underrepresented racial minorities (URMs). Yet, these are the very same groups of students today that earn college degrees in STEM fields at lower rates than do their majority peers. Understanding the impact of factors that promote URM student access, persistence and completion in STEM is of critical importance to the country's standing in a globally competitive economy. This literature review examined various studies, both quantitative and qualitative, that collected meaningful data and discussed factors critical to the success of URM students in STEM. Some of those factors looked at the campus environment, others dealt with the social and cultural capital of URM students and implications for persistence and completion in STEM degrees. Briefly, the role of the faculty member and the interaction that takes place with students in and out of the classroom was examined as well relative to faculty impact on academic engagement.

In reviewing the literature, many studies address the programs that are in place within a given institution, but the SUNY system provides a rich source of data on persistence and educational attainment across a broad population in a range of colleges, providing more tangible evidence of the relevance of personal goals, preparation, support, and many other facets of institutional response in the enrollment and graduation of STEM students within the State University of New York. Many forces are at play in this context, but public higher education institutions can implement a number of different and coordinated services, ranging from financial aid options to academic strategies and even affirmative action, to improve minority student degree completion. In this study, we reflect on the predictors of college admission and preparation as determinants of persistence in STEM and interventions designed to influence student growth and degree attainment (Perna, 2013).

Chapter 3: Research Design Methodology

Introduction and Purpose

While graduating well educated students in STEM disciplines has become a national priority, institutions of higher education continue to face challenges in attracting, retaining, and graduating enough students to avoid the impending shortfalls of scientists and engineers. The literature is replete with studies that reflect best practices and intervention strategies both at the institutional and individual student level, yet there is much that is not known, particularly as it relates to the successful graduation of underrepresented minority students (URMs) in STEM disciplines. Increasing the recruitment, retention and graduation rates of URMs in STEM is of critical importance, if we are to maintain our competitiveness in a global economy. The urgency of this national concern is illustrated further by a report issued by the National Academies Press (NAS), the Talent at the Crossroads report (NAS, 2011) which emphasized that the effort "to sustain and strengthen science and engineering must…draw on the talents of all Americans, including those minorities…who embody a vastly underused resource and a lost opportunity for meeting our nation's needs" (p.1). The same report called for doubling, tripling and even quadrupling the number of URM students earning science, technology, engineering, and mathematics degrees.

Given the paucity of URM students graduating in these disciplines, "the dramatic increases of underrepresented racial-ethnic groups in STEM are necessary not only to grow a strong, talented and innovative science and technology workforce, but to ensure democratic rights, civic leadership, and political participation (Dowd & Malcom, 2012, p.1). Hence, examining institutional characteristics and/or factors that promote such a worthy goal needs more exploration to further add to the great body of literature that exists on this critically important topic of our day.

The purpose of this quantitative study was to examine the differences in institutional success in raising the graduation rates of URMs in STEM disciplines at four-year institutions with the State University of New York. The study identifies the highest performing institutions at graduating URMs in STEM disciplines. Further the study investigated whether there were institutional correlates of URMs success in STEM disciplines using data from both the SUNY System Office of Institutional Research and the IPEDS reports.

This chapter briefly reviews the research questions, provides research context and describe methods, including sources of data collection, and concludes with the summary.

Research Questions

Specifically, the study was designed to explore the following research questions:

1. Are there differences in STEM URM completion rates among the selected four-year SUNY institutions?
2. If so, is the variability among graduation rates explained by institutional characteristics of the institution? To what extent?

Research Context

As mentioned earlier, this study examined 20 selected four-year institutions of the State University of New York (SUNY). SUNY was established on April 4, 1948 by the 47th Governor of New York, Thomas E. Dewey. Since that time SUNY has become the nation's largest comprehensive system of public higher education. It consists of 64 institutions across the state of New York, which incorporates community colleges, colleges of technology, university colleges, research universities, medical schools, and health science centers. It also includes specialized campuses in fields as diverse as optometry, ceramics, horticulture, fashion, forestry, maritime training, and an online learning network (Clark, Leslie, & O'Brien, 2010). As a collective, these institutions currently serve more than 465,000 students from throughout New York State, the nation, and several foreign countries. There are approximately 88,000 faculty and 2.4 million alumni worldwide. In a nutshell, SUNY provides access to almost every field of academic and professional study at the associate's, bachelor's, master's, doctoral, and certificate levels of study (Clark et al., 2010).

In comparing SUNY with other public higher education systems from around the country, the fundamental difference is that other systems, for example, California and Texas, are not as comprehensive. That is to say, that some of these other systems singularly do not have oversight for all three higher education sectors: community colleges, university colleges, (up to the master's degree level) and doctoral serving institutions, that is, they are separate and apart with different governing bodies. Whereas with SUNY, all three sectors are under the same administrative governing body, that is, the SUNY System Administration.

The information depicted in Table 3.1 gives a brief overview of the characteristics of the selected institutions for the study. They range from a total undergraduate student population of just under 2,000 to over 19,000. Graduate students range from a low of just under 100 at one institution to a maximum of almost 9,500. Campus setting covers all geographical locations: rural, urban and suburban type settings. The percentage of URM students ranges from a low of 8% to over 51% at one institution.

Table 3.1

Characteristics of Selected Institutions

Institution	Undergrad Enrollment	Graduate Enrollment	Full Time Faculty	Campus Setting	% URM
University at Albany	12,878	4,434	598	Urban	19
Binghamton University	12,997	3,080	543	Suburban	15
Cornell Statutory Colleges	-	-	-	Rural	-
University at Buffalo	19,506	9,446	1,448	Suburban	9
Stony Brook University	16,126	8,152	1,556	Suburban	15
College at Brockport	7,166	1,247	328	Rural	11
Buffalo State College	9,731	1,483	397	Urban	22
SUNY Cortland	6,400	710	284	Rural	11
College of ESF	1,650	600	-	Urban	6
SUNY Fredonia	5,103	302	254	Rural	8
SUNY Geneseo	5,347	98	241	Rural	8
Maritime College	1,800	50	-	Urban	16
SUNY New Paltz	6,685	1,082	337	Rural	21
College at Oneonta	5,800	206	259	Rural	11
SUNY Oswego	6,500	1,500	299	Rural	12
SUNY Potsdam	3,988	298	244	Rural	11
Purchase College	4,267	123	165	Suburban	21
College at Old Westbury	5,198	269	134	Urban	51
SUNY Plattsburgh	5,706	461	271	Rural	12
Empire State College	12,145	924	200	Mixed	16

Procedures for Data Collection and Analysis

The procedures for the collection of data involved the utilization of a secondary data set. Essentially, the data was obtained from two publically available sources: the SUNY Institutional Research (IR) office and the Federal IPEDS system. The SUNY IR office has broad responsibility for data collection and dissemination; maintaining three of the University's major information systems: the Student Data File, the Automated Degree File, and the Course and Section Analysis File, and it also collects additional campus information. The Federal IPEDS is the Integrated Postsecondary Education Data System. It is a system of interrelated surveys conducted annually by the U.S. Department's National Center for Education Statistics (NCES). "IPEDS gathers information from every college, university, and technical and vocational institution that participates in the federal student financial aid programs" (National Center for Education Statistics, 2014, p. 1).

In Table 3.2, the independent variables are shown along with the source of where data is kept, followed by a brief description of each variable. The dependent variable is the 6-year STEM graduation rate of URMs by race/ethnicity, and gender of those students in the fall 2006 entering cohort from each of the selected institutions. Note, the SAT is an entrance exam juniors and seniors in high school take prior to admission to many U.S. colleges and universities. The SAT contains three parts: critical reading, writing, and math. Each subset is scored on a normally distributed curve with an average 500 and maximum 800. The total score is simply the addition of the three sub-scores. The ACT exam is composed of four tests. All questions are in a multiple-choice format. The four subject areas contained in the ACT include English, Mathematics, Reading, and

Science. ACT scores consist of a multiple-choice score, a composite score, and a national rank. The composite score represents an average of four subject scores.

Table 3.2

Description of Independent Variables

Independent Variables	Data Source	Description
SAT score of entering class	SUNY IR	For each institution the average total SAT score is provided.
ACT composite score	SUNY IR	For each institution the composite score is provided.
Age of entering cohort	SUNY IR	Average age of the entering cohort captured.
Race and Ethnicity		The race and ethnicity of the students are identified. Emphasis will be given to URM students.
Gender		Both men and women included in the analysis.
High School GPA	SUNY IR	Grade point average of student cohort.
Avg. family income estimated	SUNY IR	Estimated avg. family income of cohort
STEM enrollment	SUNY IR/IPEDS	Overall STEM enrollment of entering cohort
STEM degree (by race & ethnicity)		The overall graduation rate of STEM students is captured at the 4, 5 and 6 year levels.
Bachelor's degree (by race & ethnicity)	SUNY IR	Bachelor's degree is captured at the 4, 5, and 6 year levels.
Receiving Pell Grants	IPEDS	Percent of students receiving federal Pell Grant aid
Campus Selectivity	SUNY IR	The campus selectivity categories are defined by the SAT/H.S. Avg. matrix and apply to students accepted and enrolled by the institution as regularly admitted first-time, full-time freshman. There are five categories: Most Selective are group 1; Highly Selective are group 2; Very Selective group 3; Selective is group 4; and General Admission which is not meeting any of the other categories.
Instruct	IPEDS	Expenditures/FTE for instructional activities including but not limited to, general academic instruction, community education and remedial and tutorial instruction conducted by the instruction's teaching faculty.
%Instruct	IPEDS	Percentage of expenditures for instructional activities including general academic instruction, community education and remedial and tutorial instruction conducted by the institution's teaching.

Table 3.3

Independent Variables: Faculty Characteristics

Faculty Independent Variable	Data Source	Description
Race and Ethnicity	IPEDS	Percentage of race and ethnicity for all groups
Gender	IPEDS	Percentage of gender for each
Avg. Salary by Rank	IPEDS	The average salary by rank of the faculty will be reported (Assistant, Associate and Full Professor).
Tenure	IPEDS	Percent faculty with tenure status

It is important to understand how STEM is defined and how SUNY evaluates its position relative to recognized STEM fields along a range of important measures such as enrollment, retention, and degrees granted. There are multiple STEM classification systems in use nationwide. The Department of Homeland Security (DHS) has the broadest STEM definition with 424 programs distributed across 21 disciplines (see Table 3.4 for CIP Family Code). The DHS definition is accepted by most institutions of higher education including SUNY as well as the National Center for Education Statistics (NCES). As such, the academic programs that comprise STEM fields are defined using the nationally-recognized Classification of Instructional Programs (CIP). Academic programs are given a CIP code (2, 4, and 6 digit) to identify the field of study. The range of CIP codes in the DHS definition of STEM is provided in appendix A.

