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Degree Completion of Underrepresented Minorities Majoring in Mathematics as a Function of Undergraduate Student Programs

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Abstract

Students with disabilities, minorities, and women are underrepresented in the critical demand courses of study in Science, Technology, Engineering, and Mathematics (STEM) undergraduate college enrollment. Institutions of higher education in the United States of America are challenged with a continuous need for undergraduate students to choose and earn a STEM degree. The 2019 annual report of Women, Minorities, and Persons with Disabilities in Science and Engineering indicated these groups continue to be disproportionately underrepresented relative to the U.S. population. In 2014, the U.S. Department of Education reported that upon graduation students studying mathematics in college have higher employment rates and salaries as compared to other college majors. National, federal, state, nonprofit, and private programs aimed at increasing underrepresented minority (URM) undergraduate degree completion and integrating student involvement through delivery of targeted programs are active in trying to meet this demand for STEM college to career. A causal comparative quantitative research design was utilized to analyze the program and degree completion of African American students at colleges and universities seeking an undergraduate degree in mathematics. The researcher used Alexander W. Astin's theory of student involvement (1984) to examine elements of program delivery. The analyses indicate a statistically significant finding for degree completion at the colleges and universities which completed proposals and were awarded funding to initiate a program. The results of the independent samples t-test $p < 0.001$ and a Hedges' g large effect size = 0.8 suggests that colleges and universities advocate to access and implement the Historically Black Colleges and Universities Undergraduate Program to increase URM degree completion integrating as

core the student involvement. Based on the results of the study, the future research of comparable programs for other underrepresented groups, such as students with disabilities and undergraduate majors, such as engineering are recommended.

Keywords: underrepresentation, student involvement, mathematics, minorities

Dedication

I believe that what an individual does with their education should have at the foundation, a goal to continually help mankind. Dr. Martin Luther King, Jr. wrote, “The first question which the priest and the Levite asked was: 'If I stop to help this man, what will happen to me?' But... the good Samaritan reversed the question: 'If I do not stop to help this man, what will happen to him?'” I dedicate this dissertation to my parents whose caring examples in my life of their faith and love for God taught me there is hope amid the many, many, struggles we all face in the world. I am thankful to have been raised by parents who believed in the importance and power of helping others through education. I would also like to thank my sisters and my brothers who motivate me to live my life to the fullest.

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CHAPTER ONE

Introduction

Mathematics is a foundational subject for learning and understanding content in fields of science, technology, engineering, and mathematics (STEM) Vilorio (2014). In 2012 the Report to the President Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics underscored the influence of new technologies and innovations on every sector of the workforce. The report revealed that Americans routinely experience science, technology, engineering, and mathematics in their daily lives without recognizing the connection with STEM education and careers. Further, the report cited the decisions made daily in environments such as grocery stores or a physician's office are in part based on ideas drawn from study and employment in a STEM career field.

Many countries are trying to determine how to provide the best mathematics education for their students (Ker, 2013; Rozeka et al., 2016; Watt, 2005). Research evidence asserts and supports that promoting the relevance of STEM topics for students is effective for increasing student's STEM achievement (Rozeka et al., 2016). Undergraduate college and university research experiences for STEM majors are beneficial in that research experiences develop and build stronger interest in understanding the nature of research (Zhang & Swaid, 2017). A diverse, qualified, and educated STEM workforce is a valuable contributor to the competitiveness of the United States of America in a global economy. Leaders at institutions of higher education (IHE) should be aware and knowledgeable of all programs that support and further the education of students enrolled at their institution. To place the availability of program

opportunities for students at IHE into perspective, as of 2019 the Hispanic Serving Institutions (HSI) have funded and supported 55 standard grants, 11 continuing grants and one cooperative agreement for students (National Science Foundation, 2019). The Research Training Groups in Mathematical Sciences (RTG) have supported 16 standard grants and 83 continuing grants, and the Historically Black Colleges and University Undergraduate Program (HBCU–UP) has supported 291 standard grants, 87 continuing grants, and five cooperative agreement grants (National Science Foundation, 2019). Collectively thousands of STEM program opportunities exist for academia with integrated student involvement.

Many precollege organizations exist in the U.S. to support higher education leadership in the endeavors to assist high school students enrollment and persistence in college and graduating including; QuestBridge College Preparation, (Quest Bridge, 2019), National College Access Network (NCAN, 2019), iMentor Pre-college, (iMentor, 2019), OneGoal Pre-college, (OneGoal, 2019), College Possible (College Possible, 2019) and the National Science Foundation (NSF, 2019).

The historically low number of undergraduate students choosing and progressing to graduation with a STEM major is of increasing concern in higher education (Asunda et al., 2015; Belser et al., 2018; Blake et al., 2013; Chen, 2015; Harackiewicz et al., 2015). Institutions, corporations, and workforce leaders are working toward approaches to increase the nation's number of students majoring and graduating in the STEM fields (Belser et al., 2018; Sriram & Diaz, 2016; Williams et al., 2011). Enhancing diversity in STEM careers remains a constant challenge; and college degree completion for all fields need improvements (Flynn, 2016; Ortiz & Sriram, 2015; Sriram & Diaz, 2016). The

National Science Foundation is one organization among others that have attempted successfully to expand the diversity of student participation in STEM (Williams et al., 2011). Even with the increases in the number of undergraduate and graduate degree majors in the science and engineering fields over the past 20 years, STEM is still experiencing significant underrepresentation (Flynn, 2016; Williams et al., 2011). Approximately 37% of all undergraduate students who major in STEM complete the degree (Chen & Soldner, 2013). The number of STEM graduates' our colleges and universities prepare may influence U.S. advancements at present and for years to come.

Positive attitudes toward mathematics and early interest in STEM are statistically significant predictors of pursuing a STEM major (Hinojosa et al., 2016). The examination of the inadequate number of role models on student success in STEM is one contributing factor to low enrollment and requires insight into how colleges might be able to impact student success (Sriram & Diaz, 2016). Researchers have shown that the college environment does affect the success of students that major in STEM (Sriram & Diaz, 2016). The number of underrepresented minorities (URMs) in STEM in the United States directly influences the nation's capacity to compete, and minority underrepresentation unduly affects the citizens who suffer loss of opportunity (Flynn, 2016; Williams et al., 2011). The current underrepresentation of minorities in STEM programs of study and careers further necessitates a look at this specific course of study. The NSF concluded that the level of progress by underrepresented students in STEM has been "disappointingly modest." (Williams et al., 2011).

The nation needs an innovative and skilled STEM workforce to address the shortages of technology workers in the United States, to increase knowledge, interest, and engagement in STEM. The focused preparations in colleges and universities for STEM and potentially groundbreaking innovations by students in the U.S. for all groups may potentially produce workforce increases and impact U.S. global outcomes.

Research reports that encouraging student involvement in undergraduate research have shown student involvement can lead to increased graduation rates and that a need for students to conduct research in mathematics exist (Kuh, 2006). Philander Smith College implemented a HBCU–Undergraduate Program award in which students conducted a multiphase project to improve performance and retention in STEM. A critical component of the undergraduate program was to improve college preparedness by involvement in a summer bridge STEM program (Zhang & Swaid, 2017). Students that are involved in STEM undergraduate research have demonstrated significant persistence to graduation. The institutional control over the academic quality (Xu, 2015) was the most dominant and persuasive factor in the retention of those STEM students. Xu (2015) further suggests that administrators must develop plans to stimulate and maintain students' interest in STEM. The results of a survey of the Philander Smith College students about their academic and social experiences at the undergraduate institution indicated class level made a significant difference in STEM students' intention to dropout with students in a higher class level more likely to dropout than first-year students; emphasizing the importance of administrators and leaders active role in student persistence to degree completion Astin (1985).

A student's involvement in research-focused opportunities as a part of university programming can provide an array of engagement and academic supports. In these programs students acquire critical thinking and soft skills such as communication skills that are integral in their transition to degree completion and STEM careers. The current percentage of student-conducted mathematics research has not been extensively researched. Student involvement which includes peer and mentor components in mathematics is a significant indicator of interventions and innovations that provides a path to persistence to graduation (Summerskill & Jones, 2013). While the research continues on why students do not persist to graduation, according to (Tinto, 1993; Astin, 1999) the more students are involved in the social and intellectual life of the institution, the more frequently they interact with faculty and other students about the questions of learning, even outside of the classroom environment, the more students are likely to learn. Tinto (1993) stressed that even among the students that persist, the connection with deep faculty interaction, especially outside of the classroom, provides a connection that increases intellectual and social development.

Background of the Problem

"Mathematics preparation is often used as the litmus test for measuring academic interests in STEM due to the fact that mathematics skills are prerequisite to participate in a large number of scientific and technology-based fields, such as economics, physics and engineering." (Hackett & Betz, 1981). Without a strong foundation in mathematics, empowering a path to a STEM degree completion is often plagued with enrolling in freshman year remedial mathematics courses and change to a non-STEM major.

In 2014, a key finding of the Hanover Research Report concluded that institutions of higher education acknowledged challenges and obstacles hindering retention rates; the report exposed that institutions in part are unable to have long-term change due to ineffective allocation of resources. The number of jobs in STEM is expected to increase by millions in the U.S. between 2012 and 2022 (Cromley et al., 2016; Vilorio, 2014). The Bureau of Labor Statistics forecast in 2018 more than 3 million additional STEM job openings will exist (Lacey & Wright, 2009). During a graduate study project in the mathematics department of the University of Georgia Stinson (2004) in "Learning to Teach Elementary Mathematics" viewed mathematics literacy as a "critical filter" and a gatekeeper to economic success. College and university leaders and administrators should be motivated to encourage students to take advantage of the future job market and higher salaries projected for STEM majors entering these fields (Philipp et al., 2016).

Many minority groups are underrepresented among those earning a STEM degree and among employees in STEM fields (Beede et al., 2011). In the year 2042, the U.S. Census Bureau (2008, 2010) estimates that 50% of the total population in the United States will be African American, Asian, and Hispanic (Ortiz & Sriraman, 2015; Williams et al., 2011). Higher education faculty and administrations are urged to continue to be innovative and communicate in a manner that attracts and promotes underrepresented minority student participation in the STEM disciplines. The reasons why underrepresented minorities (URM) are not completing STEM degrees is of national concern (Flynn, 2016; Mau & Mau, 2016). Diversifying the nation's workforce is beneficial to businesses and corporations as diversifying addresses the issues of equity and possible biases in higher education and careers.

Activities (Maher et al., 2013) that lead students to feel they are part of a community are important. Institutions that do not design programs that consider change for student and faculty with appropriately funded programs which include recruitment and retention will either fail at diversity or move diversity forward superficially (Clark, 2011). It is essential to understand that student awareness, involvement and knowledge of these programs that are offered at the undergraduate level are essential to increasing the number and rate that college students complete a STEM major and progress towards career. A major change in colleges and universities over the past 20 years is an increase in academic support programs (Cromley et al., 2016). Mathematics as a major and career for URMs may increase with continued programs connected with recruitment efforts that move students through completion to graduation.

Problem Statement

In the period from the years 2000-2015, computer sciences and mathematics benefited from the billion-dollar federal funding in STEM (National Science Board, 2018). Investment in student involvement and development in their education correlate strongly with economic growth (Schalin, 2010). This investment supports the persistence of a society which benefits all socially and economically. The need for URMs to become undergraduate mathematics majors in the United States demands the existence of innovative and diversity centered programs (Sithole et al., 2017). Student involvement in strategically targeted programs is a necessary component to increase the number of additional college graduates needed in the U.S. STEM field and careers. The ability to determine if a STEM program leading to graduation in mathematics can be replicated is of additional significance to STEM college efforts to enhance STEM major's

representation and career attainment. A gap exists in the literature of the study of undergraduate mathematics majors in STEM programs and student involvement that lead to degree completion for URMs majoring in mathematics.

Purpose

The purpose of the study is to address the gaps in the literature of assessment of college and university undergraduate level STEM programs designed to increase the number of URM student's mathematics degree completion. The existing literature that examined program influences on the mathematics degree completion of the students is limited by the overall, generalized topic of STEM degree completion.

Research Question

In order to address the gaps in the literature the following research question is posed: Is there a significant difference in undergraduate degree completion for African American students majoring in mathematics as measured by degree completion at Historically Black Colleges and Universities that have implemented a HBCU–Undergraduate Program and Historically Black Colleges and Universities that have not implemented a HBCU–Undergraduate Program?

Research Hypothesis

The hypothesis was formulated in response to the research study question and informed by the literature review:

H_0: There is no statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program

and the institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

$H_{\alpha:}$ There is a statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

Significance of the Study

Obstacles in STEM education (Israel, 2017) are interrelated in that first, the students entering college as a STEM major do not complete their degree either by a decision to change the choice of a STEM major or second, a decision to drop out and leave college. The study examined degree completion and implementations of a college and university program under the designation of a Historically Black College and University with a goal to increase the number of undergraduate URMs completing a degree in mathematics. Researchers have not studied the long-term effect of the HBCU-UP program compared to institutions that have not implemented the program for undergraduate mathematics degree completion. The replication and implementation of an effective program may lead to a national surge of increased undergraduate URMs mathematics college graduates that proceed on to further study or careers in mathematics. The levels of success of these programs may also result in useful data for similar programs at colleges and universities to meet their goals of enhancing the number of all groups students seeking an undergraduate degree in STEM. The colleges and universities that have implemented the HBCU–UP enter a conditional agreement of understanding

with the funding agency (National Science Foundation, 2019) to implement the elements of the program strategically with innovation and the intensity to reach the goal of persistence to degree completion. Each program award specifically identifies the specific criteria and conditions that are applicable to the award. Of additional importance is the program once funded are eligible to receive supplemental extensions to the initial program award.

Theoretical Framework

Alexander W. Astin's Theory of Student Involvement

The theoretical framework of Alexander W. Astin's theory of student involvement (1985) which is linked to the Freudian concept cathexis served as the basis for exploring the effectiveness of HBCU STEM student's persistence to complete an undergraduate degree in mathematics. According to Astin, cathexis is the process of investment of mental or emotional energy in a person, object, or idea. Sigmund Freud asserted that people cathect or invest physical and psychological energy into the academic experience with mental and emotional energy (Astin, 1975; 1977; 1984; 1985). Astin's Cooperative Institutional Research Program is an ongoing study of fifteen million students, 250,000 faculty and staff, and 1,800 higher education institutions. Astin surmised that while his theory is focused on students, faculty can be characterized in terms of their degrees of involvement. The physical and psychological energy a student devotes to their academic development are core to his theory of student involvement. Astin's (1984) determined student undergraduate research participation and student-faculty involvement have favorable outcomes for institutions of higher education and are viewed relative to how students change and develop as a result of being involved co-curricularly. Astin's theory

of student involvement (1984) describes the importance of student involvement in college and relates directly to the basic components of the HBCU–Undergraduate Program to strengthen STEM undergraduate education at HBCUs.

Vincent Tinto's Theory of Student Retention

Vincent Tinto's theory of student retention contends that the first-year university experience has an indelible influence on a student's intention to complete their undergraduate studies (Tinto, 1993,1999). Further Tinto (1993) argued students who become a part of their campus academically and socially are more likely to stay in their program of study. Tinto has conducted research and written extensively on higher education, first generation college students, and particularly on student success and the impact of learning communities on student growth and attainment. Based on Tinto's theory the focus on academic and social integration provides activities and services that build up a set of positive interactions between URM students and the academic and social systems of the university illustrated in Figure 3. The professionalization of a student in STEM, characterized as the socialization of a student into science prepares students for the future and teaches them the skills and attitudes of a STEM discipline.

The overall undergraduate student experience provides useful information on approaches for higher education administrators, faculty, and staff to make decisions that are effective in supporting interests of their students that promote a successful graduation outcome. Student development theories are psychological findings whose positions are centered around or are applicable to college students. The importance of these theories in higher education for URMs majoring in historically underrepresented fields cannot be underestimated and enables administrators and staff to understand the complexities

college students encounter towards graduation and is foundational to the HBCU–Undergraduate Program STEM initiatives.

Assumptions

The assumptions present throughout the research are first, the program managers at the colleges and universities implemented their program award with conformity to the required standards and second, researcher bias will be effectively limited throughout the course of the study.

The limitations and delimitations of the study should caution against overgeneralizations made from the results of the research.

Limitations and Delimitations

A limitation of the study is the effect of the, 1) social, financial, and family environment factors that influence all undergraduate students' path to degree completion, 2) the researchers did not observe firsthand the implementation of the program reported in the study, 3) lack of randomization because the groups are already formed, 4) the possibility exists that the groups are not equivalent on one or more important variables.

The delimitations of the study are, 1) the population consisted of only one group of URM students, 2) the researcher chose only to examine the undergraduate mathematics degree completion category of STEM, 3) the unbalanced design may have an increased negative effect of violation of an assumption on the validity of the research. Generalizability of findings is limited to similar populations of students enrolled at the HBCUs with a HBCU–UP and the environment and culture of the individual campuses.

Definition of Programs and Terms

Co-curricular. Programs and learning experiences that compliment what students are learning. Experiences that are connected to the academic curriculum.

Hispanic Serving Institutions (HSI). The HSI Program seeks to enhance the quality of undergraduate STEM education at HSIs and to increase retention and graduation rates of undergraduate students pursuing degrees in science, technology, engineering, and mathematics.

Historically Black Colleges and Universities (HBCU). The Higher Education Act of 1965 defined an HBCU as any historically black college or university that was established prior to 1964. During segregation African Americans were prohibited from enrollment in IHE. HBCUs offer enrollment to all students, regardless of race.

Institutions of Higher Education (IHE). Institutions of higher education include universities, colleges and professional schools that provide preparation in fields such as medicine and institutes of technology.

Historically Black Colleges and Universities Undergraduate Program (HBCU–UP). HBCU–UP provides awards to strengthen STEM undergraduate education and research at HBCUs. The Historically Black Colleges and Universities Undergraduate Program through Targeted Infusion Projects supports the development, implementation, and study of evidence-based innovative models and approaches for improving the preparation and success of HBCU undergraduate students so that they may pursue science, technology, engineering, or mathematics (STEM) graduate programs and/or careers.

Research Training Groups in the Mathematical Sciences (RTG). The long-range goal of the Research Training Groups in the Mathematical Sciences program is to strengthen

the nation's scientific competitiveness by increasing the number of well-prepared U.S. citizens, nationals, and permanent residents who pursue careers in the mathematical sciences. The RTG program supports efforts to improve research training by involving undergraduate students, graduate students, postdoctoral associates, and faculty members in structured research groups centered on a common research theme. Research groups supported by RTG must include vertically-integrated activities that span the entire spectrum of educational levels from undergraduates through postdoctoral associates (National Science Foundation, 2019).