Table 3.4

STEM Classification by CIP Family & Agency

CIP 2010 Family Code*	DHS	NSF	NCES
01 Agriculture, Agriculture Operations, and Related Sciences	X	X	
03 Natural Resources and Conservation	X	X	
04 Architecture and Related Services		X	
09 Communication, Journalism, and Related Programs	X		
10 Communications Technologies/Technicians and Support Services	X		
11 Computer and Information Sciences and Support Services	X	X	X
13 Education	X		
14 Engineering	X	X	X
15 Engineering Technologies/Technicians	X	X	X
19 Family and Consumer Sciences/Human Sciences		X	
26 Biological and Biomedical Sciences	X	X	X
27 Mathematics and Statistics	X	X	X
28 Military Science, Leadership, and Operational Art	X		
29 Military Technologies and Applied Sciences	X		X
30 Multi/Interdisciplinary Studies	X	X	
40 Physical Sciences	X	X	X
41 Science Technologies/Technicians	X		X
42 Psychology	X		
43 Homeland Security, Law Enforcement, Firefighting and Related Protective Services	X		
45 Social Sciences	X		
49 Transportation and Materials Moving	X		
51 Health Professions and Related Programs	X		X
52 Business, Management, Marketing and Related Support Services	X	X	X
Total	21	12	10

* *Note:* IPEDS has not updated to 2010 yet

The research design included the utilization of the current Statistical Package for the Social Science (SPSS), Software, version 22 for data analysis. The advantages of using SPSS were threefold: (1). given the number of variables in the study, the software allowed for more effective data management and organization; (2). SPSS has a wide range of options allowing for the generation of graphs and charts used in the study; and (3). an in depth analysis of the data was also possible. More specifically, the analysis performed was focused at the institutional level and the dataset had an n=20; thus the data was non-parametric and non-parametric statistical procedures were used. Data analysis for research question 1, STEM URM 6 year graduation rates, were examined using histograms. Data analysis for research question 2 consisted of Spearman correlation coefficients between the dependent variables and both the factor scores, and the most salient independent variables. Statistical significance was set at the standard .05 level.

Summary

This quantitative study was designed to examine differences in institutional success that lead to the graduation of URMs in STEM disciplines at 20 institutions in the SUNY system. The dependent variable is the 6-year graduation of URMs in STEM taken from the entering class of first-time, full time students in 2006. Several independent variables were cited and described. The two sources from which the secondary data was collected were the Federal IPEDS and the SUNY IR office. It was determined to use non-parametric statistical procedures in this study due to the relatively small sample size of n=20.

Chapter 4: Results

Introduction

There are national implications related to the shortage of underrepresented minorities and women enrolled in, and successfully completing degrees in the fields of science, technology, mathematics, and engineering (STEM). This problem is further exacerbated by the current and future demographic realities being faced by our nation and within the state of New York. Few states have been as influenced by the forces of globalization and immigration as has New York, which is now the fourth most populous state in the nation, and one of the most culturally diverse. According to census data, within the next 10 years, it is projected that New York's population will consist of 43% students of color and 57% non-Hispanic whites, and by 2030 we will serve a "majority-minority" population of public high school graduates. The need for more New Yorkers trained for STEM careers, coupled with the increase in overall population for persons of color, illustrates the critical need for greater numbers of URMs pursing STEM disciplines more than ever. The current study investigated the differences in institutional success in the graduation rates of URMs in STEM disciplines at the four-year institutions within the State University of New York (SUNY).

This chapter outlines the data analysis and results of the study. The chapter is organized by research question, followed by an analysis and tables depicting the findings. The chapter concludes with a summary of the results.

Data Analysis

The first research question is “are there any differences in STEM URM graduation rates among the selected four year SUNY institutions?” To examine this first research question, STEM URM 6-year graduation rates were examined by computing differences in STEM and non-STEM graduation rates, STEM and URM-STEM graduation rates, and also examining gender differences in URM graduation rates.

The second research question is “if there are differences in graduation rates, can these graduation rate differences be explained by institutional characteristics?” To examine this second research question, Spearman correlations were conducted examining the association between institutional characteristics and the difference in graduation rates. All analyses were conducted by using the Statistical Package for the Social Sciences (SPSS) software, version 22.

Results – Research Question 1 – URM Graduation Rates

The first research question asked if there are differences in STEM URM graduation rates among the SUNY institutions. All 20 colleges reported URM STEM graduation rates. The highest URM graduation rate was at Binghamton University with a 75.4% completion rate. Cornell Statutory Colleges had a 73.6% completion rate for URMs. There were three other colleges that had an URM graduation rate of 50% or higher: the University at Albany (54.9%), State University College at Potsdam (50.0%), and the College of Environmental Science and Forestry (50.0%). The three lowest URM graduation rates were at the College at Old Westbury (13%), and two colleges that had 0% URM graduation rates were the State University College at Cortland and Empire State College.

It is important to mention that the number of URM STEM majors at these two institutions were in the single digits (making the data less stable). Therefore, the answer to the first research question is that there are differences in STEM URM graduation rates. The graduation rates for STEM URM ranged from 0% to 75.4%, as evident in Table 4.1 and shown in a histogram format depicted in Figure 4.1.

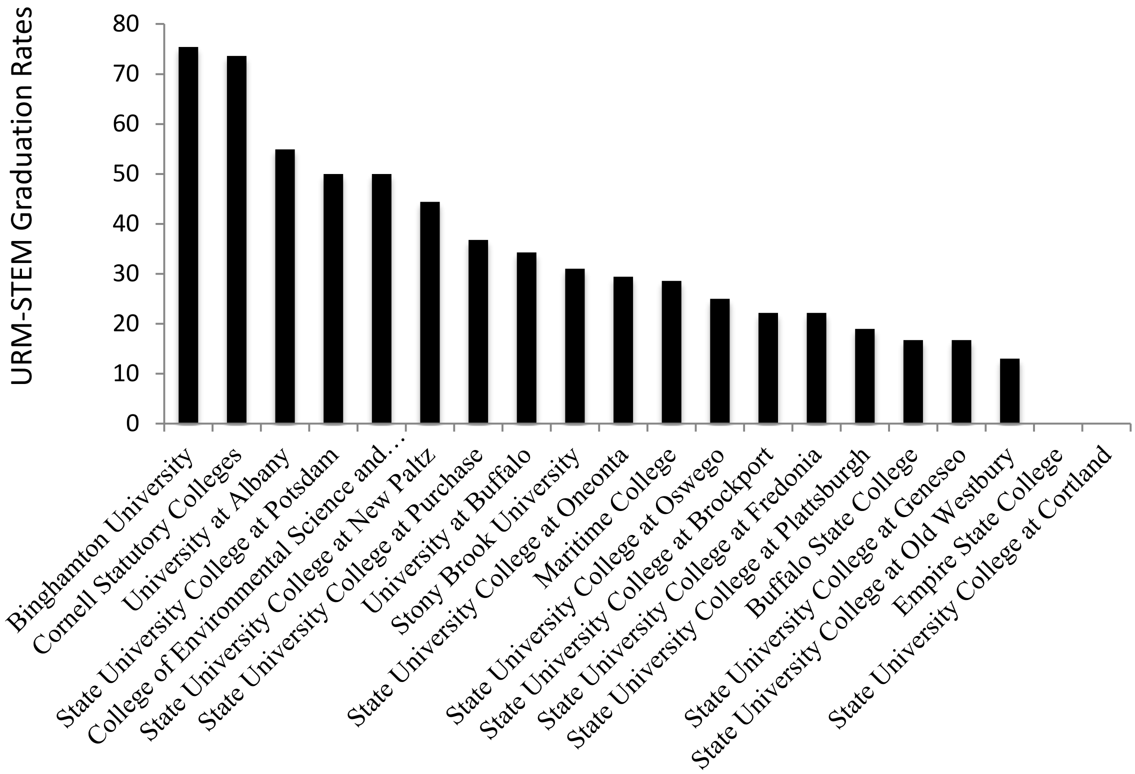

Figure 4.1. Overall URM STEM Graduation Rates by College.

Table 4.1

Overall URM STEM Graduation Rates by College

College	6-Yr. URM-STEM Graduation Rates	URM STEM Majors
Binghamton University	75.4	65
Cornell Statutory Colleges	73.6	87
University at Albany	54.9	51
State University College at Potsdam	50.0	6
College of Environmental Science and Forestry	50.0	12
State University College at New Paltz	44.4	18
State University College at Purchase	36.8	19
University at Buffalo	34.3	70
Stony Brook University	31.0	155
State University College at Oneonta	29.4	17
Maritime College	28.6	28
State University College at Oswego	25.0	28
State University College at Brockport	22.2	9
State University College at Fredonia	22.2	9
State University College at Plattsburgh	19.0	21
Buffalo State College	16.7	60
State University College at Geneseo	16.7	24
State University College at Old Westbury	13.0	46
State University at Cortland	0.0	6
Empire State College	0.0	4

To better understand the context of the URM STEM graduation rates, the URM STEM graduation rate can be compared to the overall STEM graduation rate to see if URM STEM students are completing more or less often than all STEM graduates. Two colleges had a higher URM STEM graduation rate: Cornell Statutory Colleges (2.8%

difference) and the College at Old Westbury (3.0% difference). There were 0 degree completions in STEM at the College at Old Westbury by majority students (comparison group). On the other end of the spectrum the largest differences between the two comparison groups were five of the colleges that have 20% or more differences in their URM STEM vs. STEM graduation rates: Plattsburgh (21.4%), Buffalo State College (24.3%), Geneseo (26.0%), Cortland (27%) and Fredonia (27.3%). The majority of colleges have a higher STEM graduation rate compared to the URM-STEM graduation rate. See Figure 4.2 and Table 4.2 for details.

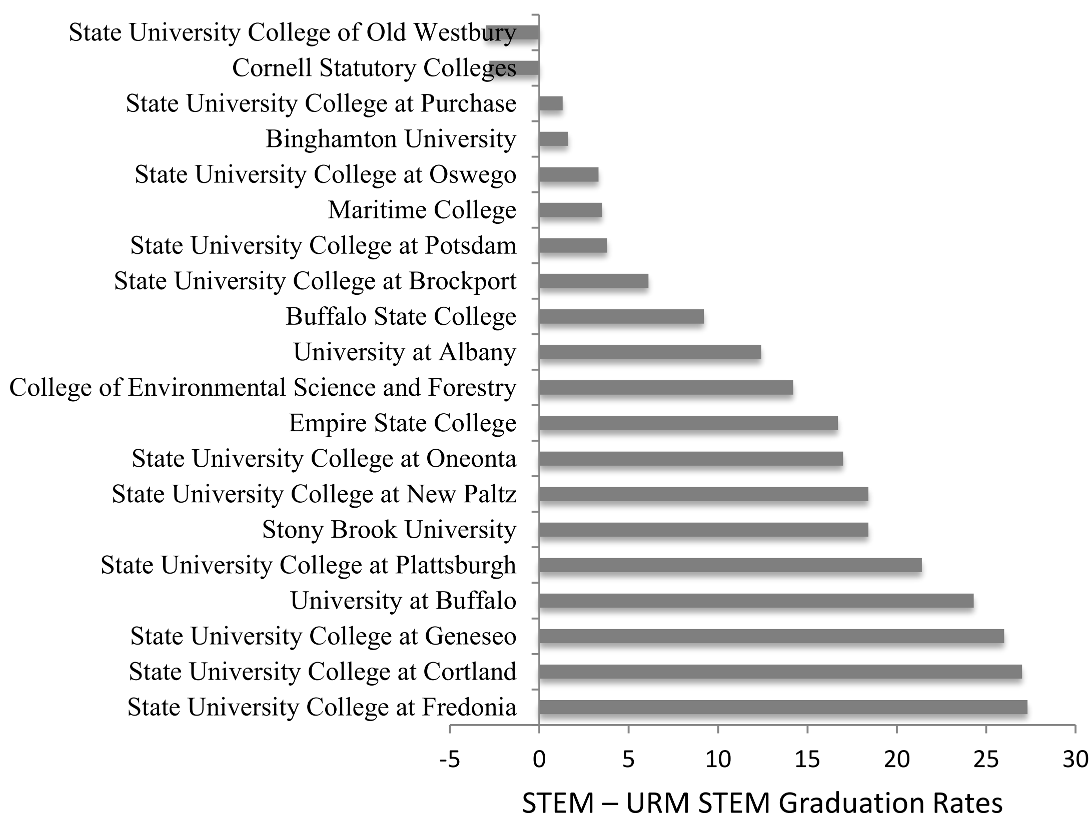

Figure 4.2. STEM-URM STEM Graduation Rates.