Science, Technology, Engineering and Mathematics (STEM). A term used to group together the academic disciplines of science, technology, engineering, and mathematics.

Undergraduate (UG). For this study, a student enrolled in a baccalaureate awarding degree program.

Underrepresented Minority (URM). An underrepresented minority is someone whose racial or ethnic makeup is from one of the following populations and historically underrepresented in the STEM disciplines: African Americans, Hispanic Americans, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders.

Summary

Astin (1977) maintained the interaction between student ability and stringent admission requirements of an institution did not determine that students persist to degree completion if they attend an institution with students of similar ability. Further, ceaseless educational justifications for ability tracking and selective admission does not answer the question of ability and the impact of student involvement and the integration of programs on degree completion. The research to examine existing program pathways at IHE to

success for students aimed at increasing the number of URM college graduates majoring in mathematics is a crucial element to identify and analyze potential factors for improvement. Diversity in STEM in the undergraduate study and career choice of mathematics is critical in the innovation, research, and development of a nation. Targeted programs rooted in student degree completion if replicable may improve the graduation outcomes in the field of mathematics. Student involvement is an especially important component to the overall college experience.

CHAPTER TWO

Literature Review

The fields of architecture, chemistry, education, and physics all require a critical understanding of mathematics. There are many more career fields that demand the same critical understanding. According to mathematician Roger Perry-Stovall (Sasso, 2008) although students have had a lot of mathematics, their exposure is not very deep. Perry-Stovall sees the effect of cumulative disadvantage every day in the remedial mathematics classes he teaches to predominantly minority and international students in college (Sasso, 2008). In the United States the National Assessment of Education Progress (NAEP) mathematics score range is from 0–300. In 2015, 12th grade high school students scale scores were American Indians/Alaska Native (138/300), Asian/Pacific Islander (170/300), African American (130/300), Caucasian (170/300), and Hispanic (139/300). The overall student score for 12th grade students in 2015 was at the basic level of 62 percent in mathematics. The basic level is defined by NAEP as partial mastery of fundamental skills.

A major element in the implementation of each targeted funded program evaluated in this study is student involvement. All students can participate in each project component, quality extant curricular, workforce and professional development activities such as seminars, public presentations, field experiences, assistantships, and workshops. The research examined data from one program funded by the National Science Foundation, the Historically Black Colleges and Universities Undergraduate Program. In 2018, the provost and chief academic officer, Winston-Salem State University reported that three proposals submitted by Winston-Salem State University leaders resulted in

approval of the proposal to implement the HBCU–UP. The university is a leading producer of URMs graduates in health sciences. On average more than 300 students earn an undergraduate degree in one of the university's health science degree programs each year. In 2018, through innovation and targeted programming to increase diversity in the Silicon Valley, Google partnered with the HBCU–Undergraduate Program at the HBCU institution Howard University to implement a three-month summer program for students studying computer science; students and staff from a total of 11 institutions which included HBCUs and HSIs were involved in the summer partnership. The questions of these relationships, outcomes, and effectiveness of the programs implementation to increase URM participation in STEM was further evident in the NSF supported Improving Undergraduate STEM Education: Hispanic-Serving Institutions Program. The HSI Program consistently recruits students, recruitment being central to program efficacy and support to degree completion shown in Table 1. In Nunez (2017) the program effectiveness is undisputed as 40% of undergraduate degrees in STEM were awarded at HSIs (Harmon, 2102; Hixson, 2009).

Table 1

Program Efficacy Supporting Increasing Minority Groups in STEM Hispanic-Serving Institutions Program Total FTE Enrollment at HSIs

Race/Ethnicity	**Undergraduate**
Hispanic/Latino	1,248,817
All	2,713,354
% Latino:	46%

Note. Enrollment in the Hispanic Serving Institutions Program, National Center for Education Statistics (2017).

In a second institution, and HBCU–UP proposal awardee, Philander Smith College from

the period of 2012-2017, this four-year baccalaureate degree awarding HBCU sought to examine STEM students in Bioinformatics and Human-Computer Interaction. Bioinformatics is the study of the development of methods and software for understanding biological data. Bioinformatics is used for "silicio analyses of biological queries using mathematical and statistical techniques". (Zhang & Swaid, 2017). The STEM project conducted in the colleges Division of Natural and Physical Science; has a mission to improve the number of "Science, Technology, Engineering, and Mathematics graduates". The foci is to develop students who are academically accomplished and equipped with: comprehensive knowledge in the science fields and to succeed in post STEM-related graduate schools; to compete in the STEM workplace, and to contribute to educational and economic advances in local, regional, national and international science and technology initiatives. The multi-phase project implementation aimed to improve students' performance through three actions, 1) preparedness to college life via a summer program, 2) introductory courses and 3) a year-long enhancement to accelerate student learning and motivation by involvement (Zhang & Swaid, 2017). The project infused student involvement through implementations using the core postulates of Astin's Theory of Student involvement (1984) which Astin argued are:

1. Involvement requires an investment of psychosocial and physical energy.
2. Involvement is continuous, and the amount of energy invested varies from student to student.
3. Involvement can be quantitative and qualitative.

4. The amount of student learning and personal development with an educational program benefit from being involved is directly proportional to the extent to which they were involved in that program.
5. The effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement. (Astin, 1984, 1987).

As a result, the institutional policies and practices may be assessed by the degree of involvement they foster in students.

The Philander Smith College project resulted in actions to benefit student's persistence to graduation and included publications of student work. The student experiences, and collaboration and communication skills were all supported by the student exposure throughout the project. (Zhang & Swaid, 2017). In total, the researcher found the HBCU–Undergraduate Program has supported 291 standard grants, 87 continuing grants and 5 cooperative agreements.

STEM Saturation

All four areas of STEM study require a strong foundation in mathematics. Saturation in some STEM majors like biology may be an indicator of a narrow view of specific STEM fields presented to undergraduates. (Belser et al., 2018; Chen, 2015; Sithole, 2017). A lack of adequate mathematic skills and understanding (Sherman et al., 2019) affects the ability to make important educational and career decisions. Undergraduate students' participation in research is widely recognized as a strategy (Belser et al., 2018; Hunter, Lauren & Seymour, 2006) to motivate students to choose a

career in STEM. Engaging students in research projects is frequently cited as an effective way to link faculty research and undergraduate teaching (Prince et al., 2007).

The National Science Foundation was established in 1950 to continue the United States science and technology functioning that emerged during World War II, a time when minorities continued to experience severe oppression and discrimination in the nation. Today the NSF funds research in 50 states in the U.S. and its territories. According to the National Science Foundation approximately 2,000 institutions conduct NSF funded academic works. Since 2010, the HBCU–UP, funded by the NSF has supported colleges and universities in 29 states, and funded approximately 405 awards in STEM to supports students earning an undergraduate degree. NSF allocates 93 percent of the $8 billon budget for grants and awards to support research projects, facilities, and STEM education. Approximately 2,000 academic public institutions in the U.S. have been approved and awarded the funding for program implementation and research. Students and faculty participating in the NSF funded Louis Stokes Alliance for Minority Participation programs are conducting research which has supported more than 650,000 URMs in earning a baccalaureate degree in science or engineering. Twenty–five percent of federally funded academic fundamental research comes from the NSF (By The Numbers, NSF Fact Sheet, 2018). Institution leaders need to maintain the awareness that these programs support the mission of the NSF to develop citizens for a STEM-literate workforce and it does so with commitment and investment in education programs.

In Sheffield et al., (2018) a report from the President's Council of Advisors on Science and Technology noted a large gap in the number of citizens prepared to work in STEM in the U.S. The U.S. Department of Mathematical Sciences supports research in

mathematics and statistics, training through research involvement of the next generation of mathematical scientists, conference and workshops, and a portfolio of national mathematical sciences research institutes. National Science Foundation (2019). Index of Funding Opportunities. *Mathematical Sciences Divisions.* A report by The National Science Board (2018) determined that kindergarten through twelfth–grade mathematics scores have improved modestly at the national level. The board also indicated these scores are lower in mathematics compared to the international achievement levels. The report indicated that "less than half of fourth, eighth, and twelfth grade students achieved a level of proficient, defined as solid academic performance or higher on the NAEP (2015) in mathematics.

Student Retention

Chen (2015), showed that students that persisted in STEM were distinguished by their high achievement in the first–year mathematics courses they took. Proportionally, these students were enrolled in advanced courses such as calculus as compared to the students who left the STEM major. While progress has been made in degree completion in some STEM areas, there is still stagnation and declining by ethnic minority students (Belser et al., 2018). Tinto (1993, 2000, 2006) emphasized the importance of students' integrating the academic and social facets of the college or university (Xu, 2015). The goal of institutional approaches to improve retention, directly connected to student success-must include non-academic and academic factors of student success. (Jorgenson et al., 2018).

Funded by a grant, faculty from nine STEM departments across three colleges within a university system which included mathematics developed a cross-disciplinary

program to strengthen STEM student learning and support utilizing trained undergraduate teaching assistants (Philipp et al., 2016). Simon et al., (2015) asserted there is evidence of an ongoing problem in retention for all students in STEM-based college programs. The past 20 years have shown that students interested in STEM majors dropped by 50% (Chen, 2015). Two of these problems are connected to the students' success or lack in high school preparation and higher order mathematical skills.

Program Elements and Mathematics Degree Completion

It is wholly beneficial for each IHE to complete the necessary steps to take advantage and take seriously the goal of increasing the number of URMs in STEM college programs and career attainment. The steps involve commitment because the grants and funding are awarded competitively to support research and education. Many of the programs have a specific goal to increase the nation's number of students graduating with a mathematics degree include local, state, and federal agencies. Integrated program approaches to STEM are vast and challenging and the information can be inaccessible for undergraduate students. Effective STEM programs for students that major in mathematics can move the next generation to solve global problems by applying approaches that stoke collaboration and imagination. For instance, the summer activities of the Mathematical Modeling in Environmental, Biological and Other Sciences Program conducted by students combines learning scientific, mathematical, and data analytics with project work and is supported by faculty mentors.

Even with these programs, the low rate that college students complete a STEM major is of global and national concern Graham et al., (2012). In the year 2042, it is estimated by the U.S. Census Bureau (2008) that 50% of the total population in the

United States will be Hispanic, Asian and African American (Graham et al., 2012; Ortiz & Sriraman, 2015; Williams et al., 2011). Higher education faculty and administration must begin and continue to enact innovation and communication that attracts and vigorously promotes underrepresented student participation in the STEM disciplines. The reasons why women and underrepresented minorities are not completing STEM degrees is of national concern (Flynn, 2016). In 2019, at the National Council of Teachers of Mathematics Annual Meeting & National Exposition speaker and author Vilson (2014) addressed the deleterious and challenging impact of equity and mathematics performance at the annual mathematics conference. National Council of Teachers of Mathematics (2019).

Programs, such as the HBCU–UP seek to enhance the overall quality of undergraduate STEM education. The goal, for example of the HSI Program established due to the Consolidated Appropriations Act of 2017, provided funding for Hispanic students with the same goal, to increase the graduation rates of URM students pursuing a degree in STEM. The HSI Program is a model that embodies the need to build capacity by the actions of leaders of higher education institutions to implement comparable programs. The HSI Program has two tracks, 1) Building Capacity and 2) HSIs New to NSF which award funding respectively between $2,500,000 for up to 5 years and is open to all eligible institutions; or $300,000 for up to 3 years and is open to eligible institutions that have never received funding in parameters that are defined. National Science Foundation (2019). Index of Funding Opportunities (2019). Hispanic Serving Institutions (HSI).

The multiple tracks of the HBCU–Undergraduate Program are also implemented in college and universities that have developed partnerships with a lead institution of the program award. The Targeted Infusion Projects provide support to achieve a short-term, well-defined goal for improving the quality of undergraduate STEM education at HBCUs. Broadening Participation Research in STEM Education projects provide support for the creation and study of new theory–driven models related to the success of underrepresented undergraduate groups in STEM. Implementation Projects support the design, implement, study, and assess comprehensive institutional efforts for increasing the number of students receiving undergraduate degrees in STEM. The NSF, HBCU–Undergraduate Program strengthens the preparation of the students by enhancing the quality of the research. HBCU–Undergraduate Program provides multiple funding opportunities for undergraduate students that focuses on educational developments National Science Foundation, Index of Funding Opportunities (2019).

Disciplines supported by HBCU–Undergraduate Program include mathematical sciences. In 2017, the meeting of Building Capacity at Hispanic Serving Institutions Subcommittee of the Advisory Committee of the Directorate for Education and Human Resources reported leaders recognized in the 1980s low amounts of resources were allocated to students and as a result HSIs were formally recognized and designated IHE for supports. Greater than half of all Latinx undergraduates, approximately 64 percent are enrolled in institutions identified as HSIs. To this extent Astin's (1985) theory of student involvement fifth postulate; the effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement

necessitates continued engagement in STEM campus events, recruitment and elements of programs like recruitment and summer bridge programs.

Motivating and Enriching URMs to Graduation

The NSF affirms that in order to meet the demands for STEM talent, higher education needs more rapid gains in successful degree completion in STEM for URM populations. It further declares the HBCU–Undergraduate Program is designed to enhance undergraduate STEM education as a means to broaden participation in the nation's STEM workforce. Additionally, the HBCU–Undergraduate Program has identified as a priority, recruitment, and retention, principally retention in STEM fields during and after the freshman year. In order to capitalize on the benefits of the HBCU–Undergraduate Program institutions have to be prepared to complete the proposals that support the HBCU–Undergraduate Program efforts to educate undergraduate students, in all STEM areas, and not sacrificing undergraduate degree completion in mathematics, computational and data-enabled science.

Co-curricular Experiences

Maltby (2016) found that co-curricular interventions contributed positively to the persistence of URMs by contributing to a sense of belonging and strengthening the students' science self-identity. Co-curricular student involvement is an extension of the courses or academic programs and are connected to academic learning. A learning experience is any interaction, program, course, or other experience in which learning takes place. A learning experience may take place in a traditional academic setting (classrooms) or nontraditional setting (research settings). King & Anderson suggested (2014) co-curricular activities are not restrictive and all serve learning whether it is in a

laboratory or the library. Adding that the "opportunities to develop outside the classroom, targeted programming offers a number of advantages." The coordinated efforts of programs with student experiences can provide growth and learning.

College and University STEM Organizations

King & Anderson (2014) and Astin (1985) stress a freshman-year curriculum that has prerequisites to success in the classroom, must include prerequisites to success outside of the classroom. In an examination of the relationship between mathematics club participation and mathematics achievement Gottfried & Williams (2013) found a positive relationship and academic performance, as measured by grade point average. Students who become involved with faculty and other students cultivate and form the characteristics that embody the importance of involvement with others. This involvement may lead to an increased probability that students will continue to be involved in the future according to Tinto (1993). Subsequently, a STEM club student involvement has the potential to make students committed on an ongoing basis. This ongoing involvement could impact schooling success, future college STEM participation, and STEM career efficacy. (Stolle-McAllister, 2011; Xu, 2015).

STEM and Summer Bridge

The HBCU–Undergraduate Program awards stipends to students that conduct and participate in summer research. The emergence of literature researching summer bridge is based in the theories of attrition and persistence (Astin, 1993b; Tinto, 1993). Overall summer bridge is important for all students, and provides new learning, especially for underrepresented minority STEM students (Stolle-McAllister, 2011; Israel, 2017). Participation in summer bridge aides' students to become comfortable in their roles as

scientists, supporting their transition into roles as college STEM students. Some colleges and universities offer college credit in mathematics courses in the summer bridge. A study of summer bridge effectiveness showed improvement of fall enrollment and increased student potential to pass and attempt college courses that lead to student success. The findings were that students in the program and control groups tried at least one mathematics course at comparable rates; additionally, these summer bridge students attempted the first college-level mathematics course at substantially higher rate than the students in the control group (Wathington et al., 2011). The Tuskegee University Research Experience for Undergraduates site is focused on training undergraduate minority students for a 10–week period each summer in the fields of nano-biomaterials science and engineering under the mentorship of interdisciplinary research faculty and their doctoral students. Israel (2017) recommends policy initiatives based on the success of bridge programs which increase STEM persistence, pass rates for mathematics courses and STEM graduation rates for URMs. Capitalizing on the opportunities, Delaware State University also submitted a proposal and was awarded the funding for a HBCU–Undergraduate Program for their students. Bir & Myrick (2015) concluded the challenges African American students encounter in higher education, such as lack of role models and peer groups with the same goals produce successful outcomes in a "short-term, highly structured summer bridge program at HBCUs because the students met the bridge's goal of passing initial courses which included mathematics. This success also resulted in admission to the institution after the summer bridge program was completed.

Campus-wide STEM Skills Day

A day or week dedicated to STEM activities are common on college and university campuses. College students beginning postsecondary education without the skills to succeed academically are faced with a "readiness gap," defined as a difference between students' academic skills upon enrolling in college and the skills they need to be ready for college-level studies. It is estimated that 75 percent of incoming students at the colleges level struggle with this readiness gap, and many of them must take developmental courses before they can begin to earn credits toward a degree or certificate, incurring additional financial indebtedness and delaying or eliminating the ability to graduate.

STEM Mentoring

Mentoring is a key component of a program administration, according to Lisberg & Woods (2018) students with mentors have higher retention and academic performance. Students' experiences or perceptions of their college or university impact their decision to stay or leave a STEM major (Chen, 2015). Low support from the institution and too few role models are examples of the factors leading to the decision. Johnson C. Smith University leaders in North Carolina implemented a Case Manager Program for their Freshman Learning Community. One of the multiple goals of the program was to improve graduation rates. (Summerskill & Jones, 2013). Faculty at the university found the case managers to be the most beneficial service of the administrative services available. Ensuring each student has a mentor has shown to be an indicator to graduation in a major (Summerskill & Jones, 2013). Targeting these mathematics majors was critically important to ensuring that URMs graduate. The mentors provided support for

students determined to be at-risk and provided the element of caring and an identified characteristic demonstrated in the mentors aimed at promoting educational resilience.

STEM Bridge to Doctorate

The prospect of earning a doctorate degree has a substantial influence on persistence for mathematics majors to graduation. The opportunity for continued support through a pathway to a doctorate are collaborative efforts in higher education that aim to increase the quality and quantity of URMs matriculating to completion of the doctoral degree in STEM. A bridge to doctorate program also offers cohort models that include developing leadership skills that can benefit a student upon completion. (Index of Funding Opportunities. Scholarships in Science, Technology, Engineering and Mathematics, 2019). Israel (2017) reinforced that bridge programs at the precollege level have resulted in improving a student's persistence in STEM to graduation. Few studies are available on institutional leadership investigation into mathematics persistence to degree completion, despite the importance of educational leadership in most countries, studies tend to focus on the professional performance of teacher of mathematics as opposed to leadership (Garcia-Martinez et al., (2018).