Table 4.2

Graduation Rates by College

College	URM-STEM	STEM	STEM-URM STEM
State University College at Fredonia	22.2	49.5	27.3
State University College at Cortland	0	27.0	27.0
State University College at Geneseo	16.7	42.7	26.0
University at Buffalo	34.3	58.6	24.3
State Univ. College - Plattsburgh	19.0	40.4	21.4
Stony Brook University	31.0	49.4	18.4
State Univ. College at New Paltz	44.4	62.8	18.4
State University College at Oneonta	29.4	46.4	17.0
Empire State College	0	16.7	16.7
College of Env. Science and Forestry	50.0	64.2	14.2
University at Albany	54.9	67.3	12.4
Buffalo State College	16.7	25.9	9.2
State Univ. College at Brockport	22.2	28.3	6.1
State University College at Potsdam	50.0	53.8	3.8
Maritime College	28.6	32.1	3.5
State University College at Oswego	25.0	38.3	3.3
Binghamton University	75.4	77.0	1.6
State University College at Purchase	36.8	38.1	1.3
Cornell Statutory Colleges	73.6	70.8	-2.8
State Univ. College of Old Westbury	13.0	10.0	-3.0

Note. Negative difference numbers indicate higher URM-STEM graduation rate.

The URM-STEM graduation rate can also be compared to the non-URM STEM graduation rate. See Table 4.3 and Figure 4.3. Table 4.3 provides information on the graduation rates by college comparing URM vs. non-URM graduation rates. Figure 4.3 provides information on non-URM-URM graduation rates.

Table 4.3

Graduation Rates by College Comparing URM vs. NON-URM Graduation Rates

College	URM-STEM	NON-URM-STEM	NON-URM-URM
State University College at Fredonia	22.2	52.0	29.8
State University College at Cortland	0	28.9	28.9
State University College at Geneseo	16.7	44.7	28.0
University at Buffalo	34.3	60.4	26.1
Empire State College	0	25.0	25.0
State University College-Plattsburgh	19.0	43.4	24.4
State University College at New Paltz	44.4	67.6	23.2
Stony Brook University	31.0	52.0	21.0
State University College at Oneonta	29.4	48.8	19.4
University at Albany	54.9	70.6	15.7
State University College at Oswego	25.0	40.3	15.3
College of Environmental Science and Forestry	50.0	65.2	15.2
Buffalo State College	16.7	31.1	14.4
State University College at Brockport	22.2	28.7	6.5
Maritime College	28.6	33.0	4.4
State University College at Potsdam	50.0	54.0	4.0
State University College at Purchase	36.8	38.6	1.8
Binghamton University	75.4	77.2	1.8
Cornell Statutory Colleges	73.6	70.4	-3.2
State University Old Westbury	13.0	0.0	-13.0

Note. Negative difference numbers indicate higher URM STEM graduation rate.

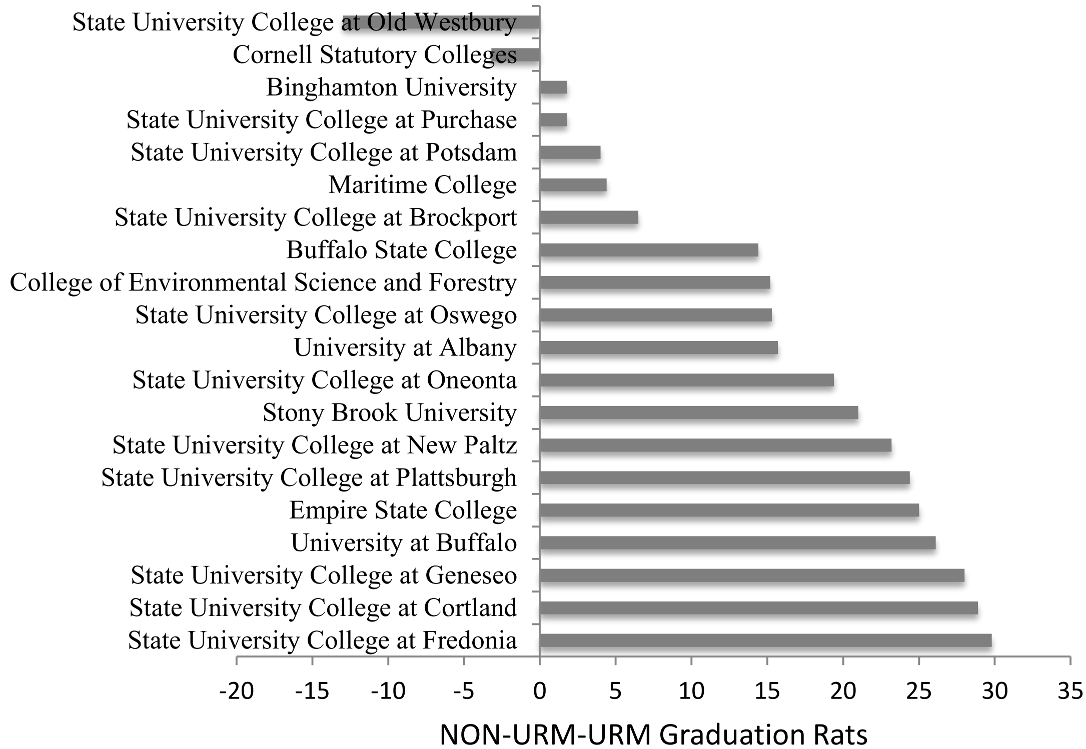

Figure 4.3. NON URM-URM Graduation Rates.

Two colleges had a higher URM STEM graduation rate: the Cornell Statutory Colleges (3.2% difference) and State University College at Westbury (13.0% difference).All other colleges have higher non-URM STEM graduation rates. Six colleges have a 20% higher non-URM STEM graduation rate: SUNY New Paltz, University at Buffalo, Stony Brook University, SUNY Fredonia, SUNY Plattsburgh, and SUNY Geneseo. Two other colleges also had 20% higher non-URM STEM graduation rate than URM stem rates (State University College at Cortland and Empire State College) but this is due to their having a 0% graduate rate for URM.

Female STEM graduation rates can be compared to male STEM graduation rates. Females have a higher graduation rate, overall, than males. Only six colleges have a higher male graduation rate: University at Albany, Stony Brook University, SUNY New Paltz, Geneseo, Fredonia, and Buffalo State College. See Table 4.4.

Table 4.4

Graduation Rates by College Comparing Female vs. Male Graduation Rates

College	Male	Female	Male Female
Empire State College	0	28.6	28.6
State University College at New Paltz	52.3	73.8	21.5
Buffalo State College	17.6	31.6	14.0
State University College at Fredonia	45.2	52.3	7.1
Stony Brook University	46.5	51.8	5.3
State University College at Geneseo	41.4	44.0	2.6
University at Albany	66.0	68.3	2.3
State University College at Cortland	28.2	26.0	-2.2
State University College at Potsdam	55.4	52.7	-2.7
State University College at Purchase	40.0	37.2	-2.8
State University College at Oswego	39.8	36.6	-3.2
State University College at Brockport	30.1	26.0	-4.1
State University College at Old Westbury	11.8	7.7	-4.1
Binghamton University	79.6	75.3	-4.3
University at Buffalo	61.6	57.1	-4.5
State University College at Plattsburgh	46.6	37.0	-9.6
State University College at Oneonta	52.2	40.6	-11.6
Cornell Statutory Colleges	76.1	62.7	-13.4
SUNY ESF	72.8	58.0	-14.8
Maritime College	53.8	29.8	-24.0

Note. Negative difference numbers indicate higher female-STEM graduation rate than male-STEM graduation rate.

Results - Research Question 2 – Institutional Characteristics

The second research question asks if the variability among graduation rates are explained by institutional characteristics of the institution. To examine this research question, spearman correlations were run to examine the association between institutional characteristics and the different graduation rates.

URM STEM graduation rate

To examine the institutional variables that associate with the overall URM STEM graduation rate, a Spearman correlation was conducted. Total SAT Score (r = .48, p = .04) was positively correlated with URM STEM graduation rate. This association means that the higher the SAT scores, the higher URM STEM graduation rate. There was no association between selectivity of the school and URM STEM graduation rate (r = -.21, p = .383). Campus Selectivity was ranked from 1 (Most Selective) to 5 (General Admission). This negative association means that the least selective schools had lower URM STEM graduation rates. There was no association between age and URM STEM graduation rates (r = -.14, p = .55). The percent of students receiving federal Pell Grant Aid was not significantly associated with URM STEM graduation rate (r = -.31, p = .142). There was also a significant negative association between percentage of female students and URM STEM graduation rate (r = -.62, p = .004). This association means that the more female students, the lower the URM STEM graduation rate. The overall URM enrollment of the school did not associate with URM STEM graduation rates (r = -.21, p = .374). Expenditures were also not significantly related to the URM STEM graduation rates (r = .42, p = .068). The only faculty variable that was significantly associated with URM STEM graduation rates was the percent of full time faculty who were female (r = -

.47, $p = .034$). This association means that the more faculty who were female, the lower the URM STEM graduation rates. The average salary of professors did not associate with URM STEM graduation rates. See Table 4.5 for details.

STEM-URM STEM difference. A Spearman correlation was also conducted to see if any institutional factors are associated with the difference between STEM and URM STEM graduation rates. None of the institutional factors were associated with the difference in graduation rates. See Table 4.5 for correlations.

Non-URM STEM - STEM difference. Similarly, a spearman correlation was also conducted to see if any institutional factors are associated with the difference between non-URM STEM graduation rates and STEM graduation rates. None of the institutional factors were associated with the difference in graduation rates. See Table 4.5 for correlations.

Difference in male-female URM STEM graduation rates. A Spearman correlation was conducted to see if any institutional factors were associated with the difference in graduation rates between males and females. There was a significant positive association between percentage of female students and URM STEM graduation rate ($r = .51$, $p = .020$). This association means that the more female students, the higher the difference between the males and female graduation rate. The only institutional factor significantly associated with the gender difference in graduation rates was percent of female full-time faculty ($r = .55$, $p = .012$). This positive correlation is showing an association between having more female full-time faculty and higher male than female graduation rates. See Table 4.5 for details.

Table 4.5

Non-parametric Correlation Matrix of Overall STEM Graduation Rate and Institutional Variables

	URM Graduation Rate	STEM-URM STEM Difference	NON-URM-URM STEM Difference	Male-Female Difference
Selectivity Score	-.21	-.33	-.30	-.15
SAT Overall Score	.48*	.35	.32	.20
High School GPA	.34	.44	.40	.21
Average Age	-.14	-.24	-.14	-.11
Pell Grant Percentage	-.34	-.47	-.37	.18
Female Student Percentage	-.62*	.15	.22	.51*
URM Student Percentage	-.21	-.39	-.24	.41
Expenditure	.42	-.15	-.11	.12
Female Faculty Percentage	-.47*	-.14	-.05	.55*
URM Faculty Percentage	-.20	-.21	-.16	.43
Salary for Full Professors	.37	-.08	-.10	-.06
Salary for Associate Professors	.32	-.26	-.25	-.06
Salary for Assistant Professors	.29	-.18	-.21	-.16

Note. * $p < .05$

Summary

This quantitative research study examined data from 20 selected colleges and universities at the State University of New York's (SUNY) system of higher education. Since the study's focus was on URM graduation rates at the baccalaureate level the selected institutions were all four year schools. The makeup of the institutions differed by size, sector and geography. The smallest of the campuses has an enrollment of fewer than 2,000 students, while the largest campus has well over 25,000 students both undergraduate and graduate combined

The first research question was "are there any differences in STEM URM graduation rates among the selected four year SUNY institutions?" The analysis revealed that there are differences in STEM URM graduation rates among the selected SUNY institutions. The results showed there is quite a range of graduation rates among the SUNY institutions. More specifically, the graduation rates for STEM URM students ranged from 13.0% to 75.4%.

The second research question explored the graduation rate differences at each institution and whether those differences could be explained by institutional characteristics. The results showed that for the overall STEM URM graduation rates, there were a few institutional characteristics found to be related: percentage of students who were female and percentage of faculty who were female. The data also revealed that the salary of professors did not relate to the graduation rates. One student characteristic that was directly related to STEM URM graduation rates was SAT overall score. There were no associations when examining associations between why there may be differences in graduation rates and institutional characteristics. Only the percentage of the URM students related to the difference in STEM and URM STEM graduation rates. To account for gender differences in STEM graduation rates, only the percent of female faculty and the percentage of female students were found to be associated.

Chapter 5 includes a discussion of the implications of the findings as well as recommendations for professional practice, decision making, limitations of the study, and future research.

Chapter 5: Discussion

Introduction

The focus of this dissertation study has been the critical importance of Underrepresented Minority (URM) students' persistence and graduation in Science, Technology, Engineering, and Mathematics (STEM). The literature reflects a preponderance of evidence relative to our nation's demonstrated need to focus on STEM fields in education in order to maintain its level of competitiveness in a global economy (Chen & Weko, 2009). A recent report by some of this country's most respected analysts have predicted that within the next decade, the US will need approximately one million more STEM professionals, which equates to increasing the number of students earning STEM degrees by as much as 35% per year over existing rates (President's Council of Advisors on Science and Technology, 2012). Conversely, given these projections, the present reality is that the US has fallen behind other nations in the production of STEM to non-STEM bachelor's degree attainment worldwide (Kuenzi, 2008).

The review of the literature has shown that given the current demographic realities of our state and nation, colleges and universities are drawing more students from the growing minority populations which are still largely underrepresented in higher education, particularly in STEM disciplines. Historically, this population has been shown less likely to pursue a STEM major and those that do, are not completing at the same rate as majority students. Based on the related literature, it's been highlighted that student persistence is a complex phenomenon affected by many influences such as student backgrounds, institutional factors, and student choice. The studies cited in the literature review looked at a comprehensive set of factors both on the individual student level and environmental conditions that impact student persistence and degree attainment. However, a gap in the literature remains with respect to continuing to examine institutional factors that play a role in URM degree completion and success. A supporting statement on this point is cited in a study conducted at the University of North Dakota on predicting graduation rates, "the effects of institutional characteristics, while theoretically relevant to predicting graduation rates, have largely been ignored in past studies," (Goenner & Snaith, 2004, p. 414).

This quantitative study investigated the differences in institutional success in raising the graduation rates of URMs in STEM disciplines at 20 of the four-year institutions within the State University of New York (SUNY). The study identified the highest performing institutions at graduating URMs in STEM disciplines. Furthermore, the study examined the institutional correlates of URMs success in STEM disciplines. More specifically, the study looked at two research questions:

1. Are there differences in STEM URM completion rates among the selected four-year SUNY institutions?
2. If so, is the variability among graduation rates explained by institutional characteristics and if so, to what extent?

The research questions were answered through quantitative analysis, using data from both the SUNY System Office of Institutional Research and the IPEDS reports. The dependent variable was the six-year URM graduation rate and a number of independent variables were used that examined both individual student and institutional factors.

This chapter will discuss and interpret the results presented in chapter 4 making a connection to the significance of the study relative to professional practice, decision-making, theory and scholarly understanding of the field as appropriate.

Implications of Findings

All of the analyses were conducted using the current Statistical Package for the Social Sciences (SPSS) software, version 22. Descriptive statistics were used and Spearman correlations were conducted in examining the institutional variables associated with URM graduations rates. The results of the study demonstrated which of the selected SUNY institutions performed the highest at graduating URMs in STEM. There was a sizable variance shown in the graduation rates of URMs from a low of 13% to a high of 75%. For a clearer understanding for the context of the student population in STEM, it is important to mention that the overall population of URM students in STEM majors in the entering cohort of 2006, was 735 among the chosen colleges and universities. The total number of STEM majors the same year at the 20 selected institutions was 6,130. Therefore, the URM population of students who were STEM majors accounts for 12% of the overall population of STEM majors in 2006. Additionally, there were five institutions that had a URM STEM enrollment of less than 10 students (Potsdam, Brockport, Fredonia, Cortland, and Empire State College). Each of these institutions with the exception of Empire State College are located in rural communities throughout the state. Empire State College is largely a distance learning institution with over 30 satellites/installations throughout New York. An important observation to point out is that the data from these five institutions with single digit enrollment of URMs in STEM does not offer the same statistical significance as the data from the other institutions whose enrollment of URMs were much higher.

The SUNY range in graduation of URMs in STEM was noticeably widespread. The lower end of the spectrum, while alarming, was not too dissimilar from the national completion data in STEM degrees. Based on a study by the Higher Education Research Institute (HERI) at UCLA (2010), data from the National Student Clearinghouse (NSC) was used to determine STEM completion rates for students who entered in the fall of 2004 at over 200 colleges and universities across the country. The five-year completion rates for URM students in STEM majors were:

- Latino - 22.1%,
- African American - 18.4%
- Native American - 18.8%

In this study however, the six year graduation rates were not available and therefore a direct comparison to six year graduation rates cannot be made. The relevant research literature on graduation rates in STEM has shown that five and six year graduation rates are statistically not too dissimilar. The above five year graduation data for the three minority groups taken as an average approximates a 20% degree completion rate. The majority of the SUNY schools (14 out of 20) examined had URM graduation rates above 22%, with several of the largest and most selective of the institutions showing completion rates of over 50%. Overall, the data showed a negative association between selectivity of the institution and the URM STEM graduation rate. This association indicates that the least selective schools had lower URM STEM graduation rates. The selectivity ranking of institutions go from 1 (Most Selective) to 5 (General Admission). Higher SAT scores, higher secondary school GPA, and class rank of entering students is more pronounced at the selective institutions. This finding is supported by the literature on student persistence and graduation (Herrera & Hurtado, 2011).

The relationship between institutional selectivity and graduation rates is highly correlated, that is to say that there is a positive outcome resulting in increased graduation rates. A study conducted by the American Enterprise Institute on Hispanic college graduation rates, found that Hispanic students who attend more selective postsecondary institutions graduate at higher rates. The report on the findings posited that the highest-performing schools graduated up to three times as many of their Hispanic students, on average, as the lowest-performing schools in the study (Schneider, Kelly, & Carey, 2010). These outcomes are consistent with those found in similar studies that have focused on African American and Native American students. Among the most selected schools in the SUNY system are the doctoral serving institutions, the majority of which performed best as part of this study: Binghamton University, Cornell Statutory, University at Albany, and the College of Environmental Science and Forestry. Somewhat surprising were the URM STEM graduation rates of the University at Buffalo and Stony Brook University. While their performance is better than the national average at 34.3% and 31.0% respectively, they did not fare as well as the top four institutions in this study on a percentage basis. Examining the data from the absolute number of URM graduates rather than on a percentage basis, shows a slightly different account. Looking at performance from this perspective situates Cornell Statutory as first in graduating the most URMs in STEM, followed by Binghamton University, and Stony Brook University a close third.

It is important to mention that both Stony Brook University and the University at Buffalo are very selective institutions, particularly in the STEM disciplines. Additionally, both of these institutions have larger student bodies overall and in the case of the University of Buffalo the highest number of URMs in STEM. These two institutions are also members of the Association of American Universities (AAU) known for their leading edge innovation and scholarship. The 60 AAU universities in the United States award more than one-half of all U.S. doctoral degrees and 55% of those in the sciences and engineering. This level of competition particularly within STEM, might explain the lower level of URM STEM graduation. Fairly recent research conducted by Herrera and Hurtado (2011) implies that while attending a four-year private college may benefit URMs persistence in STEM, attending a highly selective institution may negatively impact persistence of URMS in STEM disciplines. Lastly, it is difficult to speculate given the design of this study, that increased numbers of URMs in STEM might also reflect a higher participation of first-generation students which the research has shown to have a negative impact on graduation rates. More specifically, first-generation status has been found to be negatively associated with students' persistence and graduation attainment (Nunez & Cuccaro-Alamin, 1998). This suggests that the challenges that URMs face in persisting in STEM disciplines will also apply to many first-generation students and institutions will need to provide the appropriate interventions in order to ensure persistence amongst this population of students.

As part of the second research question there were two variables that were not significantly associated with URM STEM graduation rates. The first was the average student age and URM STEM graduation rate and the percent of students receiving federal

Pell Grant Aid. A closer look at the age of the 2006 incoming cohort showed little to no variance in the ages of students, thus this finding was not surprising. This was due to the overwhelming majority of students coming from a traditional background of study, meaning that students in the cohort came directly upon high school completion to college as first-time, full time students (average age was 19). The only exception was Empire State College (ESC) with an average student age of 31. This is expected due to ESC being primarily a distance learning institution which caters to the more non-traditional student. An important observation is that ESC only enrolled four URM students in STEM in the 2006 cohort and by 2012, none had graduated. Most studies that examine age as a factor of college completion have found this variable to be negatively related to graduation rates, particularly in STEM. That is, as the average age of students' increases, the graduation rates decline. In a study of institutional factors at doctoral universities, it was found that a one-year increase in the average age of the student body resulted in a decrease of the five and six-year graduation rates by slightly more than 2% (Goenner & Snaith, 2004).