STEM Internships

Real-world and practical experience is a vital component of student development in higher education. Variability in internships experiences were found to be inconsequential as long as the experiences were educational. Post-secondary institutions understand the positive impact of internships on student learning by incorporating internships into the student academic experiences (Kuh, 2008; Stirling et al., 2017). The

impact of internships still has a wide breadth for improvement which can provide further innovation and open doors for persistence to graduation.

STEM Research Programs

Mathematics programs provide support and opportunities for a large number of student undergraduate experiences. Students have access and opportunities to present research at annual regional and national conferences. The conference environment is essential in that it provides informational seminars and other involvement, which equip students with knowledge to take back and discuss with an academic advisor or peers at their institutions. In a study to connect undergraduate research participation to graduate school ability Gilmore et al., (2015) reported a strengthened and increased performance in critical STEM research skills attributed to undergraduate research. Forty-seven out of 58 participants in the Gilmore et al., (2015) study conducted undergraduate research. In the analysis of preproposal and postproposal performance the students with undergraduate research experience scored higher overall than students without undergraduate research experience. Performance in areas such as experimental design, data presentation, and discussion were reported as having a statistical significance.

Research Training Groups in Mathematical Sciences

In 2004, the first NSF Research Training Groups in the Mathematical Sciences program award was funded to strengthen scientific competitiveness in the U.S. and raise the overall number of citizens who pursue careers in the mathematical sciences. URMs participation and the faculty in the HBCU–Undergraduate Program have an opportunity to improve the diversity of STEM students through the RTG Program. Research groups that receive support from the RTG are required to “vertically-integrate” activities across

the educational life cycle which include cohorts of undergraduate through doctoral students and faculty. A project at HBCU, Alabama A&M University sought to improve undergraduate students' preparation and success towards a career in nuclear engineering or an advanced degree by focusing on active learning strategies. Undergraduate students were involved in the project as researchers. The project objectives were: 1) enhance student learning and, 2) technical skills by integrating active learning units into nuclear engineering courses, 3) study the efficacy of the active learning model and units on nuclear engineering skill-set development and 4) improve retention and graduation rates in nuclear engineering programs, thus increasing the participation of women and underrepresented minorities in the nuclear engineering workforce. The project was guided by formative and summative evaluations. This program award reflected NSF's statutory mission and was deemed worthy of support through evaluation using the foundation's intellectual merit and broader impacts review criteria.

Recruitment of STEM Majors

The HBCU–Undergraduate Program is committed to the recruitment of students in STEM as a degree choice. The Davari et al., (2017) research example of recruitment efforts prior to enrollment that continue throughout the college experience resulted in extensive success in recruitment and enrollment. See Table 2 from Davari et al., (2017). STEM recruitment executed in program delivery is a critical element to increase enrollment and the improvement results have been substantial. Total enrollment and transfer enrollment student increased after implementation of the strategies for STEM recruitment in Table 3 Domene et al., (2011) recommended connecting career related outcomes to academic programs to encourage persistence. As a result, students majoring

in STEM fields may already be aware of the connection to career paths thus increasing their academic motivation. In the institutions Bridge to STEM Careers, three funded project activities successfully recruited students into focused STEM programs each year.

Table 2 Total Enrollment Data: Tested Strategies for Recruiting and Retention of STEM Majors

Program	**Enrollment in Spring 2013**	**Enrollment in Spring 2017**
Computer Engineering	37	146
Computer Information Systems	58	98
Computer Science	51	185
Information Technology	51	74
Mathematical Sciences	51	127
Physics	15	38
Total	**283**	**667**

Note. Davari, S., Perkins-Hall, S., Abeysekera, K. (2017). Department of Computing Sciences, University of Houston-Clear Lake. Tested strategies for recruitment and retention of STEM majors.

Table 3 Transfer Enrollment Data: Tested Strategies for Recruiting and Retention of STEM Majors

Program	**Enrollment in Spring 2013**	**Enrollment in Spring 2017**
Computer Engineering	21	54
Computer Information Systems	26	42
Computer Science	33	73
Information Technology	23	46
Mathematical Sciences	30	51
Physics	10	15
Total	**153**	**281**

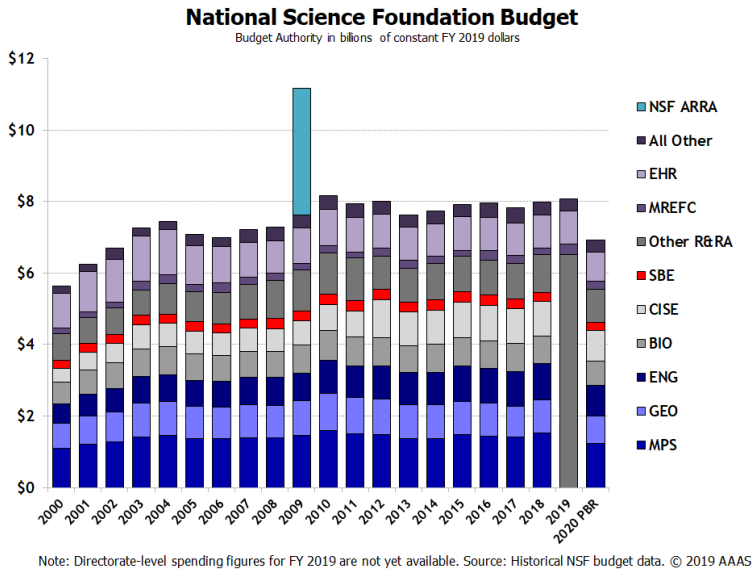
Note: Davari, S., Perkins-Hall, S., Abeysekera, K. (2017). Department of Computing Sciences, University of Houston-Clear Lake. Tested strategies for recruitment and retention of STEM majors.

Institution Financial Support for Programs

Institutions with limited budgets or searching for funding have a wide range of opportunity within the annual budget of the NSF. Since the inception of the HBCU-Undergraduate Program the institutions that submitted proposal for funding have received

approximately $154 million dollars. Funding for the program proposals does exist as indicated in Appendix A and B. NSF funds are available to all 50 states in the U.S. through awards based on proposal submissions awarded in the form of grants to IHE and other types of institutions (National Science Foundation, 2019). If IHE need financial support for program implementation the NSF offers sufficient opportunities for program funding, however the leadership must assemble a committed team to write or respond to the proposals request the funding and available proposal supports. In 2019, mathematical and physical sciences funding encompassed a proposed projection of approximately $1.5 billion dollars illustrated in Figure 1, in supporting the importance of mathematics and the influences of mathematical sciences on daily life as fundamental and pervasive. (Fatima, n.d.). Every element illustrated in Table 4 involves mathematical sciences; American Recovery and Reinvestment Act, Education and Human Resources, Managing the Major Research Equipment and Facilities Construction, Research and Related Activities, Social, Behavioral and Economic Sciences, Computer and Information Science and Engineering, Biological Sciences, Engineering, and Geoscience are positioned to receive substantial funding based on the proposed projections , see Figure 1 (American Association for the Advancement of Science, 2019).

Figure 1 National Science Foundation Budget Authority



In D'Souza et al., (2015) and Eagan et al., (2019) findings suggested that federal and state grants that included NSF awards support the educational infrastructure of IHE and increase diverse participation in the STEM fields. Gandara & Maxwell-Jolly (1999) concluded it is necessary to create a "safe place" for students who need the psychological and social support of other students from like backgrounds, who have experienced similar struggles which may include financial obstacles.

Historically Black Colleges and Universities Undergraduate Program

The HBCU–Undergraduate Program is awarded to Institutions of Higher Educations to strengthen STEM undergraduate education and began in 1998. HBCU–Undergraduate Program has funded a total of 85 of the HBCUs. Goals of the HBCU–Undergraduate Program include strengthening STEM undergraduate education and research at HBCUs which in turn strengthens our nation. Additionally, the NSFs HBCU–Undergraduate Program supports students' persistence to complete their degree in what it defines as a timely manner which supports financial advocacy for its students. Program

participation from two-year institutions is further encouraged as these students may continue on to complete a baccalaureate degree. The HBCU–Undergraduate Program leadership recognizes that financial aid and support while important can't increase graduation in STEM, it seeks to advance the adaption, implementation, and study of effective evidence-based curricular and co-curricular activities that support recruitment, transfer, student success and graduation in STEM among the other programming attributes. The current scope of the HBCU–Undergraduate Program encompasses 385 standard awards, 55 continuing awards, a cooperative agreement and contract interagency agreement substantiating the existence of opportunities for IHE. The magnitude of the HBCU–Undergraduate Program and its goals are therefore critical to URMs and the college journey for student involvement and STEM degree seekers.

Accountability for the HBCU–Undergraduate Program implementation is assured through project management which consist of a management plan that ensures the activities and reporting audits required are implemented on time and within the budget.

Findings of the National Evaluation of HBCU-Undergraduate Program

In 2010 the Urban Institute completed an evaluation of the HBCU–Undergraduate Program (Clewell et al., 2010). The institute examined the social, economic, and governance problems in the U.S. and evaluates the public and private measures to mitigate them. The evaluation of the HBCU–Undergraduate Program measured the program outcome of the education and retention of URM students in STEM. The evaluation of the program sought to understand the programs implementation and outcomes. Two key findings of the report were 1) the HBCU–Undergraduate Program yielded an intervention model characterized by a cores set of strategies

associated with successful student outcomes which included summer bridge programs and 2) HBCU–UP graduates outperformed national samples of STEM undergraduate degree holders in degree completion. Compared to African American STEM graduates nationally, HBCU–Undergraduate Program graduates (mostly African Americans) were more likely to be employed in STEM, and more likely to be employed in STEM and hold a graduate degree in STEM. This suggests that HBCU–Undergraduate Program graduates are making a double contribution to the STEM workforce: they are more likely to enter the STEM workforce than African Americans nationally and are also more likely to bring higher levels of academic training than STEM baccalaureate degree holders nationally.

The literature supports that institutions must be proactive in seeking programs that support STEM degree choice and lead to degree completion, see Table 4. Faculty at institutions that implemented the HBCU–Undergraduate Program held that their institutional reward systems increased expectations that faculty seek and obtain research grants. At the institutions implementing the HBCU–Undergraduate Program, STEM courses were revised to reflect national trends for effective pedagogy (Clewell et al., 2010). See Table 4.

Table 4

2010 Findings of the National Evaluation of the HBCU–Undergraduate Program											
HBCU–Undergraduate Program Evaluation: Data Collection Summary											
				Primary Data Sources		Secondary Data Sources					
				HBCU–Undergraduate Program Survey (%)		National Comparisons Survey					
						Graduates	Faculty				
HBCU–UP Cohort	Academic Years	Institutions Included	Document Review	Telephone Interviews (%)	Case Studies	Graduates	Faculty	Course Revisions	SESTAT 06	NSOPF 99	NSOPF 04
2	1999-2004	13	Yes	92.9	3	64.9	80.0	72.2	X	X	X
3	2001-2006	5	Yes	100.0	1						
4	2002-2007	5	Yes	100.0							
5	2002-2008	6	Yes	100.0							

Source: Urban Institute HBCU–UP Graduate Survey (2010).
Notes: A number provides a count of participants in the given collection. A percentage indicates the response rate achieved for the given data collection. The early 1998 awards (cohort 1) were excluded, as these were pilot cases that later received grants and entered the evaluation through subsequent cohorts. The

2003 awards (cohort 5) were excluded because they had just been funded and, therefore, insufficient time had elapsed to observe outcomes.

Through an assessment the HBCU–Undergraduate Program graduates were compared to national samples. The findings resulted in five recommendations. Of significance is that the institutions have enormous latitude to determine how to construct strategies that address their long-term goals. The two components of the evaluation were: strategies used by the HBCU–Undergraduate Program and a summative element that was used to measure student, faculty, and institutional outcomes. The questions used in the evaluation components were, 1) How are the HBCU–UP projects being implemented 2) What components or strategies have facilitated attainment of goals, 3) What mix of strategies optimized linkages among activities and resources? Of the population sampled an 80 percent response rate was obtained (see Table 4a).

Table 4a Findings of the National Evaluation of HBCU–Undergraduate Program

The institutional reward system has increased expectations that faculty seek and obtain research grants.	Strongly agree 34.2	Somewhat agree 28.5	Somewhat disagree 22.3	Strongly disagree 15.1
STEM courses have been revised to reflect national trends for effective pedagogy.	Strongly agree 26.7	Somewhat agree 45.2	Somewhat disagree 18.8	Strongly disagree 9.3

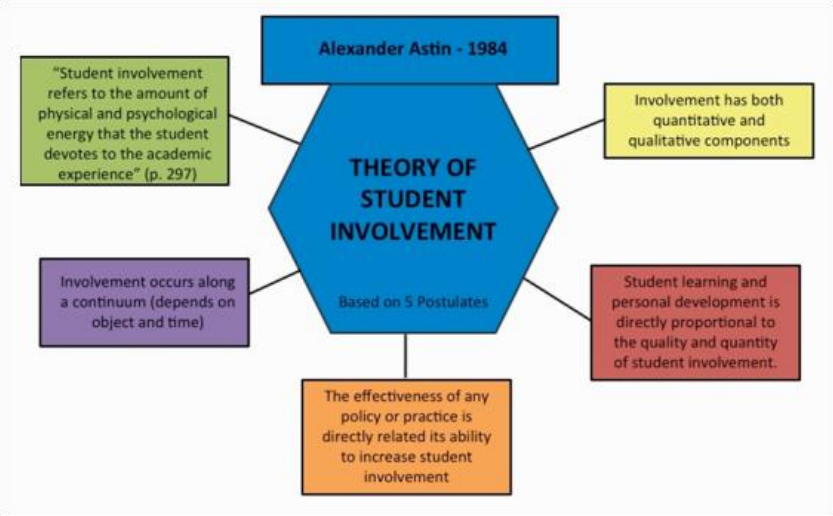
Note: Faculty Perceptions of the HBCU–Undergraduate Program (percent), Clewell et al., (2010).

Critical findings of Clewell et al., (2010) were that, 1) the HBCU–Undergraduate Program grantees succeeded in building an institutional infrastructure supportive of STEM majors, 2) the HBCU–Undergraduate Program yielded an intervention model characterized by a core set of strategies associated with successful student outcomes to include summer bridge programs and recommended, 3) replication of the core model components in proposals from HBCU–Undergraduate Program awarded applicants. The

HBCU–Undergraduate Program core model is considered successful based on student satisfaction for the institutions and to the degree they had implemented the program with and integration into the academic environment supportive of Astin's theory of student involvement (Astin, 1984).

The theory has three central elements: inputs, environments, and outcomes. See Figure 2.

Figure 2. Astin's Theory of Student Involvement



Note. Alexander W. Astin's Theory of Student Involvement illustrating the five postulates of the theory. Stock (Image Created by Whitney Jones Archer, Alexander W. Astin, 1984).

Astin's theory of student involvement (1985) has direct implications for talent development in that students learn by becoming involved. The theory puts into context environmental influences of student development. The involvement applies equally to students and to faculty. The theory on involvement can be used by researchers as a guide in the attempts to design more effective learning environments. The elements of input are demographics, background, and previous experiences. A core concept of the theory is the student's environment which represents and is defined as all the experiences a student would have during college. According to Astin's theory the student outcomes are a

student's characteristics, knowledge, attitudes, beliefs, and values that exist after a student has graduated college. (Astin, 1999; Tinto, 1993). Astin's frustration with the lack of efficacy in prioritizing the outcomes measured such as achievement measures, GPAs and standardized testing revealed that the effectiveness of an educational policy or practice directly affects that policy or practice ability to increase student involvement. Further, according to Astin (1999), a trait of a highly involved student includes, the amount of time a student spends on campus. Additionally, it is what the student does and how the student behaves that defines and identifies involvement.

Astin (1985) points out in his theory that there are desirable outcomes for institutions of higher education including facilitating student co-curricular involvement. Outcomes impacts career as they are the characteristics, knowledge, attitudes, beliefs, and values that remain after a student has completed their college studies. The assumptions of involvement are psychosocial and physical energy and the involvement is described as continuous, qualitative, or quantitative. Astin (1985) stated "What a student gains from being involved is directly proportional to the extent to which they were involved in quality or quantity." Additionally, academic performance is positively correlated with the elements of student involvement.

Student involvement in co-curricular or high impact activities Kuh (2008) for instance, student culminating experience in organizations and leadership positions has a positive correlation with retention and academics. According to Kuh (2008) a positive relationship exists at institutions with students that persist to complete their degree. Involvement and importance expressed by faculty corresponded to a 20% increase in student involvement, Kuh (2008). These positive aspects of co-curricular student

involvement have led to universities encouraging students to become involved. Astin's Postulates 1, 3 and 5 are widely demonstrated in the enrichment and motivation of each of the programs goal leading to student degree completion (Astin, 1984).

Alexander Astin's Five Basic Postulates

The theoretical framework provided by Alexander Astin (1984) can be explained through his five basic positions in Astin's theory of student involvement. See Figure 2.

1. Involvement refers to the investment of physical and psychological energy in various "objects." The objects may be highly generalized (the student experience) or highly specific (preparing for a chemistry examination).
2. Regardless of its object, involvement occurs along a continuum. Different students' manifest different degrees of involvement in a given object, and the same student manifests different degrees on involvement in different objects at different times.
3. Involvement has both quantitative and qualitative features. The extent of student's involvement in, say, academic work can be measured quantitatively (how many hours the student spends studying) and qualitatively (does the student review and comprehend reading assignments, or does the student simply stare at the textbook and daydream?).
4. The amount of student learning and personal development associated with any educational program is directly proportional to the quality and quantity of student involvement in that program.
5. The effectiveness of any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement.

Astin (1984) defines the last two postulates number 4 and 5 as the "key education postulates" because they suggest valuable information and give insight to designing more effective educational programs for students. Astin's student involvement theory can be further applied to many pedagogical practices to affect student learning outcomes redirecting attention to student motivation and behaviors.

Each individual measures of student involvement with faculty produce patterns of correlations with student outcomes (Astin, 1993b). A composite measure of student-faculty interaction comprised of elements such as working on a professor's research projects have significant positive correlations with every academic attainment outcome. In a study conducted by Astin (1993b) Astin concluded that variations in student faculty contact within any given institutional environment can have positive implications for students. A student's cognitive, affective, psychological, and behavior are affected. Students tend to change their academic plans in the direction of the dominant orientation of their peer group. The peer interactions on the programs in the study are another core element that may lead to selection of mathematics as a degree choice and pursuit of degree completion.

Involving Students and Developing Talent

Astin (1985) points out that there are practical strategies for increasing students' involvement in college and that institutions can stimulate participation through instruction, student life and feedback. He asserts practices for heightening students' involvement are beneficial. The practice of targeted use of resources are modeled throughout the HBCU–Undergraduate Program. Institutions frontloading their actions on behalf of student retention especially in the first year is a strategic leverage point Tinto

(1987). These actions where resources are critically applied provide future benefits in learning and retention for students. The effective actions include student orientation transition courses and first year symposiums, summer bridge programs learning communities, intrusive advising, tutoring/peer tutoring, study groups, supplemental instruction, mentoring, study skills seminars, and student-faculty research (Kuh et al., 2006). The impact of student involvement in targeted educational activities are meant to provide consistency and focus. Each of these actions are infused into the proposals submitted for review at the institutions and awarded the HBCU–Undergraduate Program.

Use of Resources and Student Involvement

Astin (1977) maintained measures of student involvement are connected with major changes when students begin in college and changes after college entry may be attributed to the college experience-a central aspect of the HBCU–Undergraduate Program, rather than maturation. Student involvement underlines an existing deficit in focus which institutions invest the majority amount of resources for instruction primarily in graduate and professional studies and the next largest amount in upper-division undergraduate students. Further, the smallest amount of resources goes to lower-division UGs, heightening the impracticality of not correctly focusing involvement and the problems where they need is the greatest continues. The majority of students that do not complete the baccalaureate degree leave college in the first or second year of college. (Astin 1993b, Tinto 1993, 1997). Additionally, Astin recommends that institutions devote the most effort and resources to the freshman and sophomore student populations.

Student-Faculty Contact

Research asserts student involvement is best when personal contact with faculty and students is maximized (Astin, 1985). Faculty mentorship is a fundamental element of the HBCU–Undergraduate Program. According to Astin (1985, 1993b) practices at institutions are restrictive for student involvement in that classes are large and lecture style, office hours are limited and advising is conducted by nonfaculty personnel.

Student Advising

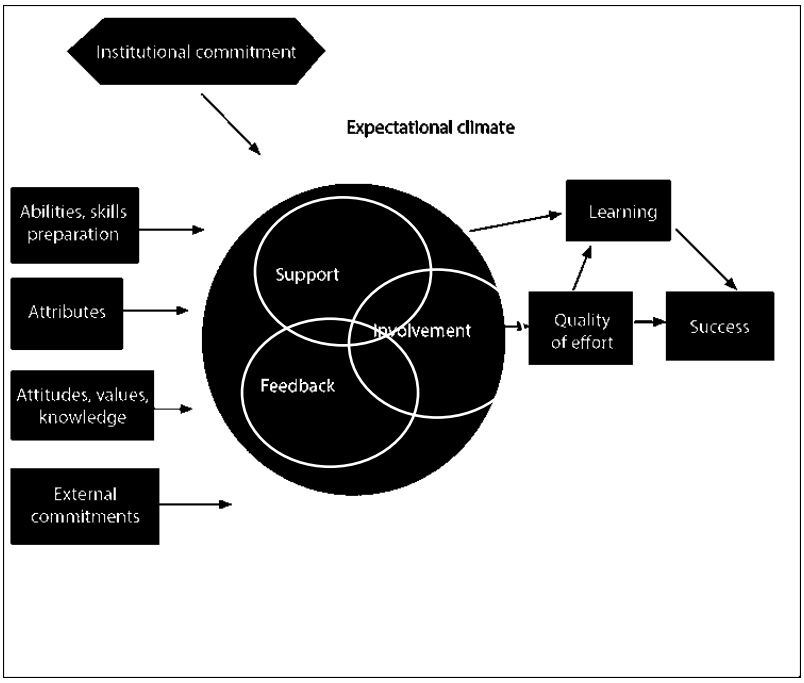
According to Tinto (1987, 1993, 2012) and Astin (1984, 1993b) **t**he use of special support programs is designed to increase a student's persistence to degree completion. As indicated the HBCU–Undergraduate Program promotes student conference attendance, summer bridges and internships in addition to multiple other student involvement practices. As such, the HBCU–UP promotes the use of special advising for the students participating in the program. (National Science Foundation, 2019). Student life and activities outside of the classroom can be used to increase student involvement (Astin, 1977, 1984; Tinto, 1982, 2004). Astin asserted student advising that does not include faculty guidance distances the student from faculty and is not optimal for student involvement. Additionally, this absence of guidance causes faculty to be less able to identify with the student's problems in deciding on a major and the specific courses to take.

According to Tinto (2007) institutions have not been able to translate existing knowledge about student retention into actions that produced marked gains to persistence and degree completion. He further asserted that program implementation warrants continued research if institutions want students to succeed. Student retention in the past

was blurred in a lack of complexities and relegated to the responsibility of the department of student affairs. Therefore, an understanding of how retention as a process differs in different institutional setting is needed. Tinto (2007) cited the importance of classroom involvement and student events outside of the classroom. Understanding and directing intentional changes which may result in the further study of student retention makes clear the importance of student involvement and that retention matters most during the first year of college. Central to the core of student retention remains the shaping of institutional practice, and a substantive and actionable focus on low-income students. Tinto asserted that an increase in social and academic integration will increase students' commitment to their goals and the institution.

Nothing is more critical to student retention than academic support Tinto (2012). Studies of effective institutions revealed they institute systems with early warning that enable them to act in enough time to make a difference in their students' success and persistence to degree completion (Tinto, 2012). Astin (1984) also informs us that institution leaders must recognize that virtually every institutional policy and practice, including advising can affect the way students spend their time and efforts in academic pursuits.

Figure 3
Student Integration Model



Note 2. The figure highlights involvement in the core of the Vincent Tinto Student Integration Model (1975).

Summary

The HBCU–Undergraduate Program provides an extensive field of opportunities at every higher education level. There are approximately 40,000 submissions for HBCU-UP proposal each year that include education and training projects and research. Institutions to be successful at gaining support must, in making decisions for solicitation funding analyze the characteristics of successful HBCU–UP projects in completing the work to target the cooperative agreements and funding to target and complete these submissions to impact the number of URMs obtaining an undergraduate degree in mathematics, Clewell et al., (2010). Current research that examines the targeted funded HBCU–UP and the integration of student involvement is limited. A dedication to the sustainment of relationships from high school to completion of an undergraduate degree

in mathematics for URMs may be improved if leaders at IHE make time for students to learn and experiment with mathematics topics and research. A review of the literature considered a spectrum of undergraduate programs for students majoring in mathematics funded and supported by the NSF. The results of a longitudinal study (Astin, 1977, 1999) of students that chose to drop out of college showed that the factors which contributed to students persisting suggested involvement, where those that contributed to the students dropping out inferred lack of involvement. The theoretical framework of Astin's (1984) Theory of Student Involvement and Tinto's (2006) Theory of Student Retention for the analyses of underrepresentation in the field of mathematics-threatens the potential and excellence of the U.S. as it continues to lack undergraduate URMs majoring in STEM to meet the demands for the nation's workforce.

CHAPTER THREE

Research Design and Methodology

The research design and methodology were established to examine the targeted programs and student involvement which supported URM degree completion for undergraduate mathematics STEM majors. Underrepresented minority groups, persons with disabilities and women are underrepresented in STEM National Science Foundation. National Center for Science and Engineering Statistics (2019) Women, Minorites, and Persons with Disabilities in Science and Engineering. Overall, their representation in STEM education and employment is smaller than their representation in the U.S. population (National Science Foundation. National Center for Science and Engineering Statistics, 2019).

Student involvement is a key factor and central to the implementation of the HBCU–Undergraduate Program elements agreed upon when submitting a proposal for funding to implement a program. Student involvement (Astin, 1985) and implementation of the programs possibly influence an increase of degree choice and completion to graduation (Astin, 1985). Determining the effectiveness of such programs will contribute to existing knowledge by reporting the outcomes of program that have at their focus student involvement at institutions for URMs majoring in mathematics. The results should be of interest to the recipient colleges and universities and other institutions with the goal to increases the nation's number of URMs students selecting and pursuing a baccalaureate degree in mathematics.

According to Astin, when institution leaders seek to develop students that have chosen mathematics as degree choice and degree completion the interconnection to

student involvement is necessary as it not effective to site underrepresentation for URMs in STEM and neglect student involvement (Astin, 1997). The research could provide a pathway for replication with future researchers who are interested in conducting programs designed to increase the nation's number of URMs selecting a mathematics, science, technology, or engineering college major and STEM career choice.

Research Design

The research was conducted utilizing an ex post facto causal-comparative quantitative research method to analyze and attribute a change between the independent variable, HBCU–Undergraduate Program and the dependent variables, undergraduate degree completion in mathematics, and African American undergraduate students majoring in mathematics. The data was collected from a preliminary population of the HBCU–Undergraduate Program from n = (296) standard grants, n = (86) continuing grants and n = (5) cooperative agreements open to solicitation and awarded for institutions and organizations National Science Foundation (2019). The analytic process began by utilizing data compiled from the Institution of Education Sciences, National Center for Education Statistics, Integrated Postsecondary and the Education Data System. The institutions for which the data were collected are designated HBCUs and have implemented a HBCU–Undergraduate Program between the period of 2011-2018. A four-year completion for a baccalaureate degree in mathematics as a first major utilizing the Classification of Instructional Programs (CIP) codes were collected. Program institutions data are represented in group A – program institutions (n=68) and group B – nonprogram institutions (n=26) data are represented in Appendix C. The independent samples t-test was utilized to determine if the mean difference of the population of the

two groups is statistically significantly different from zero. The independence of observations will be maintained for the group A – institutions with program (n=68) and group B – institutions without program (n=26).

There is no statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and the institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

There is a statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and the institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

Population and Sample

In total, 104 HBCUs were compiled to the specific criteria for the population and sample of institutions identified in Appendix A. A random sampling was used to select the list of colleges and universities to obtain a sufficiently large sample to address sampling error. The data for each HBCU and CIP were exported from The National Center for Education Statistics (NCES) which collects, analyzes, and makes available data related to education in the United States and other countries. First, the HBCU–Undergraduate Program 4-year group A – institutions with the undergraduate program n = (68) and second, group B – institutions without the undergraduate program n = (26) that submitted a solicitation proposal and were awarded and implemented with fidelity

the elements of the HBCU–Undergraduate Program were in the purposive sample of colleges, universities and institutions and selected based on the criteria for the period of 2011-2018 covered for the scope of the program. The student samples are African American male and female undergraduate mathematics majors. The population and sample are for the periods of 2011-2018. The study utilized each category under the Institute for Education Sciences (IES) National Center for Education Statistics (NCES) Integrated Postsecondary Data System (IPEDS) of selected institutions.

The CIP defined mathematic and statistics instructional programs that focus on the systematic study of logical symbolic language and its applications in undergraduate mathematics majors were used in the analyses. The accredited colleges and universities are HBCUs in the U.S. that award an undergraduate baccalaureate degree in mathematics. HBCUs that did not meet the study criteria for the time period are; Barber-Scotia College, Birmingham-Easonian Baptist Bible College, Carver College, Charles Drew University of Medicine and Science, Hood Theological, Johnson C. Smith Theological Seminary, Knoxville College, Miles School of Law, Morris Brown College, and Payne Theological Seminary. Of the 104 HBCUs, the six community colleges are not included in the study population. Instances where the programs were implemented by a corporation or at a community college are not included in the study.

Research Variables

The analyses include the categorical nominal demographic and independent variables: Institutions with the HBCU–Undergraduate Program (independent variable) and institutions without the HBCU–Undergraduate Program; nonprogram institutions, 17 total major categories of mathematics, dependent (outcome variable) four-year degree

completion in mathematics, gender male and female were included in the study, and race/ethnicity of African American.

Instrumentation

The data were obtained from the databases of the Institution of Education Sciences (IES) statistics, research, and evaluation arm of the U.S. Department of Education. IES is independent and non-partisan. The research utilized the IES, NCES CIP for all institutions in the study is 27.01. The purpose of the CIP is to provide a taxonomic scheme that supported the accurate tracking, assessment, and reporting of fields of study and program completion.

Table 5 Institutions Group A HBCU–Undergraduate Program

National Science Foundation, Research Areas. 2019. Arlington, VA. Available at https://www.nsf.gov/about/research_areas.jsp.

Alabama A & M University – Group A
Alabama State University – Group A
Albany State University – Group A
Alcorn State University – Group A
Benedict College – Group A
Bennett College – Group A
Bethune-Cookman University – Group A
Bowie State University – Group A
Central State University – Group A
Cheyney University of Pennsylvania – Group A
Claflin University – Group A
Clark Atlanta University – Group A
Delaware State University – Group A
Dillard University – Group A
Elizabeth City State University – Group A
Fayetteville State University – Group A
Fisk University – Group A
Florida Agricultural and Mechanical University – Group A
Florida Memorial University – Group A
Fort Valley State University – Group A
Grambling State University – Group A

Hampton University – Group A
Harris-Stowe State University – Group A
Howard University – Group A
Huston-Tillotson University – Group A
J. F. Drake State Community and Technical College – Group A
Jackson State University – Group A
Jarvis Christian College – Group A
Johnson C Smith University – Group A
Kentucky State University – Group A
Lane College – Group A
Lincoln University 1 – Group A
Lincoln University 2 – Group A
Livingstone College – Group A
Mississippi Valley State University – Group A
Morehouse College – Group A
Morehouse School of Medicine – Group A
Morgan State University – Group A
Morris College – Group A
Norfolk State University – Group A
North Carolina A & T State University – Group A
North Carolina Central University – Group A
Oakwood University – Group A
Prairie View A & M University – Group A
Saint Augustine's University – Group A
Savannah State University – Group A
Shaw University – Group A
South Carolina State University – Group A
Southern University and A & M College – Group A
Southern University at New Orleans – Group A
Southern University at Shreveport – Group A
Spelman College – Group A
St Philip's College – Group A
Tennessee State University – Group A
Texas Southern University – Group A
Tougaloo College – Group A
Tuskegee University – Group A
University of Arkansas at Pine Bluff – Group A
University of Maryland Eastern Shore – Group A
University of the District of Columbia – Group A
University of the Virgin Islands – Group A
Virginia State University – Group A

Virginia Union University – Group A
Virginia University of Lynchburg – Group A
Voorhees College – Group A
West Virginia State University – Group A
Wiley College – Group A
Winston-Salem State University – Group A

Note: Group A Program Institution with a HBCU-Undergraduate Program and Group B Nonprogram Institution without a HBCU-Undergraduate Program

Table 6 Institutions Group B HBCU–Undergraduate Program

National Science Foundation, Research Areas. 2019. Arlington, VA. Available at https://www.nsf.gov/about/research_areas.jsp.

Allen University – Group B
American Baptist College – Group B
Arkansas Baptist College – Group B
Bluefield State College- Group B
Clinton College – Group B
Concordia College Alabama – Group B
Coppin State University – Group B
Denmark Technical College – Group B
Edward Waters College – Group B
Langston University – Group B
Le Moyne-Owen College – Group B
Meharry Medical College – Group B
Miles College – Group B
Paine College – Group B
Paul Quinn College – Group B
Philander Smith College – Group B
Rust College – Group B
Selma University – Group B
Shorter College – Group B
Simmons College of Kentucky – Group B
Southwestern Christian College – Group B
Stillman College – Group B
Talladega College – Group B
Texas College – Group B
Wilberforce University – Group B
Xavier University of Louisiana – Group B

Data Collection Procedures

The data was collected from the Institution of Education Sciences, National Center for Educations Statistics, Integrated Post-Secondary Education Data System. The sample population were drawn from mathematics baccalaureate degree seeking students at HBCUs in the United States. The mathematics categories are Classification of Instructional Programs (CIP) code 27 with 16 CIP mathematics majors 1) applied mathematics general 2) applied mathematics other 3) aromatherapy 4) biomathematics, bioinformatics, and computational biology, other 5) computational and applied mathematics 6) computational mathematics 7) financial mathematics 8) mathematics biology 9) mathematical statistics and probability 10) mathematics and computer science 11) mathematics and statistics 12) mathematics and statistics, other 13) mathematics teacher education 14) mathematics, general 15) mathematics, other 16) theoretical and mathematics physics. Data for the IHE CIP mathematics majors were collected for the periods of 2011-2018 for program institution, nonprogram institution, and four-year mathematics degree completion and are documented in the NCES Database for programs in the Appendix A awards.

Timeline

The doctoral research study timeline for completion of the dissertation began in August of 2017. The researcher submitted the proposal to the University of Missouri-St. Louis Institutional Review Board (IRB) in March of 2019. The IRB approval was received in August of 2019. The data collection began in fall 2019 and was completed in the fall of 2019. The exempt category application identified the researcher as the principal investigator, identified the project description, methods, and participants.

Permissions and Ethical Considerations

The approval to conduct the research was granted by the Institutional Review Board and ethical considerations were administered according to the required guidelines for the duration of the study. The exempt application provided the information about the description of the research to be conducted and the principal investigator. Permission to conduct the study was obtained before beginning the study with compliance of the regulations of the University of Missouri St. Louis-Institutional Review Board. The criteria for the exempt research involving the collection or study of existing data documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that subjects cannot be identified directly, or through identifiers linked to the subjects were followed.

Summary

The research purpose, design, population, sample, and data collection procedures for the quantitative study were utilized to examine the program, student involvement and degree completion at the institutions. The researcher accessed the public database of the NSF funding opportunities for the HBCU–Undergraduate Program. The program awards are maintained in the funding for recent awards category. The awards were exported by state and award instrument type (n=3) and total awards (n=394). The data will be exported to an Excel spreadsheet and filtered for HBCUs (n=94) for the period of 2011-2018. The R statistical package and Laerd statistical package was used to conduct the statistical tests. The next chapter will provide the results and analyses of the research study.

CHAPTER FOUR

Results and Findings

The effectiveness of student programs aimed to increase the nation's number of underrepresented groups studying and earning a degree in mathematics through the HBCU–Undergraduate Program was evaluated utilizing Alexander W. Astin's theory of student involvement (Astin,1984). The study analyzed the data for mathematics degree completion at the institutions implementing the HBCU–Undergraduate Program for the period of 2011-2018. The researcher rejected the null hypothesis as the data offered significant support for the alternative hypothesis: There is a statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and the institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

Research Hypothesis

There is no statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and the institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

There is a statistical significant difference in degree completion for African American students majoring in mathematics at the colleges and universities that have implemented the Historically Black Colleges and Universities Undergraduate Program and the

institutions that have not implemented the Historically Black Colleges and Universities Undergraduate Program.