Surprisingly, the variable related to federal Pell Grant Aid did not yield a statistically significant association with URM STEM graduation rates. Federal Pell Grants have been recognized as one of the primary means for subsidizing college tuition for low-income students. However, in more recent years, it has become more difficult to receive and maintain Pell Grants. At one time students could receive Pell via a standardized "ability to benefit" test without a high school diploma; as of 2012 a student must have a high school diploma and upon entering into postsecondary education, maintain a satisfactory academic progress standard to keep the award (Sawhill &

Goldrick-Rab, Spring 2014). Overall, approximately one third of SUNY students receive Pell Grant aid which is a sizable number. When examining the raw data for the selected institutions in the study, it yielded some interesting observations when looking at the top five colleges receiving Federal Pell, as well as the bottom five receiving such aid for its students (Pell data was for the overall entering cohort in 2006 not URM STEM specific). The top five institutions are: Empire State College 54%, College at Old Westbury 54%, State College at Buffalo 46%, Maritime College 41%, and Potsdam College 37%. The institutions receiving the lowest Pell aid were: the College of Environmental Science and Forestry 10%, Geneseo 13%, Oneonta 23%, Cortland 22% and Purchase College 24%. Incidentally, what was found is that the top five Pell institutions also had much higher numbers of URMs than the bottom five. With regard to STEM URM graduation rates the difference between the two sets of institutions in the aggregate was nominal and therefore confirms the original findings. A study that focused on undergraduate student success based on student and institutional factors was similar to the findings of this dissertation study. The study found that need-based aid showed no significant effects on graduation rates of several of the cohorts examined (Redlinger, Etheredge, Zhao & Stigdon, 2008). However, what is perceived to be important is that financial assistance for higher education is critical to low income students' attending and persisting in college. Essentially, since national data show that many URM students tend to also be low income; ensuring persistence through to graduation requires this level of support and commitment. Conversely, a possible argument that can be made is that without Pell support the numbers of URMs within SUNY and across the country would be significantly lower and their persistence and graduation reduced over current enrollment figures. Along these lines, research in this area by scholars Pascarella and Terenzini (2005), particularly as it relates to a public policy focus, have helped illuminate a commonly limited understanding of the importance of financial support and college access. They espouse that the elimination of financial barriers to college access:

> is unnecessarily narrow, it appears to rest on the assumption that if such barriers can be reduced or removed, everything else will take care of itself, and any social or moral imperative to provide equal access to the benefits of college will have been satisfied. (Pascarella & Terenzini, 2005, p.644)

Lastly, Pascarella and Terenzini (2005), go on to say that

> the emerging evidence suggests that financial considerations are part of a complex longitudinal process that begins long before students enter college, perhaps as early as the middle school years, shaping whether students have college aspirations as well as the nature of these aspirations and the ensuing college search and selection process. (p. 644)

There was also a negative association found between percent of female students and URM STEM graduation rates. The finding that this variable is associated with lower URM graduation rates is not surprising and consistent with the findings of related literature. There is evidence that gender serves as one of the most prevailing and robust predictors of choice of college major particularly for minority and female students who more often choose not to major in STEM but instead tend to major in the liberal arts and the social sciences (Simpson, 2001). For those who decide to major in STEM, many women end up not continuing in STEM and transferring to non-STEM majors or departing all-together. Research conducted by Cole and Espinoza (2008) found that gender predicted college grade point average among STEM majors. Female students who experience lower grades in their STEM courses end up leaving. Many of the reasons in addition to grades that account for why women and minorities end up leaving STEM are due to what has been described as a "chilly" climate. Women in particular often feel isolated, intimidated, and face inimical male peers as well as male professors (London, Rosenthal, Levy, & Lobel, 2011). Additionally, female students in STEM majors tend not to get as much positive reinforcement and encouragement from faculty, instructors, and mentors as men (Buday et al., 2012). The gender breakdown for URMs was not available; only the overall STEM female and male graduation rates were given and analyzed as a result. Since the overall URM STEM population is only 12%, a safe assumption is that the overwhelming number of female students in STEM are White and Asian. This may explain the negative association between females and URM graduation rates. That is to say there are many more White females majoring in STEM than URM female and male students. Overall, however, it can be more difficult for women and URM students to feel socially and academically integrated. As posited by Tinto's (1987) model, institutional departure is based on academic and social integration, the greater the amount of integration, the greater the probability of retention.

An interesting finding was the overall URM enrollment of the institution did not significantly associate with URM STEM graduation rates. Given this finding, an observation to keep in mind is that overall URM enrollment, much less STEM URM enrollment was not very pronounced at a good number of the institutions examined. Not having a sizable number of enrolled URMs could therefore explain the lack of significant association. Another observation is that several of the campuses that had larger numbers of URMs also had fairly strong URM graduation rates. Therefore, this finding is somewhat mixed relative to the evidence examined. It is important to highlight that studies have shown the significance of higher URM student numbers in a college resulting in higher graduation rates (Palmer & Gasman, 2008). URM students on predominantly white campuses, particularly those majoring in STEM, often feel a sense of academic and cultural isolation that can lead to performance difficulties especially in cases where there are low expectations and/or stereotypes. Higher numbers of URM students can ensure more of an opportunity for support and development of a network infrastructure for those students. More specifically, work done by Herrera and Hurtado (2011) found that URMs who retained interest in STEM were influenced by the percentage of URM students in STEM majors at their institution. Higher rates of URMs on a campus speaks directly to overall campus involvement and climate factors for URM students. Astin (1975, 1993), known for his theory of involvement, using large national data sets, identified involvement (academic involvement, involvement with faculty and with student peers) as a key factor in retention.

In keeping with the second research question centered on the variability among graduation rates and institutional characteristics, there were two other independent variables that were not significantly associated with URM graduation rates. The first was the expenditures for instructional activities and the second was average salaries of full-time faculty. This was not a surprise finding, mainly because throughout the related literature these factors have been shown to have an impact on graduation rates, but not necessarily on URM STEM graduation rates. The data for this study did not allow for expenditures to be disaggregated by specific program area, therefore impact related to specific STEM related expenditures are undetermined.

The only faculty variable that was significantly associated with URM STEM graduation rates was the percent of full-time faculty who were female. In essence, this association means the more female faculty, the lower URM STEM graduation rates. Initially, this finding is somewhat troubling. However, a closer examination on female faculty shows that there is a sizable number of female faculty at the selected institutions, but very few female faculty of color. Additionally, since the original data was not able to be differentiated by STEM faculty vs. non-STEM, a safe assumption is that there are even fewer female STEM faculty members. Therefore, the potential for a positive impact on URM STEM graduation rates from female faculty is limited at best. A fairly recent study conducted on the persistence of women and minorities in STEM majors, the author stated "if professors of the same gender or race serve an important role as mentors, women and minority students may be at a disadvantage as both groups are also under-represented as faculty members in STEM field departments" (Griffith, 2010). While this study was not designed to look specifically at the interactions between faculty and student. It is important to mention that many studies have shown that faculty-student interaction especially outside of the classroom is a critical factor in student persistence. For URM students, relationships with minority faculty has proven to be the most significant dimension of social integration in affecting grade point average (Pancer, Hunsberger, Pratt, & Alisat, 2000). The importance of having more female faculty from underrepresented minority populations in the academy and particularly in STEM cannot be underestimated. Given the low numbers of minority faculty within SUNY this is of particular importance.

As part of this study some background research was conducted as to the status of SUNY advancing STEM programming across the system. There is a clear need to continue to grow this critical area by encouraging and supporting more students, particularly those from URM backgrounds, to pursue majors and careers in STEM.

The following information is a snapshot of SUNY's efforts in this area from a system-wide perspective and some of the campus efforts in the study. Efforts in this area in the last decade have led to modest increase in enrollments in STEM academic programs, now comprising 15.1% of SUNY's total enrollment from 11.9% almost 10 years ago.

- **Afterschool STEM Mentoring Program** – With almost a $3 million grant from NSF, SUNY and the New York Academy of Sciences expanded this program, which pairs student mentors from SUNY campuses with local middle school students.
- **Collegiate Science and Technology Entry Program (CTEP)** – In 2012-13, 22 SUNY campuses participated in CSTEP, a New York State program designed to increase the number of students from under-represented minority groups who are pursuing professional licensure and careers in mathematics, science, technology, and health related fields.
- **SUNY Replication Project** – Baccalaureate and Beyond Community College Mentoring Program. This STEM seamless transfer program is modeled on the nationally recognized Baccalaureate and Beyond Community College

Mentoring Program established at Purchase College. SUNY is replicating Purchase College's ideas for seamless STEM transfer throughout the SUNY System.

- **SUNY High Needs Program** – This program provides grants to campuses to link academic programs to workforce needs. Prior to 2012-13, it provided nearly $28 million to 28 campuses, principally to support or expand nursing and engineering programs. As part of SUNY's Strategic Enrollment Management plan, the Request for Proposal for 2013-14 called for programs relating to high need occupations identified by Empire State Development, the New York State Department of Labor, and others in six STEM-related areas: Engineering, Engineering Technologies, Health Care, Renewable Clean Energy, Biomedical-Biotechnical, Agriculture-Agriculture Business, and Information Technology.
- **Doctoral Diversity Fellowships in STEM** – these fellowships are awarded to diverse academically exceptional students who have been admitted to SUNY's doctoral degree granting institutions and will commence their graduate studies in a STEM major.

The following is a snapshot of specific campus based programs and initiatives at some of the institutions in this study that are helping to advance and support URMs in STEM fields:

- **Binghamton University** – Formal undergraduate research programs include: Howard Hughes Medical Institute STEM interdisciplinary Research Program; Louis Stokes Alliance for Minority Participation (LSAMP); Collegiate

Science and Technology Entry Program (CSTEP); The Ronald E. McNair Post-baccalaureate Achievement Program; Computer Science REU; and the NIH Bridges to the Baccalaureate Program.

- **Stony Brook University** – The Office of Undergraduate & Creative Activities (URECA), oversees several externally-funded undergraduate research programs including NIH's BioPREP and Minority Access to Research Careers (MARC) and NSF's REU programs, plus CSTEP, LSAMP, Chancellor's Education Pipeline and STEM Exploration. URECA also administers its own Summer Research Grant, Small Grant/Travel Grant Programs, and the Battelle Summer Research Program at the Brookhaven National Lab.
- **University at Buffalo** – The Center for Undergraduate Research & Creative Activities (CURCA) provides small grants and travel awards to students. Its formal undergraduate research projects include STEM, LSAMP and CSTEP.
- **Buffalo State College** – The Office of Undergraduate Research provides a small grants program, travel awards, a summer research program and symposia, and support the integration of undergraduate research into the STEM curriculum.
- **SUNY Oswego** – The Office of Research and Individualized Student Experiences (RISE), and the Global Laboratory program connect students to undergraduate research experiences in the US and abroad and operate externally-funded programs, such as SMILES (Science & Math Increased Learning Experiences in STEM).

Limitations

This study was limited by the type of data available from both the Institutional Research Office at SUNY and IPEDS. For a wide range of reasons, graduation rates of full-time, first-time URM STEM students along with some of the independent variables associated with STEM graduation rates was not easily accessible making for a much more challenging process of data collection. In essence many theoretically interesting variables were not available for analysis simply because they are not routinely collected or reported. Enrollment data has always been readily available due to reporting requirements, but graduation rates haven't always been reported and less so by discipline. Additionally, the dependent variable of six-year URM graduation rates yielded some very good information on the selected institutions level of performance, but it does not account for many aspects of institutional effectiveness.

Recommendations

As briefly mentioned above, the utilization of a qualitative or mixed methods approach to the study would provide a rich and robust set of findings on the interrelationships between student background, institutional factors, and URM STEM graduation rates. Further research is needed to examine and clarify these interrelationships in helping to illuminate what is most salient in URM STEM student persistence and ultimately degree completion in these highly competitive disciplines. Part of this study looked at institutional variables such as instructional expenditures, faculty salaries, percentage of female faculty, and other measures. A need to further disaggregate relevant data can be useful at pinpointing what variables have the most impact on graduation. For example, expenditures on instructional activities is a broad category and may not take into account specific programs and services directly associated with STEM instruction and supportive type services especially for URM students.

Based on the findings of the study there were nine institutions that had URM STEM graduation rates over 30% and five schools whose URM graduation rates in STEM were over 50%. Two of the schools above 50% actually achieved URM STEM graduation rates over 70%. Given the success of these institutions more research needs to be conducted on the extent to which these campuses provide a supportive environment and/or other institutional factors impacting URM STEM success accounting for the high graduation rates. Earlier in this chapter a variety of support type programs known for their positive effects on URM student success were briefly highlighted. There needs to be more scientific inquiry done on such programs to further illuminate what strategies and overall interventions are having a positive effect on persistence and graduation. Some of the successful interventions of these programs have involved undergraduate research, summer Bridge Programs that increase student involvement on many levels, mentoring, faculty support and learning communities. Additionally, successful practices and institutional commitment from leadership, faculty and staff need further inquiry as well.

In the current political and overall public policy arena pressure is bearing down on higher education to be more accountable than ever, especially in light of increasing tuition costs. This level of expectation is calling for better assessment and outcomes. Public officials want to see more students graduate and be better prepared for the world of work. This calls for college and university administrators on all levels to be increasingly vigilant by spending more time, effort, and resources to expand programs and initiatives that support access and ensures success. The author of a study that looked at factors which affect graduation rates of university students very aptly said “Retention is complex and multi-dimensional, and extends far beyond the academic qualifications of entering freshmen. Data must be further disaggregated to examine more of the personal and socio-cultural issues that impact student retention” (Creighton, 2007, p. 8).

Policy and Practice

According to the National Center for Public Policy and Higher Education (2008), current statistics on student success in the State of New York is devastating. Based on their analysis, if you look at 100 ninth graders within the state:

- 57 graduate from high school four years later
- 41 immediately enter college
- 31 are still in college their sophomore year
- 19 of the original 100 receive an associate’s degree in three years or a bachelor’s degree in six years

Placing these alarming statistics within the context of a STEM driven workforce needed presently and well into the future within the state of New York, raises some additional concerns. It is projected that by 2018 New York will demand a total of 423,200 STEM jobs, up from 385,140. This represents a 10% increase in STEM jobs and seven percentage points below the national average. Approximately, 93% of these jobs will require postsecondary education and training (Carnevale et al., 2011). While this study focused on higher education there is little question that policy and practice recommendations have to involve a systemic approach that involves the higher education community working in conjunction with secondary education and the lower grades. The key to increasing the number of URM STEM majors and degree completers at the undergraduate level is to markedly improve the overall mathematics and science competencies among middle and high school students. Once in college URM students need to be part of an expanded effort of programs and supportive services that have shown to positively impact persistence and graduation. Many of the programs and initiatives mentioned above as part of several SUNY campuses outlined need to be replicated throughout the entire system.

The State University of New York's mission is grounded in its fundamental commitment to providing broad access to affordable, high-quality higher education for all eligible New Yorkers. As such, in order to continue to ensure more college ready students, especially for those wanting to major in the STEM disciplines, the separation of higher education from the experience students have before college cannot be ignored. Ensuring access and success, particularly in the STEM disciplines has to become a national, state, and local priority. To SUNY's credit as a system of public higher education, it is implementing a system-wide strategic plan that applies evidence-based intervention strategies to help close gaps in its STEM education pipeline. This high level accountability approach will certainly help mitigate some of the issues of concern that have been presented. However, the following are additional recommendations for the higher education community based on what is known about promising practices:

- SUNY's Replication Project – based on the highly successful "Bridges to the Baccalaureate Program." This program model which was developed by Dr. Joseph Skrivanek, a STEM faculty member at Purchase College, focuses on URM and first generation students. Students are actively recruited for entry into a STEM major at the two-year college level. Activities include recruitment and advising at the SUNY two-year institutions, summer undergraduate research experience, active coordination between two-year and four-year SUNY faculty in order to increase the articulation among the two institutional sectors in order to ensure a 2-4 year seamless transfer. Given that the two-year institutions have shown to be the entry point into higher education for most first-generation college students, particularly those from low-income, historically underrepresented and immigrant populations replicating such a successful program throughout SUNY would have a sizable positive impact on increasing and graduating URMs in STEM.

- STEM faculty diversity – the importance of diverse faculty in STEM is critical in helping URM students with developing a STEM identity and having faculty that understand their culture. There needs to be an expressed commitment to supporting and promoting diversity and faculty of color. As important is the development of programs that can foster a culture of student-faculty mentorship and offer incentives to faculty to build closer relationships with their students (Toldson & Esters, 2012).
- Institutional leadership commitment – eliminating the achievement gap and improving the academic outcomes for URMs in STEM will require an intentional effort and commitment by the leadership of each institution. This includes a focused investment on accountability measures that provides relevant data on outcomes. Examining disaggregated data by race, ethnicity, gender, academic discipline and other relevant measures to ensure a baseline for further inquiry and effective decision making. Additionally, support

programs need to be assessed to ensure that performance outcomes are being met.

- Meyerhoff Scholars Program – highly successful programs like the Meyerhoff at the University of Maryland Baltimore County should be replicated. This program has been recognized nationally and praised for its many successes in being a leader in supporting and graduating URMs in STEM. Its highly selective admissions process coupled with granting students full-financial support and a cohort model ensures a high degree of success. Selected students participate in a very structured six-week residential summer bridge program, and are continuously monitored by assigned academic advisors and mentors throughout their undergraduate experience. Extracurricular activities are centered on paid internships, research projects and conferences in STEM and study abroad programs.

Although the literature is fairly replete with research that helps explain many of the factors that influence URM student persistence and graduation in STEM, there is still much work to be done.

Conclusion

As stated throughout this dissertation study, the importance of our nation's ability to maintain its global leadership in research, innovation, and economic competitiveness is directly tied to the production of high-quality STEM graduates. Given the current demographic realities, there are national implications if we fail to increase the representation of underrepresented minorities and women enrolled in and successfully completing degrees in STEM. Chapter 1 explored the background of this major concern throughout our nation and in particular the need to produce many more bachelor's degree holders in STEM disciplines with the express interest in fortifying the skilled STEM labor force currently in decline. The vast underrepresentation in STEM fields by African Americans, Hispanics, and Native Americans continues to be a major challenge. Despite the importance associated with the demand for high skilled workers, colleges and universities have not been able to rectify the lower participation and still lower graduation rates for URMs in STEM fields. The chapter also discussed several programs, institutional strategies and other practices that have been shown to combat the loss of potential graduates from URM populations. Overall, this chapter clearly stated the theoretical rationale for the study as well the purpose along with the questions to be addressed.

Chapter 2 explored much of the relevant literature on student engagement and persistence as well as some of the causes that lead to attrition. This extensive review of the literature highlighted several prominent scholars in the field of student retention such as Vincent Tinto's (1987) model of institutional departure. This model is based on academic and social integration factors which describe student retention and success as a result of high levels of student engagement within the culture of the institution.

In Chapter 3 the methodology used in the study was described. The study was designed to be quantitative in nature examining differences in institutional success leading to graduation of URMs in STEM disciplines at 20 of the four-year institutions in the State University of New York. The dependent variable was designed to look at the six-year graduation rates of URMs in STEM taken from the entering class of first-time full-time students in 2006. Independent variables were designed to look at a mix of student as well as institutional factors, for example, high school GPA, average SAT, average age, faculty salaries, educational expenditures, Pell Grant aid, etc. The two sources from which the set of secondary data was collected are the Federal IPEDS data and the Institutional Research Office of SUNY. It was determined that non-parametric statistical procedures (Pearson Correlations) would be used in the study due to the small sample size of n=20.

Chapter 4 consisted of the results of the data which yielded a widespread variance in URM STEM graduation rates at the selected institutions that ranged from a low of 0% to a high of 75.3%. The two institutions that had the highest graduation rates were Binghamton University and the Cornell Statutory sector. The overall percentage of URM STEM majors at the selected institutions amounted to 12%. As expected, the majority of institutions were found to have higher STEM graduation rates than the URM-STEM group of students. A positive correlation between SAT score and URM STEM graduation rate was found. There were no significant associations found when examining between why there may be differences in graduation rates and institutional characteristics.

This chapter looked at the overall implications of the study relative to the findings. The limitations of the study were discussed and the recommendations made based on the understanding of the data.

Lastly, in a special report to the President in 2010, recommendations submitted by the President's Council of Advisors on Science and Technology (PCAST), very aptly said the following (relative to closing the achievement and participation gap),

> Our national needs cannot be met without drawing on the full potential of our Nation. The United States cannot remain at the forefront of science and

technology if the majority of its students—in particular, women and minorities underrepresented in STEM fields—view science and technology as uninteresting, too difficult, or closed off to them. We must close the achievement and interest gap in STEM subjects among racial, ethnic, and gender groups. Closing these gaps cannot be limited to helping students and groups at the remedial level in STEM subjects. It also requires unleashing the full potential of all our students who have not historically been drawn to STEM fields. STEM education needs to recognize and cultivate untapped talent. Many of our future STEM experts can and must come from traditionally underserved populations. STEM fields will greatly benefit from drawing on a diversity of perspectives, cultures, and ideas. (PCAST, 2010, p.7)

Given the enormous task before us, we cannot sit idly; the time to take action is now. The future of our global competitiveness as a country is at stake. It will take higher education leaders working in partnership with elementary, middle, and secondary schools to ensure rigorous curricula with the right supports is available to all our students. It will also take the full engagement of families, the business community, government officials and politicians alike, to work together in ensuring a collective front and equitable opportunity for all. In the words of President Obama, “We must educate our children to compete in an age where knowledge is capital, and the marketplace is global” (PCAST, 2010, p. 5).

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Appendix A

STEM Classification by CIP Family & Agency

CIP2	CIP4	CIP6	Title	DHS	NSF	NCES
01		010308	Agroecology and Sustainable Agriculture	X		
01	0109	010901	Animal Sciences, General	X	X	
01		010902	Agricultural Animal Breeding	X		
01		010903	Animal Health	X		
01		010904	Animal Nutrition	X		
01		010905	Dairy Science	X		
01		010906	Livestock Management	X		
01		010907	Poultry Science	X		
01		010999	Animal Sciences, Other.	X		
01	0110	011001	Food Science	X	X	
01		011002	Food Technology and Processing	X		
01		011099	Food Science and Technology, Other.	X		
01		011101	Plant Sciences, General	X		
01		011102	Agronomy and Crop Science	X		
01		011103	Horticultural Science	X		
01		011104	Agricultural and Horticultural Plant Breeding	X		
01		011105	Plant Protection and Integrated Pest Management	X		
01		011106	Range Science and Management	X		
01		011199	Plant Sciences, Other.	X		

01		011201	Soil Science and Agronomy, General	X	X
01		011202	Soil Chemistry and Physics	X	
01		011203	Soil Microbiology	X	
01		011299	Soil Sciences, Other.	X	
01	0199		Agriculture, Agriculture Operations and Related Sciences, Other		X
03		030101	Natural Resources/Conservation, General.	X	X
03		030103	Environmental Studies	X	X
03		030104	Environmental Science	X	X
03		030199	Natural Resources Conservation and Research, O	X	
03	0302		Natural Resources Management and Policy		X
03		030205	Water, Wetlands, and Marine Resources Management	X	
03	0303		Fishing and Fisheries Sciences and Management		X
03		030502	Forest Sciences and Biology	X	
03	0305		Forestry		X
03		030508	Urban Forestry	X	
03		030509	Wood Science and Wood Products/Pulp and Paper	X	X
03	0306		Wildlife and Wildlands Science and Management		X
03		030601	Wildlife, Fish and Wildlands Science and Manag.	X	

03	0399		Natural Resources and Conservation, Other		X	
04	0402		Architecture		X	
09		090702	Digital Communication and Media/Multimedia	X		
10		100304	Animation, Interactive Technology, Video Graphi	X		
11	1101		Computer and Information Sciences, General		X	
11		110101	Computer and Information Sciences, General	X		X
11		110102	Artificial Intelligence	X		X
11		110103	Information Technology	X		X
11		110104	Informatics	X	X	
11		110199	Computer and Information Sciences, Other.	X		
11		110201	Computer Programming/Programmer, General	X		X
11		110202	Computer Programming, Specific Applications	X		X
11		110203	Computer Programming, Vendor/Product Certifi	X		X
11		110299	Computer Programming, Other.	X		
11		110301	Data Processing and Data Processing Technolo	X		X
11	1104		Information Science/Studies		X	
11		110401	Information Science/Studies	X		X
11		110501	Computer Systems Analysis/Analyst	X		X