Analyses

The researcher found during the period of 2011-2018 undergraduate students majoring in mathematics completing their baccalaureate degree at institutions without the HBCU–Undergraduate Program totaled n = 227, see Table 7 and institutions with the HBCU–Undergraduate Program during the period of 2011-2018 undergraduate students majoring in mathematics completing their baccalaureate degree totaled n = 2,218, see Table 7. During this period n = 384, HBCU–UP program solicitations were awarded and funded at the IHE listed in Appendix A.

Independent Samples T-Test

The independent samples t-test is a parametric test. The researcher conducted and independent samples t-test to compare an analysis and determine if there is statistical evidence a mean difference existed in the two independent populations between group A (n) = 68 institutions with the undergraduate program and group B (n) = 26 institutions without the undergraduate program, and if the difference was statistically significant Table 7. The research showed the independent samples t-test significance level and p-value of $p < 0.001$ result of the means and standard deviation of group A, $M = 29.28$, $SD = 24.61$ and group B, $M = 8.73$, $SD = 10.85$ indicating a significant difference for students completing the undergraduate degree in mathematics between group A – institutions with the undergraduate program and group B – institutions without the undergraduate program, $t(90) = , p < 0.001$. The independent samples t-test includes the approximate t statistic that is not based on assuming equal population variances.

The number of URM undergraduate students completing a degree in mathematics each year was measured for both groups and a Hedge's g effect size measure of the difference between the means of group A and group B of 0.8 results indicated Table 9 that it is unlikely that the mean of the two groups group A – institutions with the undergraduate program and group B – institutions without the program are equal in the population. The 95% confidence interval for the mean was useful to determine how accurately the sample mean estimated the means of the population from where the sample was derived. The data analyses showed outliers in the group A – program institution distribution of mathematics degree completion compared to the group B – nonprogram distribution. The distribution in group A – program institutions did not disproportionately influence the mean difference and although they yield an increase in variability, the distribution in Figure 4 for the institutions did not change the conclusion of the independent samples t-test. The negative t-value of 6 with a degrees of freedom of 90. group A – program institutions had a higher mean 29.28 than group B – 8.73 and a higher SD 24.61 than group B – nonprogram institutions 10.85 indicating the undergraduate program had a greater influence on degree completion for the students majoring in mathematics. These results support Astin's postulates and theory of student involvement (1985). The mean difference is significant at the .05 level.

Descriptive Statistics

Table 7

Independent Samples T-test Mathematics Degree Completion

	Institutions						95% CI for Mean Difference			
	Nonprogram			Program						
	N	Mean	SD	n	Mean	SD	lower	upper	t-value	df
Mathematics majors	26	8.73	10.85	68	29.28	24.61	-27.8	-13.3	-6***	90

Note: *** $p < 0.001$

Table 8

Descriptive Statistics for Degree Completion*

	n	M	SD	Min	Max	2011	2012
Program Institution	68	29.28	24.61	0	119	249	265
Nonprogram Institution	26	8.73	10.85	0	40	29	18

*First major

Descriptive Statistics for Degree Completion*

	n	M	SD	Min	Max	2013	2014
Program Institution	68	29.28	24.61	0	119	264	262
Nonprogram Institution	26	8.73	10.85	0	40	40	31

*First major

Descriptive Statistics for Degree Completion*

	n	M	SD	Min	Max	2015	2016
Program Institution	68	29.28	24.61	0	119	252	224
Nonprogram Institution	26	8.73	10.85	0	40	32	30

*First major

Descriptive Statistics for Degree Completion*

	n	M	SD	Min	Max	2017	2018
Program Institution	68	29.28	24.61	0	119	247	228
Nonprogram Institution	26	8.73	10.85	0	40	27	20

*First major

Skewness	1.29	1.03
Kurtosis	1.8	0.29

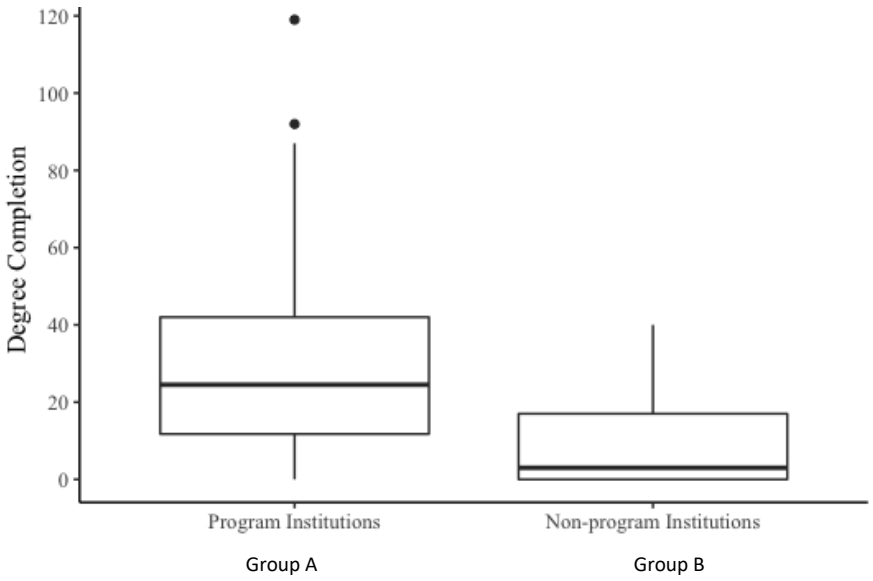
Note: Mean difference is significant at the .05 level.

Program Data Distribution for Total Degree Completion for Group A and Group B

The program data boxplot in Figure 4 in the distribution of group A – program institutions with the undergraduate program compared to the group B – nonprogram institutions without the undergraduate program distribution were not significant in that they were significantly small compared to the number of mathematics degree completion at the institutions and exerted no influence in the outcome.

Figure 4

Mathematics degree completion

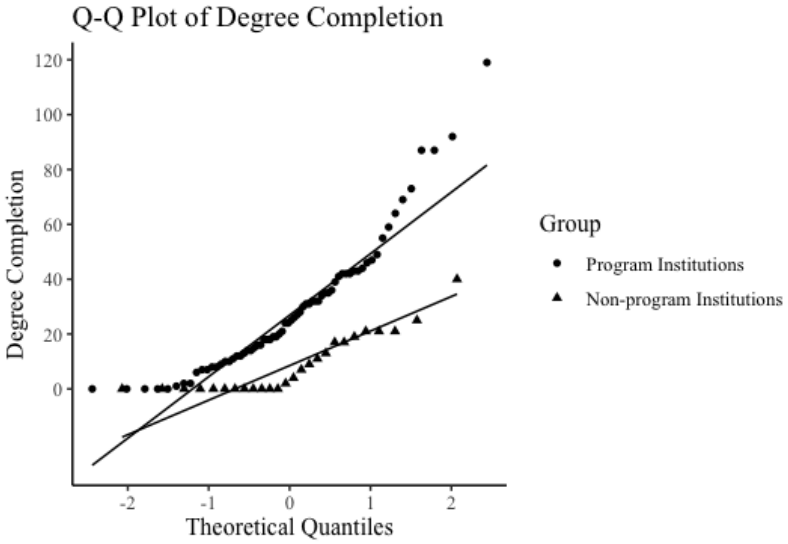


Quantile-Quantile Plot for Degree Completion

The Quantile-Quantile (Q-Q) probability plot of the distributions of group A – institutions with the STEM program compared to the group B – institutions without the STEM program in Figure 5 show the two distributions for mathematics degree completion. Inspection of the Q-Q plots revealed that degree completion was not

normally distributed for both groups. A normal distribution would be a straight line on the graph. The points are not clustered suggesting that the data is not normally distributed. The degree completion for normally distributed data on the Q-Q plot would present as a straight line with the same mean and standard deviation. In Figure 5 and in Table 8 skewness and kurtosis quantify deviations from normality of the degree completions of group A and group B. The circles on the Q-Q plot are the data for the degree completion at institutions that implemented the undergraduate program in group A – program institutions. The triangle on the Q-Q plot are the data for the degree completion at institutions that did not implement the undergraduate program in group B – nonprogram institutions. The circles above the straight line represent the data for mathematics degree completion that are higher or more extreme than would result if the degree completion at the institutions were normally distributed. Skewness is 1.29 and 1.03 and the kurtosis of 1.08 and 0.29 listed on Table 8. A value close to zero are the result of distributions that are close to normal. These results indicate the presence of a significant statistical difference in degree completion.

Figure 5



Note: Normal Quantiles with outliers identified.

Effect Size Hedges' g

The Hedges' g with pooled weighted SD was utilized and is appropriate for sample sizes that are largely different and represents the standardized difference between means. Hedges' g was used to measure the effect size for the difference in the means of group A – institutions with the undergraduate program and group B – institutions without the undergraduate program. The Hedges' g effect size shown in Table 9 is 0.89 with a 95% CI: lower = 0.4157327, upper = 1.36891. The effect size is large with a marked difference in group A – institutions with the undergraduate program and group B – institutions without the undergraduate program. The effect size informed the researcher of how different the two groups are an allowed the researcher to inform the practical consequences of the findings for a program implementation that integrates and supports robust and intensive student involvement.

Table 9

Hedges' g

Hedges' g	
Effect Size	Strength
.2	small
.5	medium
.8	large

Note: Effect size for Group A – IHE with program and Group B – IHE without program; 0.8=> large difference between means.

In 2017 and 2019 the results of three independent rankings of effective STEM programs at HBCUs, the top 10 strongest and highest ranking STEM programs included institutions in group A and none in group B ad were ranked as extremely effective shown in Table 10–12 Agugliaro (2019); The Hundred-Seven (2017; 2019). A recommendation of the HBCU–Undergraduate Program for institutions that are seeking to increase URM STEM recruitment and utilize the HBCU–Undergraduate Program is to review the index of program awards in Appendix A. Content such as atmospheric collaborative research and nanotechnology are areas of discussion to inspire interest for potential students.

Table 10

Independent Institution Ranking A 2019
1. Florida A&M University, Tallahassee, FL
2. Howard University, Washington, D.C.
3. Hampton University, Hampton, VA
4. Morgan State University, Baltimore, MD
5. North Carolina A&T State University, Greensboro, NC
6. Alabama A&M University, Huntsville, AL
7. Spelman College, Atlanta, GA
8. Prairie View A&M University, Prairie View, TX
9. Jackson State University, Jackson, MS
10. Alabama State University, Montgomery, AL

Note: Independent ranking 2019 Danielle Agugliaro, The Top 10 HBCUs with the Best STEM Programs

Table 11

Independent Institution Ranking B 2019
1. North Carolina A&T State University, Greensboro, NC
2. Florida A&M University, Tallahassee, FL
3. Alabama A&M University, Huntsville, AL
4. Howard University, Washington, D.C.
5. Jackson State University, Jackson, MS
6. Alabama State University,
7. Norfolk State University, Norfolk, Virginia
8. Prairie View A&M University, Prairie View, TX
9. Morgan State University, Baltimore, MD
10. Fort Valley State University, Fort Valley, Georgia

Note: Independent Ranking 2019 National Institute of Health Top 10 STEM HBCUs

Table 12

Independent Institution Ranking C 2017
1. North Carolina A&T State University, Greensboro, NC
2. Florida A&M University, Tallahassee, FL
3. Alabama A&M University, Huntsville, AL
4. Howard University, Washington, D.C.
5. Jackson State University, Jackson, MS
6. Alabama State University, Huntsville, AL
7. Norfolk State University, Norfolk, Virginia
8. Prairie View A&M University, Prairie View, TX
9. Morgan State University, Baltimore, MD
10. Fort Valley State University, Fort Valley, Georgia

Note: Independent Ranking 2017 The Hundred-Seven Top STEM HBCUs

Summary

The statistical data of the independent samples t-test, quantile-quantile plot, and Hedges'g were used to examine the effectiveness of degree completion for URMs majoring in mathematics at IHE that implemented the HBCU–Undergraduate Program. The results of these statistical analyses suggests that with intention the solicitations and

utilizations of the HBCU–Undergraduate Programs classifications of standard, continuing or cooperative agreement or fellowship, may provide further insight in increasing the number of URMs that successfully complete an undergraduate degree in mathematics. Participation in a HBCU–Undergraduate Program is an intentional action which requires planning for students by administrators at IHE and as such is deliberate and not happenstance. The ex post facto causal comparative research design sought to understand the cause or reasons for the differences of the institutions that were proactive in recognizing the potential difference for STEM degree completion in delivery of a HBCU–Undergraduate Program.

Based on the results the null hypothesis was rejected and the alternative hypothesis was accepted.

A strategic plan to infuse co-curricular experiences, promoting organizational participation, STEM summer bridges, skills days, STEM mentoring, STEM internships, and research programs are embedded in the core of student involvement in the HBCU-Undergraduate Program. Reinforcing mentorships and research experiences are elements Gross (2019) identified as key to the success of students earning a degree. Agugliaro (2019) wrote in the Top Ten HBCUs with the Best STEM Programs in Table 10-12 Group A and see Appendix C that these IHE had highly ranked STEM programs which in 2019 had awarded 25 percent of the nation’s STEM degrees.

CHAPTER FIVE

SUMMARY AND RECOMMENDATIONS

The study utilized the theoretical frameworks of Astin's (1985) theory of student involvement to examine URMs and underrepresentation of undergraduate degree completion in mathematics. There continues to be an important and persistent message to improve and diversify the number of STEM degree seeking students that successfully progress to degree completion for all URMs according to (Lyon et al., 2012; Israel 2017). Further, college and university leaders and policymakers should continue to focus on STEM innovative pedagogy, after school programs, and an increase in STEM concept focused elementary and secondary schools. Actions by institutions committed to improving mathematics can be successful with program specificity that will routinely begin with involving precollege students and end with undergraduate degree completion (Clewell et al., 2010).

In 2011, the National Academies recommended that programs engage students in STEM associations to increase and improve the students' identification with STEM. The report emphasized the need to provide supports which included social support to students and that these programs need to support critical undergraduate transitions. Historically the HBCU–Undergraduate Program institution recipients have been successful in forming a framework that supported the education of STEM majors (Clewelll et al., 2010) which included collaborative relationships with other entities. The HBCU–UP practices and framework are documented in the growing, and higher numbers of IHE submitting solicitations to the NSF's HBCU–UP and comparable programs.

Implications for Practice

Belser et al., (2018) urged educators of the importance for students to take higher-level mathematics courses and obtain support to develop a higher mathematics self-efficacy which may lead to better outcomes for STEM college majors (Carnevale et al., 2013; Chen & Soldner, 2013; Nosek & Smyth, 2011). As such, correlation in college retention for STEM majors was positively correlated with taking high school calculus. Additionally, the evidence for the need to increase the underrepresentation of groups in mathematics continues to be extensively discussed (Chen & Soldner, 2013). As the nation becomes more diverse, recognizing and preparing URMs in STEM programs should be considered by every IHE with what Astin (1985) asserted in that undergraduate students learn by becoming involved. Further Astin (1985) affirmed, “a number of mechanisms are available to most institutions to bring about greater student participation” which include academic programs. (Astin, 1977, p. 148). Astin emphasized the importance of relationship between the quality and intensity of the highs school curriculum and the academic experience to essentially every aspect of a postsecondary education (Kuh et al., 2006).

Local school districts offer college preparatory programs, summer bridge programs, and other programs designed to ease the transition to college and support postsecondary student success, U.S. Department of Education, Institution of Education Sciences (2016). The NSF program review boards (2019) recommended that student and faculty review the past and current program awards to identify content and ideas for their students, particularly for incoming freshman or students struggling with their decision to major in STEM, identified in Appendix A.

Recommendations for Future Research

Building Relationships with Local School Districts

In 2007, a report by The National Academies Press recommended that an increase in the nation's talent pool would be supported by improving K-12 primary and secondary education, science, and mathematics education. Stinson (2004) recommended in 'The Mathematics Educators' that professional educators view mathematics as an inclusive instrument for empowerment rather than exclusive for stratification of enrollment in high school mathematics courses. Further, a measure to recruit 10,000 science and mathematics teachers and incentivize the teachers with a 4-year scholarship fund was recommended by the U.S. Congress to support STEM education in the 21st Century. The 2019 NSF NCSES annual report indicated that in the past twenty-years the number of women earning an undergraduate degree in mathematics and statistics has declined. Many students enter college unprepared for the college level mathematics courses. The remedial requirement for passing the mathematics courses which do not qualify for graduation credit contribute to existing financial burdens. Studies show that many students from underrepresents groups in STEM fields are within a few points of mathematical proficiency on college admission examinations. Targeting and identifying these students is a logical course of action.

Further, college and university leaders and policymakers need to answer the questions of innovative pedagogy, collaboration with after-school programs, and an increase in STEM concept elementary, secondary, and college preparatory schools. To the extent that this research examined the mathematics element independently in STEM , deficiencies with other underrepresented groups of student programs and the student

involvement impact on degree completion in underrepresentation for science, technology, engineering will need continued research because the topics have not been explored in this study. A further recommendation is the potential benefits of degree completion in underrepresentation of other groups and majors like students with disabilities; the student involvement impact on degree completion in underrepresentation of science, technology, mathematics, and engineering has not been thoroughly examined in research studies. Because participation in the student programs is based on a voluntary and self-directed process; the number of institutions that have submitted proposals, received approval, and agreed to accept the provisions of the programs may provide useful data to continued research of the successful completion to graduation of the URM mathematics student majors enrolled at institutions with the HBCU–UP.

Research of Other URM Groups and STEM Majors

Underrepresentation of women in mathematics course of study in STEM (Nnachi & Okpube, 2015) persist globally and may be indicative of gender role stereotypes that exist in the job markets and underrepresentation of women choosing STEM as an UG major (Lindeman et al., 2016). In March 2019, the NSF NCSES released the 2019 Women, Minorities, and Persons with Disabilities Report. A goal of the report was to provide information to further support decision making in the goal of broadening these groups in STEM education and careers, specifically science and engineering. The report provided statistics and analysis in enrollment, field of degree, and occupation, and acknowledged that people with a disability or less likely to have completed a bachelor's degree. According to the NSF NCSES (2014), the presence of or an identification of a disability will not alone limit the ability to participate in educational experiences or be

productive in an occupation. Approximately 11% of working age population reported a disability in 2016. A disability may or may not require special accommodations to succeed in higher education and the workforce. Future research should also examine program support for URMs enrollment and degree completion in each area of the mathematics majors such a statistics and computational mathematics.