11	1107		Computer Science		X	
11		110701	Computer Science	X		X
11		110801	Web Page, Digital/Multimedia and Information	X		X
11		110802	Data Modeling/Warehousing and Database Admin	X		X
11		110803	Computer Graphics	X		X
11		110804	Modeling, Virtual Environments and Simulatio	X		
11		110899	Computer Software and Media Applications, Ot	X		
11		110901	Computer Systems Networking and Telecommunic	X		X
11		111001	Network and System Administration/Administra	X		X
11		111002	System, Networking, and LAN/WAN Management/M	X		X
11		111003	Computer and Information Systems Security/In	X		X
11		111004	Web/Multimedia Management and Webmaster	X		X
11		111005	Information Technology Project Management	X		
11.		111006	Computer Support Specialist	X		
11		111099	Computer/Information Technology Services Adm	X		
13		130501	Educational/Instructional Technology	X		
13		130601	Educational Evaluation and Research.	X		

13		130603	Educational Statistics and Research Methods	X		
14	1401		Engineering, General		X	
14		140101	Engineering, General	X		X
14		140102	Pre-Engineering	X		
14	1402		Aerospace, Aeronautical and Astronautical Engineering		X	
14		140201	Aerospace, Aeronautical and Astronautical/Sp	X		X
14	1403		Agricultural Engineering		X	
14		140301	Agricultural Engineering	X		X
14	1404		Architectural Engineering		X	
14		140401	Architectural Engineering	X		X
14	1405		Biomedical/Medical Engineering		X	
14		140501	Bioengineering and Biomedical Engineering	X		X
14	1406		Ceramic Sciences and Engineering		X	
14		140601	Ceramic Sciences and Engineering	X		X
14	1407		Chemical Engineering		X	
14		140701	Chemical Engineering	X		X
14		140702	Chemical and Biomolecular Engineering	X	X	
14		140799	Chemical Engineering, Other.	X	X	
14	1408		Civil Engineering		X	
14		140801	Civil Engineering, General	X		X
14		140802	Geotechnical and Geoenvironmental Engineerin	X		X

14		140803	Structural Engineering	X	X	X
14		140804	Transportation and Highway Engineering	X		X
14		140805	Water Resources Engineering	X	X	X
14		140899	Civil Engineering, Other.	X		
14	1409		Computer Engineering, General		X	
14		140901	Computer Engineering, General	X		X
14		140902	Computer Hardware Engineering	X		X
14		140903	Computer Software Engineering	X		X
14		140999	Computer Engineering, Other.	X		
14	1410		Electrical, Electronics and Communications Engineering		X	
14		141001	Electrical and Electronics Engineering	X		X
14		141003	Laser and Optical Engineering	X	X	
14		141004	Telecommunications Engineering	X	X	
14		141099	Electrical, Electronics and Communications E	X	X	
14	1411		Engineering Mechanics		X	
14		141101	Engineering Mechanics	X		X
14	1412		Engineering Physics			
14		141201	Engineering Physics/Applied Physics	X		X
14	1413		Engineering Science		X	
14		141301	Engineering Science	X		X
14	1414		Environmental/Environmental Health Engineering		X	

14		141401	Environmental/Environmental Health Engineering	X		X
14		141801	Materials Engineering	X		X
14	1419		Mechanical Engineering		X	
14		141901	Mechanical Engineering	X		X
14	1420		Metallurgical Engineering		X	
14		142001	Metallurgical Engineering	X		X
14	1421		Mining and Mineral Engineering		X	
14		142101	Mining and Mineral Engineering	X		X
14	1422		Naval Architecture and Marine Engineering		X	
14		142201	Naval Architecture and Marine Engineering	X		X
14	1423		Nuclear Engineering		X	
14		142301	Nuclear Engineering	X		X
14	1424		Ocean Engineering		X	
14		142401	Ocean Engineering	X		X
14	1425		Petroleum Engineering		X	
14		142501	Petroleum Engineering	X		X
14	1427		Systems Engineering		X	
14		142701	Systems Engineering	X		X
14	1428		Textile Sciences and Engineering		X	
14		142801	Textile Sciences and Engineering	X		X
14		143101	Materials Science			X
14	1432		Polymer/Plastics Engineering		X	
14		143201	Polymer/Plastics Engineering	X		X

14		143301	Construction Engineering	X		X
14		143401	Forest Engineering	X		X
14		143501	Industrial Engineering	X		X
14		143601	Manufacturing Engineering	X		X
14		143701	Operations Research	X	X	X
14		143801	Surveying Engineering	X		X
14		143901	Geological/Geophysical Engineering	X		X
14	144		Paper Science and Engineering		X	
14		144001	Paper Science and Engineering	X		
14	1441		Electromechanical Engineering		X	
14		144101	Electromechanical Engineering	X		
14	1442		Mechatronics, Robotics, and Automation Engineering		X	
14		144201	Mechatronics, Robotics, and Automation Engin	X		
14	1443		Biochemical Engineering		X	
14		144301	Biochemical Engineering	X		
14	1444		Engineering Chemistry		X	
14		144401	Engineering Chemistry	X		
14	1445		Biological/Biosystems Engineering		X	
14		144501	Biological/Biosystems Engineering	X		
14	1499		Engineering, Other		X	
14		149999	Engineering, Other	X		
15		150000	Engineering Technology, General	X		X
15		150101	Architectural Engineering Technology/Technic	X		X

15	150201	Civil Engineering Technology/Technician	X		X
15.	150303	Electrical, Electronic and Communications Engineering Technology/Technician	X		X
15	150304	Laser and Optical Technology/Technician	X		X
15.	150305	Telecommunications Technology/Technician	X		X
15	150306	Integrated Circuit Design	X	X	
15	150399	Electrical and Electronic Engineering Techno	X		
15	150401	Biomedical Technology/Technician	X		X
15.	150403	Electromechanical Technology/Electromechanical Engineering Technology	X		X
15	150404	Instrumentation Technology/Technician	X		X
15	150405	Robotics Technology/Technician	X		X
15	150406	Automation Engineer Technology/Technician	X		
15	150499	Electromechanical and Instrumentation and Maintenance Technologies/Technicians, Other	X		
15.	150501	Heating, Ventilation, Air Conditioning and Refrigeration Engineering Technology/Technician	X		X
15	150503	Energy Management and Systems Technology/Technician	X		X
15	150505	Solar Energy Technology/Technician.	X		X

15	150506	Water Quality and Wastewater Treatment Management and Recycling Technology/Technician	X	X
15	150507	Environmental Engineering Technology/Environmental Technology	X	X
15	150508	Hazardous Materials Management and Waste Technology/Technician	X	X
15	150599	Environmental Control Technologies/Technicians, Other	X	
15	150607	Plastics and Polymer Engineering Technology/Technician	X	X
15	150611	Metallurgical Technology/Technician	X	X
15	150612	Industrial Technology/Technician	X	X
15	150613	Manufacturing Engineering Technology/Technician	X	X
15	150614	Welding Engineering Technology/Technician	X	
15	150615	Chemical Engineering Technology/Technician	X	
15	150616	Semiconductor Manufacturing Technology	X	
15	150699	Industrial Production Technologies/Technician	X	
15	150701	Occupational Safety and Health Technology/Technician	X	X
15	150702	Quality Control Technology/Technician	X	X

15	150703	Industrial Safety Technology/Technician	X	X
15	150704	Hazardous Materials Information Systems Technology/Technician	X	X
15	150799	Quality Control and Safety Technologies/Technicians, Other	X	
15.	150801	Aeronautical/Aerospace Engineering Technology/Technician	X	X
15	150803	Automotive Engineering Technology/Technician	X	X
15	150805	Mechanical Engineering/Mechanical Technology	X	X
15	150899	Mechanical Engineering Related Technologies/	X	
15	150901	Mining Technology/Technician	X	X
15	150903	Petroleum Technology/Technician	X	X
15	150999	Mining and Petroleum Technologies/Technician	X	
15	151001	Construction Engineering Technology/Technician	X	X
15	151102	Surveying Technology/Surveying	X	X
15	151103	Hydraulics and Fluid Power Technology/Technician	X	X
15	151199	Engineering-Related Technologies, Other.	X	
15	151201	Computer Engineering Technology/Technician	X	X

15	151202	Computer Technology/Computer Systems Technology	X		X
15	151203	Computer Hardware Technology/Technician	X		X
15	151204	Computer Software Technology/Technician	X		X
15	151299	Computer Engineering Technologies/Technician	X		
15	151301	Drafting and Design Technology/Technician,	X		X
15	151302	CAD/CADD Drafting and/or Design Technology/Technician	X		X
15	151303	Architectural Drafting and Architectural CAD/CADD	X		X
15	151304	Civil Drafting and Civil Engineering CAD/CADD	X		X
15	151305	Electrical/Electronics Drafting and Electrical/Electronics CAD/CADD	X		X
15	151306	Mechanical Drafting and Mechanical Drafting CAD/CADD	X		
15	151399	Drafting/Design Engineering Technologies/Technicians, Other	X		
15	151401	Nuclear Engineering Technology/Technician	X		X
15	151501	Engineering/Industrial Management	X		X
15	151502	Engineering Design	X	X	
15	151503	Packaging Science	X		
15	151599	Engineering-Related Fields, Other	X		

15	1516		Nanotechnology		X	
15		151601	Nanotechnology	X		
15		159999	Engineering Technologies and Engineering-Rel	X		
19	1905		Foods, Nutrition, and Related Services		X	
26	2601		Biology, General		X	
26		260101	Biology/Biological Sciences, General	X		X
26		260102	Biomedical Sciences, General	X		X
26		260202	Biochemistry	X	X	X
26		260203	Biophysics	X	X	X
26		260204	Molecular Biology	X	X	X
26		260205	Molecular Biochemistry	X		X
26		260206	Molecular Biophysics	X		X
26		260207	Structural Biology	X		X
26		260208	Photobiology	X		X
26		260209	Radiation Biology/Radiobiology	X		X
26		260210	Biochemistry and Molecular Biology	X		X
26		260299	Biochemistry, Biophysics and Molecular Biolo	X		
26	2603		Botany/Plant Biology		X	
26		260301	Botany/Plant Biology	X		X
26		260305	Plant Pathology/Phytopathology	X	X	X
26		260307	Plant Physiology	X	X	X
26		260308	Plant Molecular Biology	X		X
26		260399	Botany/Plant Biology, Other	X		

26	2604		Cell/Cellular Biology and Anatomical Sciences		X	
26		260401	Cell/Cellular Biology and Histology	X	X	X
26		260403	Anatomy	X	X	X
26		260404	Developmental Biology and Embryology	X		X
26		260405	Neuroanatomy			X
26		260406	Cell/Cellular and Molecular Biology	X		X
26		260407	Cell Biology and Anatomy	X		X
26		260499	Cell/Cellular Biology and Anatomical Science	X		
26	2605		Microbiological Sciences and Immunology		X	
26		260502	Microbiology, General	X		X
26		260503	Medical Microbiology and Bacteriology	X	X	X
26		260504	Virology	X	X	X
26		260505	Parasitology	X	X	X
26		260506	Mycology	X		X
26		260507	Immunology	X	X	X
26		260508	Microbiology and Immunology	X	X	
26		260599	Microbiological Sciences and Immunology, Oth	X		
26	2607		Zoology/Animal Biology		X	
26		260701	Zoology/Animal Biology	X		X
26		260702	Entomology	X	X	X
26		260707	Animal Physiology	X	X	X

26.		260708	Animal Behavior and Ethology	X		X
26		260709	Wildlife Biology	X		X
26		260799	Zoology/Animal Biology, Other	X		
26		260801	Genetics, General	X	X	X
26		260802	Molecular Genetics	X		X
26		260803	Microbial and Eukaryotic Genetics	X		X
26		260804	Animal Genetics	X	X	X
26		260805	Plant Genetics	X	X	X
26		260806	Human/Medical Genetics	X	X	X
26		260807	Genome Sciences/Genomics	X	X	
26		260899	Genetics, Other	X		
26	2609		Physiology, Pathology and Related Sciences		X	
26		260901	Physiology, General	X	X	X
26		260902	Molecular Physiology	X		X
26		260903	Cell Physiology	X		X
26		260904	Endocrinology	X		X
26		260905	Reproductive Biology	X		X
26		260906	Neurobiology and Neurophysiology			X
26		260907	Cardiovascular Science	X		X
26		260908	Exercise Physiology	X		X
26		260909	Vision Science/Physiological Optics	X		X
26		260910	Pathology/Experimental Pathology	X	X	X
26		260911	Oncology and Cancer Biology	X		X
26		260912	Aerospace Physiology and Medicine	X		

26		260999	Physiology, Pathology, and Related Sciences, Other	X		
26		261001	Pharmacology	X	X	X
26		261002	Molecular Pharmacology	X		X
26		261003	Neuropharmacology	X		X
26		261004	Toxicology	X	X	X
26		261005	Molecular Toxicology	X		X
26		261006	Environmental Toxicology	X		X
26		261007	Pharmacology and Toxicology	X		X
26		261099	Pharmacology and Toxicology, Other	X		
26		261101	Biometry/Biometrics	X	X	X
26.		261102	Biostatistics	X	X	X
26		261103	Bioinformatics	X		X
26		261104	Computational Biology	X	X	
26		261199	Biomathematics, Bioinformatics, and Computational Biology, Other	X		
26		261201	Biotechnology	X	X	X
26	2613		Ecology and Evolutionary Biology		X	
26		261301	Ecology	X	X	X
26		261302	Marine Biology and Biological Oceanography	X	X	X
26		261303	Evolutionary Biology	X	X	X
26		261304	Aquatic Biology/Limnology	X		X
26		261305	Environmental Biology	X		X
26		261306	Population Biology	X		X
26		261307	Conservation Biology	X		X

26		261308	Systematic Biology/Biological Systematics	X		X
26		261309	Epidemiology	X	X	X
26		261310	Ecology and Evolutionary Biology	X		
26		261399	Ecology, Evolution, Systematics and Population Biology, Other	X		
26		261401	Molecular Medicine	X		
26		261501	Neuroscience	X	X	
26		261502	Neuroanatomy	X		
26		261503	Neurobiology and Anatomy	X		
26		261504	Neurobiology and Behavior	X		
26		261599	Neurobiology and Neurosciences, Other	X		
26	2699		Biological and Biomedical Sciences, Other		X	
26		269999	Biological and Biomedical Sciences, Other.	X		
27	2701		Mathematics		X	
27		270101	Mathematics, General	X		X
27		270102	Algebra and Number Theory	X		X
27		270103	Analysis and Functional Analysis	X		X
27		270104	Geometry/Geometric Analysis	X		X
27		270105	Topology and Foundations	X		X
27		270199	Mathematics, Other	X		
27	2703		Applied Mathematics		X	
27		270301	Applied Mathematics, General	X		X

27		270303	Computational Mathematics	X		X
27		270304	Computational and Applied Mathematics	X	X	
27.		270305	Financial Mathematics	X		
27		270306	Mathematical Biology	X	X	
27		270399	Applied Mathematics, Other.	X		
27	2705		Statistics		X	
27		270501	Statistics, General	X		X
27		270502	Mathematical Statistics and Probability	X		X
27		270503	Mathematics and Statistics	X	X	
27		270599	Statistics, Other	X		
27	2799		Mathematics and Statistics, Other		X	
27		279999	Mathematics and Statistics, Other.	X		
28		280501	Air Science/Airpower Studies	X		
28		280502	Air and Space Operational Art and Science	X		
28		280505	Naval Science and Operational Studies	X		
29		290101	Military Technologies			X
29		290201	Intelligence, General	X		
29		290202	Strategic Intelligence	X		
29		290203	Signal/Geospatial Intelligence	X		
29		290204	Command & Control (C3, C4I) Systems and Operations	X		
29		290205	Information Operations/Joint Information Operations	X		

29	290206	Information/Psychological Warfare and Military Media Relations	X
29	290207	Cyber/Electronic Operations and Warfare	X
29	290299	Intelligence, Command Control and Informatio	X
29	290301	Combat Systems Engineering	X
29	290302	Directed Energy Systems	X
29	290303	Engineering Acoustics	X
29	290304	Low-Observables and Stealth Technology	X
29	290305	Space Systems Operations	X
29	290306	Operational Oceanography	X
29	290307	Undersea Warfare	X
29	290399	Military Applied Sciences, Other	X
29	290401	Aerospace Ground Equipment Technology	X
29	290402	Air and Space Operations Technology	X
29	290403	Aircraft Armament Systems Technology	X
29	290404	Explosive Ordinance/Bomb Disposal	X
29	290405	Joint Command/Task Force (C3, C4I) Systems	X
29.	290406	Military Information Systems Technology	X
29	290407	Missile and Space Systems Technology	X
29	290408	Munitions Systems/Ordinance Technology	X

29		290409	Radar Communications and Systems Technology	X	
29		290499	Military Systems and Maintenance Technology	X	
29		299999	Military Technologies and Applied Sciences, Other	X	
30	3001		Biological and Physical Sciences		X
30		300101	Biological and Physical Sciences	X	
30	3006		Systems Science and Theory		X
30		300601	Systems Science and Theory	X	
30	3008		Mathematics and Computer Science		X
30		300801	Mathematics and Computer Science	X	
30	3010		Biopsychology		X
30		301001	Biopsychology	X	
30		301701	Behavioral Sciences	X	
30		301801	Natural Sciences	X	
30		301901	Nutrition Sciences	X	X
30		302501	Cognitive Science	X	
30	3027		Human Biology		X
30		302701	Human Biology	X	
30	3030		Computational Science		X
30		303001	Computational Science	X	
30		303101	Human Computer Interaction	X	
30	3032		Marine Sciences		X
30		303201	Marine Sciences	X	
30		303301	Sustainability Studies	X	

40		400101	Physical Sciences	X		X
40	4002		Astronomy and Astrophysics		X	
40		400201	Astronomy	X		X
40		400202	Astrophysics	X		X
40		400203	Planetary Astronomy and Science	X		X
40		400299	Astronomy and Astrophysics, Other	X		
40		400401	Atmospheric Sciences and Meteorology, General	X		X
40		400402	Atmospheric Chemistry and Climatology	X		X
40		400403	Atmospheric Physics and Dynamics	X		X
40		400404	Meteorology	X		X
40		400499	Atmospheric Sciences and Meteorology, Other	X		
40	4005		Chemistry		X	
40		400501	Chemistry, General	X		X
40		400502	Analytical Chemistry	X		X
40		400503	Inorganic Chemistry	X		X
40.		400504	Organic Chemistry	X		X
40		400506	Physical Chemistry	X		X
40		400507	Polymer Chemistry	X	X	X
40		400508	Chemical Physics	X		X
40		400509	Environmental Chemistry	X	X	
40		400510	Forensic Chemistry	X	X	
40		400511	Theoretical Chemistry	X	X	
40		400599	Chemistry, Other	X		

40	4006		Geological and Earth Sciences/Geosciences		X	
40		400601	Geology/Earth Science, General	X	X	X
40		400602	Geochemistry	X		X
40		400603	Geophysics and Seismology	X		X
40		400604	Paleontology	X		X
40		400605	Hydrology and Water Resources Science	X		X
40		400606	Geochemistry and Petrology	X		X
40		400607	Oceanography, Chemical and Physical	X	X	X
40		400699	Geological and Earth Sciences/Geosciences, Other	X		
40	4008		Physics		X	
40		400801	Physics, General	X		X
40		400802	Atomic/Molecular Physics	X		X
40		400804	Elementary Particle Physics	X		X
40		400805	Plasma and High-Temperature Physics	X		X
40		400806	Nuclear Physics	X		X
40		400807	Optics/Optical Sciences	X	X	X
40		400808	Condensed Matter and Materials Physics	X		X
40		400809	Acoustics	X	X	X
40		400810	Theoretical and Mathematical Physics	X		X
40		400899	Physics, Other	X		
40	4010		Materials Science		X	
40		401001	Materials Science	X		

40		401002	Materials Chemistry	X	X	
40		401099	Materials Sciences, Other	X	X	
40	4018		Materials Engineering		X	
40		409999	Physical Sciences, Other	X	X	
41		410000	Science Technologies/Technicians, General	X		
41		410101	Biology Technician/Biotechnology Laboratory	X		X
41.		410204	Industrial Radiologic Technology/Technician	X		X
41		410205	Nuclear/Nuclear Power Technology/Technician	X		X
41		410299	Nuclear and Industrial Radiologic Technologies/Technicians, Other	X		
41		410301	Chemical Technology/Technician	X		X
41		410303	Chemical Process Technology	X		
41		410399	Physical Science Technologies/Technicians, Other	X		
41		419999	Science Technologies/Technicians, Other	X		
42		422701	Cognitive Psychology and Psycholinguistics	X		
42		422702	Comparative Psychology	X		
42		422703	Developmental and Child Psychology	X		
42		422704	Experimental Psychology	X		
42		422705	Personality Psychology	X		

42	422706	Physiological Psychology/Psychobiology	X	
42	422707	Social Psychology	X	
42	422708	Psychometrics and Quantitative Psychology	X	
42	422709	Psychopharmacology	X	
42	422799	Research and Experimental Psychology, Other	X	
43	430106	Forensic Science and Technology	X	
43	430116	Cyber/Computer Forensics and Counterterrorism	X	
45	450301	Archeology	X	
45	450603	Econometrics and Quantitative Economics	X	
45	450702	Geographic Information Science and Cartography	X	
49	490101	Aeronautics/Aviation/Aerospace Science and Technology, General	X	
51	511002	Cytotechnology/Cytotechnologist	X	
51	511005	Clinical Laboratory Science/Medical Technologist	X	
51	511401	Medical Scientist	X	X
51	512003	Pharmaceutics and Drug Design	X	
51	512004	Medicinal and Pharmaceutical Chemistry	X	
51	512005	Natural Products Chemistry and Pharmacognosy	X	

51	512006	Clinical and Industrial Drug Development.	X		
51	512007	Pharmacoeconomics/Pharmaceutical Economics	X		
51	512009	Industrial and Physical Pharmacy and Cosmeti	X		
51.	512010	Pharmaceutical Sciences	X		
51	512202	Environmental Health	X		
51	512205	Health/Medical Physics	X		
51	512502	Veterinary Anatomy	X		
51	512503	Veterinary Physiology	X		
51	512504	Veterinary Microbiology and Immunobiology	X		
51	512505	Veterinary Pathology and Pathobiology	X		
51	512506	Veterinary Toxicology and Pharmacology	X		
51	512510	Veterinary Preventive Medicine Epidemiology	X		
51	512511	Veterinary Infectious Diseases	X		
51	512706	Medical Informatics	X		
52	521201	Management Information Systems, General		X	
52	521301	Management Science	X	X	
52	521302	Business Statistics	X		
52	521304	Actuarial Science	X	X	X
52	521399	Management Science and Quantitative Methods, Other	X		