The primary reason cited for the low number of engineering degrees is access barriers which begin at the K-12 levels (Wood, 2016). According to Woods, in 2016, Historically Black Colleges and Universities made up five percent of the total number of IHE with engineering undergraduate programs and produced 17 percent of the total number of undergraduate engineering degrees for African American students. Many programs for social and academic support apply to all students in STEM courses of study, for underrepresented minority student these and comparable programs are critical for opening doors of opportunity.

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Appendices

Appendix A

HBCU– Undergraduate Program Awards Active and Inactive n=384

National Science Foundation, Research Areas. 2019. Arlington, VA. Available at https://www.nsf.gov/about/research_areas.jsp.

Research Initiation Award: Determining the Role of Cytoskeletal Proteins in the Fibrillation of Amyloid-beta Peptides in the presence of Tryptamines and Flavones	MS	Tougaloo College
Targeted Infusion Project: A MakerLab at Delaware State University	DE	Delaware State University
RCN-UBE: Course-based Undergraduate Research Network 2	GA	University of Georgia Research Foundation Inc
Investigating the Effect of Active Flipped Learning in STEM Education	MS	Jackson State University
Targeted Infusion Project in Interdisciplinary Data Analytics (TIP-IDA)	GA	Savannah State University
Targeted Infusion Project: Infusing Computational Thinking and Visual Learning into an Introductory Computer Science Course to Promote Students' Success and Retention	MD	Morgan State University
Targeted Infusion Project: Enhancing STEM Recruitment, Retention and Engagement by Establishing the Shaw University Center for Computer Science Living, Learning and Research	NC	Shaw University
Targeted Infusion Project in Interdisciplinary Transportation Studies (TIP-ITS)	GA	Savannah State University
GP-EXTRA: Increasing Minorities in the Atmospheric	MS	Jackson State University
Collaborative Research:Interpreters and Scientists Working On Our Parks	NC	Winston-Salem State University
Implementation Project: Strategic Plan for the Integration of Nanotechnology in Undergraduate Programs (SPIN-UP)	AL	J F Drake State Technical College
DCL: HBCU Conference Proposal: A National Symposium to Build Research Capacity at Historically Black Colleges and Universities through Collaborations with STEM Advocates and Practi	DC	QUALITY EDUCATION FOR MINORITIES NETWORK
Collaborative Project: Workshops and Learning Communities for Physics and Astronomy Faculty	MD	American Association of Physics Teachers
RUI: The Function and Regulation of Invertase Inhibitors during Early Seed Development in Arabidopsis	GA	Spelman College
Center for Energy and Environmental Sustainability	TX	Prairie View A & M University
Targeted Infusion Project: Bridging Alliances to Infuse Neuroscience at The Lincoln University (BrainLU)	PA	Lincoln University
Targeted Infusion Project: Expansion and Implementation of the Interactive LearningExpress App	PA	Lincoln University
Implementation Project: Training Undergraduates in Bioengineering and Nano-Biotechnology (TUBN)	AL	Alabama State University
IMREL-CHRNS Partnership for Research and Education in Materials (IC-PREM) using a National Facility	NC	Fayetteville State University

FAMU ADVANCE IT: Using Cultural Humility to Balance the Institutional and Intersectional Barriers to Equity for STEM Faculty	FL	Florida Agricultural and Mechanical University
MRI: The Acquisition of Seahorse to measure Mitochondrial Metabolism will fuel Biological Research at an HBCU	DE	Delaware State University
Implementation Project: Improving Minority Participation and Completion through STEM at Dillard University- IMPACTS at DU	LA	Dillard University
Implementation Project: Increasing the Quality of STEM Education and Research	MS	Tougaloo College
Implementation Project: Data Driven, Engagement Based, Adaptive Learning, Growth Mindset Pedagogy Informed Course Redesign with Early Research Experiences for STEM Student Success	GA	Clark Atlanta University
Targeted Infusion Project: Infusion of Evidence-Based Strategies to Enhance STEM Majors' Mathematics Performance	AR	University of Arkansas at Pine Bluff
Implementation Project: University of Arkansas at Pine Bluff (UAPB) STEM Academy	AR	University of Arkansas at Pine Bluff
Targeted Infusion Project: Transforming Biology Laboratory Learning by the Development, Deployment and Assessment of evidenced-based research and learning (EBRL) experiences	AL	Alabama State University
Implementation Project: PERSIST – Pathways to Enhance Retention of Students in Science to Transition	MD	Morgan State University
Broadening Participation Research Center: Center for the Advancement of STEM Leadership	NC	North Carolina Agricultural & Technical State University
Collaborative Research: The Tuskegee Alliance to Develop, Implement and Study a Virtual Graduate Education Model for Underrepresented Minorities in STEM	AL	Tuskegee University
BPRC Planning Grant: Nurturing Resilient Students and Teachers	VA	Virginia State University
Research Initiation Award: Highly Stable Nanoparticle-Doped Metal-Organic Frameworks for Applications in Water Purification	VA	Virginia Union University
Broadening Participation Research Center: Center for the Advancement of STEM Leadership	VI	University of The Virgin Islands
Broadening Participation Research Center: Center for the Advancement of STEM Leadership	CA	Fielding Graduate University
Implementation Project: The VESTEM Innovation and Collaboration (VESTEMic) Model	NC	Elizabeth City State University
Workshops to Broaden the Participation of HBCU STEM Faculty in NSF's Education Research-focused Programs	DC	QUALITY EDUCATION FOR MINORITIES NETWORK
Implementation Project: Education Innovation Initiatives – Ecosystem for Student Success at BSU	MD	Bowie State University
Center for NanoBiotechnology Research	AL	Alabama State University
Targeted Infusion Project: Ensuring the Vitality and Sustainability of the Virginia Union University Physics and Pre-Engineering Program	VA	Virginia Union University
Catalyst Award: pH Regulation in the Mammalian Brain	VA	Virginia Union University
Excellence in Research: Human Factors Approach to Facilitate Ambient Assisted Living Accessible and Usable to People with Visual Impairments: Loneliness Self-Monitoring System	NC	North Carolina Agricultural & Technical State University

Broadening Participation Research Center: Center for the Advancement of STEM Leadership	DC	Association of American Colleges and Universities
Hampton-Brandeis Partnership for Research and Education in Materials	VA	Hampton University
Implementation Project: Preparing Interdisciplinary Minority Material Scientists and Engineers of the Future	AL	Tuskegee University
Targeted Infusion Proposal: Virginia Union University Undergraduate Research Training Program in the Biological Sciences	VA	Virginia Union University
Implementation Project: Using Mathematics to Transform the STEM Undergraduate Landscape	MS	Mississippi Valley State University
Research Initiation Award: Advancing Research on Data Analysis with High Performance Computing	TX	Prairie View A & M University
Implementation Project: From Learning Community to Teaching Community – A Grass Roots Approach to STEM Undergraduate Teaching and Learning	GA	Albany State University
Targeted Infusion Project: Implementation of an HBCU Undergraduate Bioinformatics Program – Lincoln University (LUBi)	PA	Lincoln University
Targeted Infusion Project: Lincoln University Bioinformatics Program (LUBi)	PA	Lincoln University
Research Initiation Award: Studying the Dynamics of Network Systems by Using Ordinary Differential Equations and Boolean Frameworks	TX	Texas Southern University
Target Infusion Project: Transforming Physics Courses Using the Scale-Up Active Learning Model	NC	North Carolina Agricultural & Technical State University
EAGER: Novel Applications of Mobile Observational Strategies to Non-Severe Atmospheric Scenarios	MS	Jackson State University
EAGER: Competition and interactions among predators of bacteria in microbial loop dynamics	FL	Florida Agricultural and Mechanical University
EAGER: Microfluidic-based device to transform the T cell manufacturing process for adoptive T cell therapy	NC	North Carolina Agricultural & Technical State University
Expanding the Network of STEM Scholars through the ADVANCE Women of Color Summer Writing Retreat	MS	Jackson State University
Targeted Infusion Project: Bowie State University Applied Biotechnology Initiatives	MD	Bowie State University
Catalyst Award: Integration of Biotechnology and Cyberinstruction in the Biological Sciences at Fort Valley State University	GA	Fort Valley State University
Targeted Infusion Project: Infusing Inquiry-Based Green Chemistry into Undergraduate Laboratory Courses via Silver Recycling in a Closed Loop, Multi-course Process	AL	Tuskegee University
Implementation Project – Improving Pathways for STEM Retention and Graduation (IPSRG)	OH	Central State University
Targeted Infusion Project: Infusion of Research and Peer-Led Team Learning to Enhance Student Engagement in Foundational Courses at Lane College	TN	Lane College
Targeted Infusion Project: Infusion of Toxicology into the Biology and Chemistry Programs at Fort Valley State University	GA	Fort Valley State University
RUI: Evolutionary and ecological impacts of horizontal gene transfer in arthropods	GA	Spelman College

EAGER Self-Catalyzed Growth of Patterned GaAsSb and GaAsSbN Nanowires for Optoelectronic Devices	NC	North Carolina Agricultural & Technical State University
Excellence in Research: Dynamics of High-L States of Rydberg Atoms	TX	Texas Southern University
INSPIRE: An Evolutionary Paradigm in Design and Engineering of Bio-Adhesives from Bio-mass	AZ	Arizona State University
Targeted Infusion Project: Developing a Minor in Applied Mathematics at Savannah State University	GA	Savannah State University
Targeted Infusion Proposal: Using a Project-Based Learning Approach for Education and Training in Technological Innovation for STEM Students	NC	North Carolina Agricultural & Technical State University
Enriching Computing Curricula through HPC Teaching and Research	TX	Prairie View A & M University
ACE Implementation Grant: STEM Global Undergraduate Research Initiative	DC	Howard University
Salish Kootenai College Indigenous Research Center	MT	Salish Kootenai College
Targeted Infusion Project: Infusing Data-Enabled Active Learning in Mathematics and Statistics Courses	AL	Alabama State University
EAGER: Using eye tracking to study migrant remittances and its welfare implications	GA	Spelman College
Excellence in Research:Single Crystal Growth and Investigation of Novel Exotic Fermion Materials	VA	Norfolk State University
Targeted Infusion Project: The Impact of Infusing Soft Matter Into Undergraduate General and Physical Chemistry Courses	NC	North Carolina Central University
An Educational Network to Gain STEM Graduates and Enhance STEM Education (ENGAGE)	FL	Valencia Community College
Collaborative Proposal: EiR: Understanding Interactions of Gold and Silver Nanoparticles with Proteins to Achieve Optimum Surface Plasmon Effect	DC	Howard University
Excellence in Research: Investigation of Enhancer-Free Photogenerated Singlet Oxygen	DE	Delaware State University
Impacts of the Concept Mapping Strategy in Introductory Biology Courses on Learning and Retention of Underrepresented STEM Students	MD	Morgan State University
Multiple Consciousnesses: Investigating The Identities (Academic, Gender, Race and Disability) Of Black Women Undergraduate Students In STEM And Their Impact On Persistence	DC	Howard University
EAGER: Undergraduate Astronomy Research and Education through Observation of Jupiter Impact Flashes to Characterize Small-Body Populations in the Outer Solar System	VA	Hampton University
Research Initiation Award: The ecology of microbial communities in relation to red deep sea crabs and their surrounding environment	VA	Hampton University
Implementation Project: STEM Undergraduate Program to Promote Opportunities in Research and Training (SUPPORT)	NC	Livingstone College
Howard University ADVANCE-IT: Women of Color Faculty in STEM as Change Agents	DC	Howard University
Implementation Project: Transforming Education through Active Learning	DE	Delaware State University
REU Site: Nanobioengineering	AL	Alabama State University

HBCU-UP Collaborative for the Advancement of STEM Leadership	NC	North Carolina Agricultural & Technical State University
HBCU-UP Collaborative for the Advancement of STEM Leadership	VI	University of The Virgin Islands
HBCU-UP Collaborative for the Advancement of STEM Leadership	DC	Association of American Colleges and Universities
HBCU-UP Collaborative for the Advancement of STEM Leadership	CA	Fielding Graduate University
Targeted Infusion Project: The STEM Enrichment by Design (STEMed) Project	TX	St. Philip's College
Targeted Infusion Project: Increasing Student Motivation and Engagement in STEM Courses through Gamification	NC	Winston-Salem State University
Research Initiation Award: Evolutionary and ecological impacts of horizontal gene transfer in arthropods	GA	Spelman College
Collaborative Proposal: EiR: Understanding Interactions of Gold and Silver Nanoparticles with Proteins to Achieve Optimum Surface Plasmon Effect	NC	Winston-Salem State University
Implementation Project: Transforming Computational STEM Education at Claflin University	SC	Claflin University
Targeted Infusion Project: Development and Implementation of Computational Chemistry and Biology Courses with Research Integration	GA	Clark Atlanta University
Targeted Infusion Project: Establishment of an Undergraduate Peer-Mentor Project-Based Program in STEM at Texas Southern University	TX	Texas Southern University
Collaborative Research: AGEP North Carolina Alliance: An Institutional Transformation Model to Increase Minority STEM Doctoral Student and Faculty Success	NC	North Carolina State University
CAREER:Understanding the Effects of the Immediate Environment on Intrinsic Properties of 2D Crystals: From Fundamental Science to Real World Applications	DC	Howard University
Collaborative Research: NRT-DESE: Interdisciplinary Research Traineeships in Data-Enabled Science and Engineering of Atomic Structure	NC	North Carolina Central University
Research Initiation Award: Mechanisms of CO2 Adsorption in Amine-immobilized Porous Materials	NC	Fayetteville State University
Implementation Project: Graduation Academy – Transitioning STEM Students to Graduation and Graduate School	VA	Norfolk State University
Graduate Opportunities at Fisk in Astronomy and Astrophysics Research (GO-FAAR)	TN	Fisk University
Research Initiation Award: Mechanisms of Heat-Induced Loss of Host Plant Resistance to Insects	NC	Fayetteville State University
Targeted Infusion Project: Engaging Students for Higher Retention and Building Stronger Foundations in Pre-Calculus Using the Flipped Model	VA	Norfolk State University
Implementation Project-Institutional Change through Faculty Advancement in Instruction and Mentoring-ICFAIM	MS	Jackson State University
ACE Implementation Project: The UVI Growth Model	VI	University of The Virgin Islands
Collaborative Research: Standard: Comparison of Communications across Campus Cultures (The 4C Project): Toward Evidence-based Customization of Learning Experiences	LA	Xavier University of Louisiana

Improving student engagement in freshman engineering graphics using Student Assistant for Visualization in Engineering (SAVE)	AL	Tuskegee University
REU Site: Mathematical Modeling in Environmental, Biological and Other Sciences	FL	Bethune-Cookman University
Spectroscopy of Many-Body Processes in Nanostructures	MS	Jackson State University
HBCU: EAGER: Racial Biases and Physiological Responses	MS	Jackson State University
A Professional Development Workshop Series for STEM Faculty	CA	Fielding Graduate University
A Professional Development Workshop Series for STEM Faculty	MD	GPRA Strategic Management, Inc.
BIO-BOOST Targeted Infusion Project	MO	Harris Stowe State College
GOALI: Enhancing Cartilage Tissue Engineering through Synergistic Influence of Co-Culture, Mechano-Chemical Factors, and 3D Printed Scaffolds in a Novel Centrifugal Bioreactor	WA	Washington State University
Research Initiation Award: Magnetic Field Mapping of Pico/Nano/Micro-Satellites to Facilitate Refinement of their Guidance/Navigation Systems and Magnetic Cleanliness	AL	Tuskegee University
2019 NSBP Annual Conference	DC	Associated Universities, Inc.
HBCU-UP Targeted Infusion Project HT-ASSERT – Attaining and Sustaining STEM Excellence with Research Training	TX	Huston-Tillotson University
Targeted Infusion Project: Prompting Effective Active Learning through Implementing Self-Regulated Learning Assessment in Diverse STEM Learning Settings	MS	Jackson State University
EAGER: Overcoming the Saturation Limit of High Intensity, Fully Coherent Raman Backscattering Laser	DE	Delaware State University
A New Framework for Student Retention and Success	NC	Bennett College
Excellence in Research: Teaching Problem-Solving and Deductive Skills to K-12 Students Through a Forensics Course Based on Mobile Devices	MS	Jackson State University
Targeted Infusion Project: Infusing Quantitative Biology Methods into Cognate and Upper Division Courses: Enhancement of the Life Sciences Curriculum at Fisk University	TN	Fisk University
Research Initiation Award: Magnetic Field Mapping of Pico/Nano/Micro-Satellites to Facilitate Refinement of their Guidance/Navigation Systems and Magnetic Cleanliness	VA	Old Dominion University Research Foundation
HBCU-Excellence in Research: Understanding Atmospheric Moist Convection and Organization Using Automatic Feature Identification and Tracking	MD	Morgan State University
Implementation Project: Increasing STEM Degree Production through Undergraduate Research and Collaborations	MO	Harris Stowe State College
Career Commitment and Retention in STEM: Examining the Impact of a Career Management Intervention	TN	Tennessee State University
GP-EXTRA:Pathways to atmospheric science through immersion in geoscience research	NC	North Carolina Agricultural & Technical State University
NSF INCLUDES: Supporting Emerging Aquatic Scientists (SEAS) Islands Alliance	VI	University of The Virgin Islands
Targeted Infusion Project: Promoting Environmental Education in Urban Social-Ecological Resilience	DC	Howard University

Research Initiation Award Grant: Study of Satellite Radio Resource Management by Differential Game Models	SC	Claflin University
HBCU-Excellence in Research: Radiative Effects of Biomass Burning Aerosols Laboratory and Field Measurements and Modeling of Climate and Health Impacts	NC	North Carolina Agricultural & Technical State University
Targeted Infusion: Cyber Infused Mathematics Initiative	DE	Delaware State University
Building Sustainable Networks for Supporting Underrepresented Minorities in STEM: The 3rd Annual NOBCChE Collaborative Conference	NC	Winston-Salem State University
NSF INCLUDES Alliance: Inclusive Graduate Education Network	MD	American Physical Society
Collaborative Research: The AGEP Historically Black Universities Alliance: A Model to Advance Early Career Minority Faculty in the STEM Professoriate	AL	Tuskegee University
Excellence in Research: Evaluating thiol-peptides with auxiliary binding groups as chelators of mercury(II)	NC	Winston-Salem State University
Collaborative Research: Linking Pharmacokinetics to Epidemiological Models of Vector-Borne Diseases and Drug Resistance Prevention	DC	Howard University
Targeted Infusion Project: Infusing an Honors Curriculum to Enrich the Undergraduate Research Experience in Psychological Sciences	NC	Winston-Salem State University
Research Initiation Award: Testing the Mechanisms Underlying Noise Avoidance by Animals	NC	Winston-Salem State University
Improving Research and Education of Big Data and Cloud Computing at Winston-Salem State University	NC	Winston-Salem State University
Target Infusion Project: Integrating Data Science into the Urban Studies & Sustainability Curriculum at Winston-Salem State University	NC	Winston-Salem State University
Collaborative Research: Excellence In Research: Computational Framework and Data Science for Identification	NC	Winston-Salem State University
Research Catalyst: Environmental Quality Assurance using Ion Mobility Spectrometry	NC	Winston-Salem State University
Targeted Infusion Project: Enriching Student Learning through Biophysics and Music at Winston Salem State University	NC	Winston-Salem State University
Collaborative Research: AGEP North Carolina Alliance: An Institutional Transformation Model to Increase Minority STEM Doctoral Student and Faculty Success	NC	North Carolina Agricultural & Technical State University
Research Initiation Award: Development of Carbon-Carbon Bond Forming Strategies in the Synthesis of O-, N-Heterocycles	NC	Winston-Salem State University
EXCELLENCE IN RESEARCH: QUANTUM NANOPHOTONICS WITH PERIODIC CARBON NANOTUBE ARRAYS	NC	North Carolina Central University
Conference Proposal: The 2nd National Symposium to Build HBCU Research Capacity through Collaborative Partnerships with STEM Advocates and Policymakers	DC	QUALITY EDUCATION FOR MINORITIES NETWORK
Developing a Minor in Data Science at Johnson C. Smith University	NC	Johnson C. Smith University
Implementation Project: Blue-Shirt Program: Engineering Clinic-Based Curriculum to Enhance Retention of Underrepresented Groups at Tennessee State University	TN	Tennessee State University

Research Initiation Award: Introducing Electrochemistry in Hydrophobic Media Using Weakly Coordinating Cations	GA	Albany State University
Implementation Project: Course-based Undergraduate Research Experiences (CURE) Program	GA	Spelman College
Excellence in Research: Constraining the symmetry energy in nuclear equation of state for neutron rich systems: A study of Isovector Giant Quadrupole Resonance by Compton Scatterin	NC	North Carolina Central University
Targeted Infusion Project: Data Science eXtension (DSX): Incorporating data science fundamentals in computing curriculum at Spelman and Morehouse Colleges	GA	Spelman College
Targeted Infusion Project: Development of a Knowledge-Based System for Integrating Artificial Intelligence into the Undergraduate Engineering Curriculum	TX	Texas Southern University
Collaborative Research: LIGO Science Education Center Partnership – Broadening Participation	LA	Southern University
Broadening Participation Research Project: Investigating the Impact of Peer Mentoring on STEM Retention and Persistence among Minority Undergraduate Women	DC	University of the District of Columbia
MRI Consortium: Development of an Array of Germanium Detectors for COHERENT at the Spallation Neutron Source	NC	Duke University
Excellence in Research: GaAsSb/GaAs Nanowires based Avalanche Photodetectors on Si	NC	North Carolina Agricultural & Technical State University
Implementation Project: Trojan Center for Undergraduate Applied Research	VA	Virginia State University
Implementation Project: STEM Center for Research and Development – Increasing Minority Students in STEM Disciplines	DC	University of the District of Columbia
Research Initiation Award: Marking the Drosophila eye imaginal disc landscape with positional coordinates for precursor stem cell formation	MO	Harris Stowe State College
CREST Center for the Integrated Study of Coastal E	MD	University of Maryland Eastern Shore
Targeted Infusion Project: Infusing Machine Learning in Cognitive Psychology and Cognitive Bias Analysis: Enhancement of the Computer Science and Psychology Curricula	TN	Fisk University
Implementation Project: Achieving Greater Confidence and Competence in Quantitative and Computational Skills in STEM Disciplines at Fisk University	TN	Fisk University
Targeted Infusion Project: Strengthening the Undergraduate STEM Curriculum at Fisk University through the Infusion of Computational-Biological content in Pre-Calculus	TN	Fisk University
CREST: Center for Biological Signature and Sensing	TN	Fisk University
Research Catalyst: Laminated Object Manufacturing (LOM) of Composites using Bio-fiber Reinforcements Infused with Thermoplastic Bio-resins	TX	Prairie View A & M University
Targeted Infusion Project: Innovating the Research Educational Experiences in Johnson C. Smith University's lower/upper level Chemistry Courses	NC	Johnson C. Smith University
Broadening Participation Research: Investigating Faculty Influences on STEM Degree Production at HBCUs	TX	Prairie View A & M University
Implementation Project: Lincoln's Excellent Academic Program in Science – Transformation (LEAPS-T)	PA	Lincoln University

Research Initiation Award: Understanding Concentrated Fiber Suspensions and Deformation of Flexible Fibers in Fiber Reinforced Composite Materials Processing	TX	Prairie View A & M University
Implementation Project: Increasing Degree Production through STEM Entrepreneurship and Career Development Activities	MO	Harris Stowe State College
Excellence In Research : HBCU Collision Collaboration – J/psi Peripheral Collision Analysis and Detection	DC	Howard University
Research Initiation Award: Characterization and development of young leaves of Glyphosate Susceptible Amaranthus palmeri vs Glyphosate Resistant Amaranthus palmeri after exposure	TX	Prairie View A & M University
Collaborative Research: The Texas A&M System AGEP Alliance: A Model to Advance Historically Underrepresented Minorities in the STEM Professoriate	TX	Prairie View A & M University
Research Initiation Award: Establishment of an Integrated Analysis, Control Design and Implementation Framework for Hybrid Dynamical Systems with Constraints	TX	Prairie View A & M University
Broadening Participation Research Project: Investigating the Integration of Mathematics into Biology by Reciprocal Course Content Exchange	TN	Fisk University
Targeted Infusion Project: Active Learning Integrated Nuclear Engineering Education (ALINE)	AL	Alabama A&M University
Research Initiation Award: Uncertainty Modeling, Probabilistic Models, and Life-cycle Reliability of Floating Offshore Wind Turbines	TX	Prairie View A & M University
Metacommunity for Broadening Participation in STEM Undergraduate Education	DC	Association of American Colleges and Universities
Research Initiation Award: Uncovering the Role of Germline-Specific MAGE-B2 Protein in Maintenance of Cellular Identity	TN	Fisk University
HBCU-UP RIA: Isolation and identification of novel chemical entities from marine microorganisms	TN	Fisk University
Center for Advancing the Societal Impacts of Research	MO	University of Missouri-Columbia
Broadening Participation Research: Applying Innovative Culturally Responsive Pedagogy for African American Middle School Teachers and Students to Broaden the STEM Pipeline	TX	Prairie View A & M University
Catalyst Project: Biological Experiences Strengthen Talent through Interdisciplinary (BEST IN) Forensic and Investigative Genomics	TX	Prairie View A & M University
Breakdown of Rotational Invariance in Quantum Hall Systems with Anisotropic Interaction	TX	Prairie View A & M University
Targeted Infusion Project: Building a Learner-centered Cyberlearning Environment in Computer-Aided Design Education	TX	Prairie View A & M University
EAGER: Beam particle tracking for the MUSE experiment at PSI	VA	Hampton University
Targeted Infusion Project: Integrative Makers Course and Laboratory for STEM Undergraduates	AL	Tuskegee University
REU Site: Tuskegee University Research Experience for Undergraduates in Nano-Bio Materials Science and Engineering	AL	Tuskegee University
The Tuskegee Partnership for Personal Authenticity in College Mathematics	AL	Tuskegee University

Adapting an Experiment-centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines	MD	Morgan State University
Excellence in Research: Navigating the Double Bind: Assessing the Development and Contribution of Identity Shifting to the Recruitment & Retention of Black Women in STEM Educat	GA	Spelman College
Enhancing Additive Manufacturing Education with Cybersecurity and Virtual Reality	LA	Southern University
EAGER: MAKER: Promoting "Culturally Relevant Making" and Utilitarian Scientific Literacy to Increase Student Retention in Technology Rich Disciplines Brian Lawrence (PI), Lycurgus	GA	Morehouse College
Bridging Our Students to Their Future	OH	University of Cincinnati Main Campus
Excellence in Research: Numerical Analysis of Quasiperiodic Topology	DC	Howard University
A Model to Explain the Institutional and Student Characteristics Related to STEM Baccalaureate Graduates from Historically Black Colleges and Universities Who Earn Doctoral Degrees	DC	QUALITY EDUCATION FOR MINORITIES NETWORK
Experimental Studies of the QCD Structure of the Neutron	VA	Hampton University
National Association of Mathematicians Network of Opportunities Targeting Students and Faculty at HBCUs	GA	Morehouse College
Excellence in Research: Reconfigurable Supply Chain Network Design and Assembly Planning for Factory-in-a-Box Manufacturing	FL	Florida Agricultural and Mechanical University
HBCU Identity Research Center for STEM	GA	Morehouse College
Research Initiation Award: Ionic Liquid Derived and Assisted Green Catalytical System for the Small Molecule Sustainable Conversion	LA	Xavier University of Louisiana
NCA&T ADVANCE Institutional Transformation: Catalyzing Gender, Leadership, and Scholarship Equity through Institutional Change for All	NC	North Carolina Agricultural & Technical State University
Catalyst Project-Life STEM: Enhancing the Undergraduate Biology Curriculum to Increase Student Engagement	MS	Tougaloo College
Collaborative Research: Molecular Mechanisms of Astrocyte Neuron Interactions in the Development of Synchronous Activity in Neuronal Networks	DE	Delaware State University
Implementation Project – Center for Engineering and Science	SC	Benedict College
Broadening Participation Research: Fostering Retention in STEM Disciplines at Minority Serving Institutions	AL	Tuskegee University
Research Initiation Award: Optimization and Enhancement of Hepatic Differentiation for Mesenchymal Stem Cells via Biofunctional Modification	WI	Medical College of Wisconsin
The Impact of Making and Innovation at Historically Black Colleges and Universities	DC	American Association For Advancement Science
Research Initiation Award: Arsenic speciation in sulfidic environments	SC	Voorhees College
Targeted Infusion Project: Enhancement of Materials Science Education through Active Learning at Florida A&M University	FL	Florida Agricultural and Mechanical University
Research Initiation Award: Direct Numerical Simulation for Shock/Turbulence Interaction with Applications to Supersonic Cavity Flows	AL	Tuskegee University

Examining the Impact of a Learning Community Model and Critical Pedagogy on Minority Student Retention in STEM	SC	Benedict College
Research Initiation Award: An Intelligent Optimization, Clustering and Classification Framework for High Dimensional, Overlapped Classes, and Imbalanced Data	DC	University of the District of Columbia
Collaborative Research: Molecular Mechanisms of Astrocyte Neuron Interactions in the Development of Synchronous Activity in Neuronal Networks	DC	Georgetown University
Broadening Participation Research: Strategic Application of Science Capital to Increase African-American Students' Motivation, Retention and Persistence in STEM at an HBCU	NC	North Carolina Agricultural & Technical State University
Implementation Project: The DREAM STEM Project: Enhancing Academics, Entrepreneurship, and STEM Career Pathways	NC	North Carolina Central University
Targeted Infusion Project: Infusion of POGIL, Technology and Research into the Chemistry Curriculum to Increase Students' Success	MS	Tougaloo College
Targeted Infusion Project: Addressing the "M" in STEM – Utica Campus Community College (UC3) Improving Interventions and Instruction (I3) through STEM	MS	Hinds Community College-Utica
Targeted Infusion Project: Infusion of Geospatial Informatics to Enhance an Undergraduate Biological Science Program	TX	Texas Southern University
Implementation Project: Hinds Community College- Utica Campus Phase II- Establishing a Cohesive Community College STEM Institutional Transformation Academy – STEM-UP Academy	MS	Hinds Community College-Utica
Emerging Researchers National (ERN) Conference in STEM	DC	American Association For Advancement Science
Conference on Nonparametric Statistics	NC	North Carolina Central University
Research Initiation Award: QoS-Aware Energy Management for Sustainable Real-Time Embedded Systems	WV	West Virginia State University
Targeted Infusion Project: Engagement, Retention and Innovation in Physics Instruction	MD	University of Maryland Eastern Shore
Implementation Project: Science Community of Active Learners to Enhance Achievement and Retention	FL	Florida Agricultural and Mechanical University
Catalyst Project: Integrated Learning of Sleep Science	GA	Fort Valley State University
Preparing Diverse STEM Researchers to Address Global Challenges	DC	American Association For Advancement Science
STEM Equity Achievement (SEA Change)	DC	American Association For Advancement Science
Catalyst Award: Exploring Free Living Nematode Microbiome through Marker Gene-Based and Shotgun Metagenomic Sequencing of Single Nematodes	NC	Elizabeth City State University
Targeted Infusion Project: Establishment of a Computer Engineering Research Lab (CERL) at Southern University and A&M College	LA	Southern University
Partnership for Research and Education in Nanomaterials between Pennsylvania State University (PSU) and North Carolina Central University (NCCU)	NC	North Carolina Central University
MRI: Acquisition of an ion chromatograph mass spectrometer for research and education	SC	Voorhees College
Research Initiation Award: Regulation of Gene Expression by the CD44-ICD Signaling Pathway	DE	Delaware State University
Broadening Participation in Life STEM Workshop	GA	Spelman College

The AGEP Florida Alliance Model: Improving Minority Women Success in STEM Faculty Careers	FL	Bethune-Cookman University
Targeted Infusion Project: Stem: PipeLine for Plant Sciences	NC	Elizabeth City State University
The AGEP Florida Alliance Model: Improving Minority Women Success in STEM Faculty Careers	FL	Florida Memorial University
Research Initiation Award: Uncertainty Quantification of Multi-Phase Porous Media Flows on GPUs	OH	Central State University
Building Capacity in the Behavioral Sciences to Improve the Quality of Life on the Lake Traverse Reservation	SD	Sisseton Wahpeton Community College
Research Initiation Award: Functional Characterization of Arabidopsis RmlC-like Cupins Superfamily Proteins	WV	West Virginia State University
BDPA Collegiate Chapter Planning Workshop	GA	Morehouse College
Excellence in Research: InnovAtive Methods and Advanced Science at Alabama State University (IAM-ASU)	AL	Alabama State University
Collaborative Research: The Tuskegee Alliance to Develop, Implement and Study a Virtual Graduate Education Model for Underrepresented Minorities in STEM	AL	Alabama State University
Integration of Virtual Reality (VR) to Support Technology-based Active-learning and Retention: iVR to STAR	AL	Tuskegee University
Broadening Participation Research Project: Research for Social Justice – Broadening Participation through Data Science	NC	North Carolina Central University
Targeted Infusion Project: Enhancing the Undergraduate Computing Curriculum by Infusing Cybersecurity and Digital Forensics Concepts	AL	Alabama State University
Planning Grant: Bridging the STEM Gap – Enhancing STEM Education Using a Multitier Approach	SC	South Carolina State University
EAGER: Investigating the Use of Carbon Monofilament Wires to Improve the Design of the Slow Proton Recoil Detector for the Jefferson Lab BONuS12 Experiment	VA	Hampton University
Physics Research Experience for Undergraduates Site at AAMU	AL	Alabama A&M University
Research Initiation Award: Identification and Characterization of Cofactor-Linked RNAs in Plants	NC	Saint Augustine's College
Research Initiative Award: Deciphering the Molecular Mechanisms Preceding the Aging Skeletal Muscle Phenotype	MD	Bowie State University
Data Driven, Engagement Based, Adaptive Learning, Growth Mindset Pedagogy Informed Course Redesign with Early Research Experiences for STEM Student Success	GA	Clark Atlanta University
Targeted Infusion Project: New Physics and Astronomy Program at the University of The Virgin Islands	VI	University of The Virgin Islands
Research Initiation Award: Next generation sequencing (NGS) of Freedom Giant Miscanthus (Miscanthus giganteus)-associated fungal communities	MS	Alcorn State University
Broadening Participation Research Project: Examining the Efficacy of a Virtual STEM Peer Mentorship Program	DC	University of the District of Columbia
Targeted Infusion Project: A Redesign of First Year Mathematics Courses Using Evidence-Based Strategies	GA	Clark Atlanta University

REU Site: Collaborative Research: Genomics and Computational Biology	GA	Clark Atlanta University
Broadening Participation Research Project: Investigating the Impact of Collaborative Project-Based Learning on the Self-Efficacy of Minority STEM Students	MD	Bowie State University
Research Initiation Award: Toward Bionanoscience – Binding of Amino Acids with Graphene and N-doped Graphene	GA	Clark Atlanta University
Chequamegon Heterogeneous Ecosystem Energy-balance Study Enabled by a High-density Extensive Array of Detectors	WI	University of Wisconsin-Madison
Excellence in Research: Modulation of Synaptic Neurotransmitter Levels by Auto-receptors	DE	Delaware State University
Investigating the Effects of Socioscientific Argumentation Development on Student Academic Success	FL	Bethune-Cookman University
Research Initiation Award: Subatomic Physics at Virginia Union University	VA	Virginia Union University
Research Initiation Award: Antagonistic Bacteriophage and Metal Combination Treatment to Combat the Spread of Antimicrobial Resistance	NC	Bennett College
JSU-UCSB Partnership For Research and Education in Materials Science	MS	Jackson State University
Research Initiation Award: Mathematical model of the impact of social behavior in the transmission dynamics of HIV epidemics	AZ	Arizona State University
Broadening Participation Research Project: STEP into STEM, Investigating Successful Transitions and Effective Pathways into STEM	NC	North Carolina Agricultural & Technical State University
Computational Applications Research Engagement for Undergraduates	PA	Cheyney University of Pennsylvania
Waterbird Society – Workshop to Increase Diversity in STEM	MD	University of Maryland Eastern Shore
Catalyst Award: Assessing the Role of Natural Compounds on Mechanisms of Apoptosis in RT4-D2P6T cells	NC	Johnson C. Smith University
Collaboration to Enhance Participation of Minority and Undergraduate Students in Nuclear Science	MI	Michigan State University
HBCU-UP NSF Workshop and Outreach Day at Virginia Union University	VA	Virginia Union University
Technical Symposium for Students Underrepresented in STEM	MD	Morgan State University
Targeted Infusion Proposal: Course Development for a 21st Century Smart Grid Workforce	DC	University of the District of Columbia
The AGEP Data Engineering and Science Alliance Model: Training and Resources to Advance Minority Graduate Students and Postdoctoral Researchers into Faculty Careers	TX	Texas Southern University
Excellence in Research: Wave Effects on the Dynamics of a Multiple-Inlet Bay System During Storms	MD	University of Maryland Eastern Shore
Engaging Howard University Computer Science Students in Interactive Human-Centered Computing Infused Curricula	DC	Howard University
TARGETED INFUSION PROJECT: Providing Opportunities to Minority Students in STEM (PrOMiSS)	NC	Fayetteville State University
Implementation Project: Strengthening Student Success in STEM (S^4)	NC	Fayetteville State University

Targeted Infusion Project: Cybersecurity for Everybody – A Multi-Tier Approach to Cybersecurity Education, Training, and Awareness in the Undergraduate Curriculum	SC	South Carolina State University
Targeted Infusion Project: Infusion of Cyber Physical System Education and Research Training in the Undergraduate Curriculum in the College of Engineering at TSU	TN	Tennessee State University
Research Initiation Award: RNA-Seq Based Analysis of the Streptococcus parauberis transcriptome	VA	Norfolk State University
CREST Phase II: Computational Center for Fundamental and Applied Science and Education at North Carolina Central University	NC	North Carolina Central University
Research Initiation Award – Cellulosic Ethanol Production from Major Feedstocks: Insights from Yeast Transcriptomics	MS	Alcorn State University
Research Initiation Award: Towards Realizing a Self-Protecting Healthcare Information System for the Internet of Medical Things	TX	University of Texas at San Antonio
Targeted Infusion Project: Integration, Cultivation, and Exposure to Biomedical Engineering at the University of the District of Columbia	DC	University of the District of Columbia
Implementation Project: Preparing Interdisciplinary Minority Material Scientists and Engineers of the Future	MI	Oakland University
Research Initiation Award: Investigation of mechanisms underlying pathological rhythms in parkinsonian basal ganglia – A mathematical modeling study	NC	North Carolina Agricultural & Technical State University
Targeted Infusion Project: Infusion of Computational Science Based Data Analytics Coursework and Research to Strengthen and Enrich the Lane College Undergraduate Chemistry Program	TN	Lane College
Catalyst Project: Diversity of ecosystem services provisioning in coastal socio-ecological systems	DE	Delaware State University
Targeted Infusion Project: STEM-Business Focused Logistics and International Trade (LIT) Analytics	DC	University of the District of Columbia
Infusing Learning Initiatives for Improving the Programming Proficiency of Computer Science Majors at Morgan State University	MD	Morgan State University
Targeted Infusion Project: Academic Enhancement of Biology, Ecology and Environmental Sciences Programs at Tennessee State University	TN	Tennessee State University
Targeted Infusion Project: Mathematical Engagement for the Marine, Biological, and Environmental Realms of Science (MEMBERS)	VA	Hampton University
Targeted Infusion Project: Integrating Artificial Intelligence in Computer Science majors at Hampton University	VA	Hampton University
Targeted Infusion Project: Academic Enhancement of Electrical & Computer Engineering Program at Tennessee State University through IoT Research and Integrated Learning Environm	TN	Tennessee State University
Targeted Infusion Project: Engaging Undergraduates in STEM using Drosophila Behavioural Genetics (EUSTEM-DaBuGs TIP)	NC	North Carolina Central University
HBCU-Excellence in Research: Vertical Profiles of Aerosols and Their Radiative Impacts	DC	Howard University
Planning Project: Improving Retention and the Quality of STEM Education and Research at Oakwood University	AL	Oakwood College

Research Initiation Award: Physical forces impacting the temporal variability of mesopelagic prey at the Cape Hatteras marine top-predator diversity hotspot	GA	Savannah State University
Broadening Participation Research Project: Promoting Rural Opportunities for Student Achievement in STEM (PRO-STEM)	NC	North Carolina Central University
Targeted Infusion Project: Innovative Jarvis Undergraduate Mathematics Program (I-JUMP): Embedding Computational and Mathematical Biology into Life STEM	TX	Jarvis Christian College
Targeted Infusion Project: Course Based Research Experiences for all Biology freshmen: A model for increased retention	LA	Xavier University of Louisiana
Targeted Infusion Project: Nurturing Science Identity through Culturally Relevant Organic Chemistry Laboratories	GA	Spelman College
Targeted Infusion Project: Infusion of Active and Problem-Based Learning for Teaching and Research in the Context of Transportation Disruptive Technologies	SC	Benedict College
Implementation Project – Collaborative Methods for Addressing Student Success in Totality (CMAST III)	LA	Grambling State University
Targeted Infusion Project: Infuse Cybermanufacturing Concepts to Manufacturing Processes and Automation Courses	VA	Virginia State University
Catalyst Project: Identification of Effective Heat Conductivity Coefficient of Particulate Two-phase Materials	GA	Savannah State University
Research Initiation Award: A model plant group to study the evolution of diverse reproductive systems	DC	Howard University
Research Initiation Award: Fast Solvers for Variable-Coefficient Poroelastic Models	MD	Morgan State University
Implementation Grant: Pi-STEM E3 (Pathways into STEM Careers, Enrichment, Engagement, and Empowerment)	AL	Lawson State Community College
Targeted Infusion Project: STAR (Successfully Transitioning into the Academic Realm) Program at VSU	VA	Virginia State University
Broadening Participation Research Project: Effects of Innovative Mathematics Instruction Methods on Student Attitude, Self-efficacy, Effort and Performance	NC	North Carolina Agricultural & Technical State University
Targeted Infusion Project: Collaborative Science Initiative (CSI) Delaware	DE	Delaware State University
Targeted Infusion Project: A Multidisciplinary Approach to Infusing Data Science and Analytics into the Undergraduate Curriculum at Bowie State University	MD	Bowie State University
ACE Implementation Project: Data Science and Analytics Advancing STEM Education at North Carolina A&T State University	NC	North Carolina Agricultural & Technical State University
Research Initiation Awards: Synthesis of biomimetic melanin-like multifunctional nanoparticles for pH sensitive magnetic resonance imaging and photothermal therapy	MS	Jackson State University
Research 109nitiation Award: Long Time Behavior for Systems of Coupled Partial Differential Equations	VA	Virginia State University
Research Initiation Award: Investigation of Coherent Elastic Neutrino-Nucleus Scattering	NC	North Carolina Central University
Targeted Infusion Project: Developing the Geospatial Data Analytics Certificate Program at Fayetteville State University	NC	Fayetteville State University

Research Initiation Award – Experimental and Multiscale Simulation Study of Nanoscale Thermal Transport and Evaporation/Boiling Heat Transfer using Self-assembled Nanoemulsions	DC	University of the District of Columbia
Research Initiation Award: Integrating Image and Text Information for Biomedical Literature-Based Cross and Multimodal Retrieval	MD	Morgan State University
Targeted Infusion Project: The Intersection of Biology and Chemistry: Enhancing STEM Student Performance in Undergraduate Chemsitry Courses Using an Integrative Curriculum Approach	VA	Norfolk State University
Research Initiation Award: Engineered demographic-specific in vitro microfluidic bone microenvironment models	VA	Hampton University
Research Initiation Award: Predictive Models for Wind-Penetrated Power Systems Using Bayesian Approach	DC	University of the District of Columbia
Broadening Participation Research Project: Charting a Path to Trans-disciplinary Collaborative Design	VA	Hampton University
Targeted Infusion Project: Integrating Risk and Resilience into Undergraduate Engineering Education Towards a Hazard-Resilient Built Environment	DC	University of the District of Columbia
Research Initiation Award: Robust Management of Earthen Levee Stability in the Face of Uncertainty for Resilient Geotechnical Infrastructures	DC	University of the District of Columbia
RESEARCH INITIATION AWARD: Investigating a new Generation of Assistive, Innovative Technologies (GAIT) for balance rehabilitation	DC	University of the District of Columbia
Catalyst Project: Creating and Evaluating a Culturally Representative STEM Curriculum Supported by Next Generation Science Standards	DC	Howard University
Life STEM-Planning Project: Streamlining the Biology Curriculum and Improving the Quality of Student Academic Preparation and Achievement	SC	Morris College
CAREER: Investigating environmental acidification and temperature as drivers of morphological alteration and physiological deficits in auditory systems of soniferous fishes	VA	Hampton University
Targeted Infusion Project: Creation of a for Credit Online Scientific Literacy Pre-Freshmen Summer Bridge Program	GA	Morehouse College
Broadening Participation Research Project: Experimenting with an Augmented Reality Facilitated Instructional Model to Enhance STEM Education	MS	Jackson State University
Research Initiation Award: Thermodynamic Phase Separation in a Living, Active Matter System	NC	North Carolina Agricultural & Technical State University
Research Initiation Award: Remote Sensing for Flood Modeling and Management	NC	North Carolina Agricultural & Technical State University
HBCU-DCL EAGER: Virtually Preparing Underrepresented Students for the Engineering and Computer Science Professoriate Using Embodied Conversational Agents	GA	Morehouse College
Excellence in Research: A Network-centric Framework for Cyber Threat Intelligence	GA	Clark Atlanta University
Implementation Project: Advancing Success in STEM Undergraduate Research and Education (ASSURE)	AL	Alabama A&M University
Research Initiation Award: Mechanisms regulating intrinsic levels of antimicrobial resistance in planktonic cells and biofilms of commensal Neisseria	GA	Spelman College

Targeted Infusion Project: Enhancement of Jarvis Christian College Course-based Undergraduate Research Experiences (J-CURE) Program in the Biological Sciences	TX	Jarvis Christian College
Reviving and Strengthening STEM Instructional and Research Programs to Increase Minority Students Participation at Kentucky State University	KY	Kentucky State University
Catalyst Award: Plant and Rhizosphere Processes that Prevent Groundwater Contamination from Metals and Nitrates	NC	North Carolina Agricultural & Technical State University
Research Initiation Award: Designing Efficient Access Control Schemes for Implantable Medical Devices	NC	Fayetteville State University
Catalyst Award: Visible-range heterojunction nanofiber photocatalysts for water splitting: The effect of co-catalysts	FL	Florida Agricultural and Mechanical University
Research Initiation Award: Novel Perovskite Solar Cells Based on Interface Manipulation	MS	Jackson State University
Advancing the Research Profile of Small and Mid-Sized Historically Black Colleges and Universities Through a Virtual Proposal Development Center	MS	Jackson State University
Research Initiation Award: Environmentally friendly high performance perovskite solar cell with fortified stability	GA	Albany State University
Catalyst Project: Modeling Count Data with the Conway-Maxwell-Poisson Distribution	NC	North Carolina Central University
Research Initiation Award: Novel Imidazole Compounds to Investigate the Unfolded Protein Response (UPR)	MD	Bowie State University
Research Initiation Award: Spatial organization and temporal coordination involved in secretory vesicle trafficking and exocytosis in live cells	DC	Howard University
Catalyst Project: The Construction of the Inscribed Polygonal Periodic Functions	GA	Clark Atlanta University
Research Initiation Award: Computational Inference of Mechanisms Underlying Double Minute Chromosome Formation	LA	Xavier University of Louisiana
Research Initiation Award: A Symmetry-Adapted Perturbation Theory Approach to Reaction Force Analysis	GA	Morehouse College
Research Initiation Award: Using Zebrafish (Danio rerio) as a model to assess the role of insulin receptor signaling in renal epithelial transport function.	MD	University of Maryland Eastern Shore
Research Initiation Award: Metagenomic Approach to Assess Water Quality and Microbial Load Variability of an Urban Watershed	GA	Morehouse College
Research Initiation Award: Investigation on Tribo-charging Behavior of Agricultural Particles in the Development of Water-free Bio-separation Approach for Biomass Residues	DC	Howard University
Targeted Infusion Project: Developing a Cloud-based Cryptographic Simulator for Enhancing Undergraduates' Learning Experience in Cybersecurity Education	MD	Bowie State University
Research Initiation Award: Toward understanding the mechanisms for brain activity patterns by modeling networks of multi time- and amplitude-scale dynamical systems.	GA	Clark Atlanta University
REU Site in Physics at Howard University	DC	Howard University
Research Initiation Award: Search for the Epigenomic Mechanisms of Paternal Inheritance of Aggression in Social Honeybees	OH	Central State University

Research Initiation Award: Stochastic and Deterministic Solutions to Unsteady Nanofluid Mixed Convection Problems	GA	Albany State University
Research Initiation Awards: Tidal flow drives the viral community composition in the soil of intertidal zones	VA	Norfolk State University
Research Initiation Award: Investigating the Structure-Property Relationships of Solid Polymer Electrolytes for Lithium Ion Batteries	LA	Xavier University of Louisiana
Research Initiation Award: Structure-Property Relationships of Non-Fullerene Acceptors for Photovoltaic Applications	NC	Fayetteville State University
Research Initiation Award: Mathematical Modeling On the Geometric Optics Problem of Refraction	DC	Howard University
Research Initiation Award: Quantifying the effects of ocean acidification on visual and auditory neurobiology in marine fishes	VA	Hampton University
Research Initiation Award: Mechanisms of Interaction of Glyco-gag with Restriction Factors	GA	Savannah State University
Catalyst Project: Computational Research On Music and Audio	MO	Lincoln University
REU Site: Undergraduate Research Experience in Genomics, Proteomics and Bioinformatics	FL	Florida Agricultural and Mechanical University
Characterization of Biomolecular Response to Environmental Stress	TX	Texas Southern University
Research Initiation Award: Probing inter-compartmental cross-talk between redox and amylin signaling networks	GA	Spelman College
CAREER: Integrated Research and Education for Professional Identity Development in Undergraduate Architecture, Engineering, and Construction (AEC) Women	NC	North Carolina Agricultural & Technical Stat//e University
Excellence in Research: Neuroanatomy and development of mammalian homeostatic sleep regulation	GA	Morehouse School of Medicine
Targeted Infusion Project – Building on A Foundation of Stone: The Future Growth of Wiley College's Division of Sciences	TX	Wiley College
Workshop to Promote Participation of HBCUs in Advanced Manufacturing Research Related to the Manufacturing USA Institutes; Alexandria, Virginia; June 19-21, 2019	MD	Morgan State University
Collaborative Research: The AGEP Engineering Alliance: A Model to Advance Historically Underrepresented Minority Postdoctoral Scholars and Early Career Faculty in Engineering	FL	Florida Agricultural and Mechanical University
REU: Global Engagement Research Experience for Undergraduate Students in Food Security: A focus on Indigenous Vegetables and Grain Crops; the "Forgotten Food" Crops of Kenya	MD	Bowie State University
GP:IMPACT: Collaborative Research: TSU-Vanderbilt Partnership – A Pathway to Broaden Participation of Underrepresented Groups in Graduate School and the Geoscience Workforce	TN	Tennessee State University

Note: National Science Foundation, Research Areas. 2019. Arlington, VA. Available at https://www.nsf.gov/about/research_areas.jsp.

Appendix B

Total Institutions Awarded by State HBCU–Undergraduate Program

Total	
State	**Funded**
Alabama	25
Arkansas	2
Arizona	2
California	3
District of Columbia	42
Delaware	11
Florida	13
Georgia	43
Kentucky	1
Louisiana	10
Maryland	26
Michigan	2
Missouri	6
Mississippi	23
Montana	1
North Carolina	68
Ohio	4
Pennsylvania	6
South Carolina	10
South Dakota	1
Tennessee	17
Texas	27
Virginia	30
Virgin Islands	5
Washington	1
Wisconsin	2
West Virginia	2

Note: National Science Foundation, Research Areas. 2019. Arlington, VA. Available at https://www.nsf.gov/about/research_areas.jsp.

Appendix C

Group A – Institutions with program

Group B – Institutions without program

Group A – Top Ten rankings for effectiveness
in STEM colleges and Universities
Independently ranked

Top Ten Rankings for STEM Colleges and Universities

Group A and Group B Institutions
Alabama A & M University – Group A
Alabama State University – Group A
Albany State University – Group A
Alcorn State University – Group A
Allen University – Group B
American Baptist College – Group B
Arkansas Baptist College – Group B
Benedict College – Group A
Bennett College - Group A
Bethune-Cookman University – Group A
Bluefield State College- Group B
Bowie State University – Group A
Central State University – Group A
Cheyney University of Pennsylvania – Group A
Claflin University – Group A
Clark Atlanta University – Group A
Clinton College – Group B
Concordia College Alabama – Group B
Coppin State University – Group B
Delaware State University – Group A
Denmark Technical College – Group B
Dillard University – Group A
Edward Waters College – Group B
Elizabeth City State University – Group A
Fayetteville State University – Group A
Fisk University – Group A
Florida Agricultural and Mechanical University – Group A
Florida Memorial University – Group A

Fort Valley State University – Group A
Grambling State University – Group A
Hampton University – Group A
Harris-Stowe State University – Group A
Howard University – Group A
Huston-Tillotson University – Group A
J. F. Drake State Community and Technical College – Group A
Jackson State University – Group A
Jarvis Christian College – Group A
Johnson C Smith University – Group A
Kentucky State University – Group A
Lane College – Group A
Langston University – Group B
Le Moyne-Owen College – Group B
Lincoln University 1 – Group A
Lincoln University 2 – Group A
Livingstone College – Group A
Meharry Medical College – Group B
Miles College – Group B
Mississippi Valley State University – Group A
Morehouse College – Group A
Morehouse School of Medicine – Group A
Morgan State University – Group A
Morris College – Group A
Norfolk State University – Group A
North Carolina A & T State University – Group A
North Carolina Central University – Group A
Oakwood University – Group A
Paine College – Group B
Paul Quinn College – Group B
Philander Smith College – Group B
Prairie View A & M University – Group A
Rust College – Group B
Saint Augustine's University – Group A
Savannah State University – Group A
Selma University – Group B
Shaw University – Group A
Shorter College – Group B
Simmons College of Kentucky – Group B
South Carolina State University – Group A

Southern University and A & M College – Group A
Southern University at New Orleans – Group A
Southern University at Shreveport – Group A
Southwestern Christian College – Group B
Spelman College – Group A
St Philip's College – Group A
Stillman College – Group B
Talladega College – Group B
Tennessee State University – Group A
Texas College – Group B
Texas Southern University – Group A
Tougaloo College – Group A
Tuskegee University – Group A
University of Arkansas at Pine Bluff – Group A
University of Maryland Eastern Shore – Group A
University of the District of Columbia – Group A
University of the Virgin Islands – Group A
Virginia State University – Group A
Virginia Union University – Group A
Virginia University of Lynchburg – Group A
Voorhees College – Group A
West Virginia State University – Group A
Wilberforce University – Group B
Wiley College – Group A
Winston-Salem State University – Group A
Xavier University of Louisiana – Group B

Note: Group A institutions consistently ranked as best in STEM for * 3 independent organizations. (2017, 2016, 2015, 2014). http://www.thehundred-seven.org/stem.html.