

REDEFINING SCIENCE, TECHNOLOGY, ENGINEERING, AND
MATHEMATICS (STEM) EDUCATIONAL OPPORTUNITIES
FOR UNDERSERVED AND UNDERREPRESENTED
STUDENTS AT NASA

by

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ABSTRACT

Underserved and underrepresented students consistently leave science, technology, engineering, and mathematics (STEM) degree fields to pursue less demanding majors. This perpetual problem slowed the growth in STEM degree fields (United States Department of Labor, 2007). Declining enrollment in STEM degree fields among underserved and underrepresented students weakens the ability of the United States to remain competitive with the global community in high-tech industries. As demographics in the U.S. continue to shift towards a more diverse populous, the need to attract underserved and underrepresented students to STEM degree fields proves imperative.

For the purposes of this qualitative study, underserved and underrepresented undergraduates at two Historically Black Colleges and Universities (HBCUs) and one Hispanic Serving Institution (HSI) participated in 30 interviews. These interviews gauged student interest in STEM as a result of participation in the NASA University Research Centers (URCs) project, and sought to identify factors that deterred students from persisting in STEM degree fields by using a self-efficacy framework. Self-efficacy describes the ability of students to successfully overcome perceived challenges. Recommendations for practice encompass mentoring, the development of self-efficacy, persistence, marketing, and networking.

ACKNOWLEDGEMENTS

It is my hope that the following pages will provide insight into the challenges that NASA will encounter as we enter a new era in aeronautical history. Perhaps our greatest advantage is the ability to reach our students. Countless miles have been traveled in our unending campaign to improve STEM education for those with less accessibility. This dissertation is dedicated to the collective efforts of those at NASA who work tirelessly to ensure students receive exposure to STEM education...

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CHAPTER I:

STATEMENT OF THE PROBLEM

Preparing underserved and underrepresented undergraduates for the workforce of the future in science, technology, engineering, and mathematics (STEM) fields can stimulate economic growth and gradually diminish the outsourcing of jobs in the United States (Office of the Press Secretary, 2009). The creation of unique and enriching STEM education programs that attract underserved and underrepresented undergraduates can largely benefit students. However, the U.S. still consistently fails to retain these students in STEM fields. Since the 1957 launch of Sputnik I, the quality of STEM education has come into question (McCormick, 2004). Progressive reform efforts to improve STEM education, increase persistence in STEM disciplines, and improve STEM student experiences have frequently faltered. Often underserved and underrepresented students lack appropriate role models, have difficulty financing their education, and struggle with demanding curriculum (American Association of State Colleges and Universities [AASCU], 2005). As a result, enrollment in STEM fields among underserved and underrepresented undergraduates remains sluggish (United States Department of Labor, 2007).

The Imminent Effects of Immigration on STEM

The reliance on immigrant populations to meet demands for STEM workers in the U.S. has created a complex national problem (United States Department of Labor, 2007). A panel assembled by the Software and Information Industries Association (SIIA) that included experts representing the Business Roundtable, the National Science Teachers Association (NSTA), and the House STEM Education Caucus concluded that the U.S. largely depends on immigration to meet demand in STEM fields (Foshay, 2006). Following the tragic events of September 11,

2001, Congress passed legislation to restrict immigration. Predictably this security measure debilitated U.S. companies, causing many to establish offshore research facilities. Further, as Thomas Friedman (2005) in his influential book, *The World Is Flat*, has contended, global dominance in STEM fields shifted as a result of September 11, 2001. After this unprecedented national crisis, the U.S. strictly limited immigration. Enrollment among international students “leveled off in 2002-03 and declined by 2.4% in 2003-04, which is the first drop in enrollments of students from abroad since the 1971-72 academic year” (Bollag, 2004, p. 1). If the government prohibits the immigrant population from seeking jobs and education in STEM fields, supply only marginally can meet demand (Gohn & Albin, 2006). Additionally, if access remains restricted to the U.S., many workers will locate employment closer to home (United States Department of Labor, 2007). Traditionally, whites have largely dominated the STEM fields. However, recent projections indicate a decline by 2030 in White workers. In contrast, Asian American, Indian, African American, and Hispanic populations will continue to increase. Therefore, to support a rapidly expanding and diverse population, the U.S. will need to improve the inclusiveness of the STEM workforce (Babco, 2004).

The Role of Federal Agencies

Federal agencies provide valuable and enriching STEM educational opportunities for students throughout the U.S. (Quinn & Schweingruber, 2008). To address STEM shortages among underserved and underrepresented undergraduates, the National Aeronautics and Space Administration (NASA) offers an array of education programs that inform and inspire. Collectively, NASA undergraduate programs intend to reach populations historically disregarded for STEM. The vitality of the U.S. knowledge economy depends on the growth of STEM programs that have the capacity to reach underserved and underrepresented undergraduates.

Further, as more underserved and underrepresented undergraduates pursue STEM degrees as a result of participation in NASA education programs, “the larger will be the nation’s stock of scientists and engineers, the greater will be the quality of that stock, and the greater will be the productivity of the nation’s labor force” (Leslie, McClure, & Oaxaca, 1998, p. 240).

STEM and the Knowledge Economy

The recruitment of underserved and underrepresented undergraduates to the STEM fields has become especially troublesome for the U.S. economy (Sunal, Wright, & Day, 2004). Less than 25% of African Americans and Hispanics completed bachelor’s degrees (or higher) in STEM fields in 2000 (Committee on Prospering in the Global Economy of the 21st Century, 2006). As a result, strengthening the knowledge economy has become increasingly more difficult in the U.S. The knowledge economy consists of sometimes intangible ideas, knowledge, scientific innovation, and technology (Jaffe & Trajtenberg, 2002). Ideas vary from free market capitalism in the U.S. (e.g., Friedman, 2005) to the impact of the knowledge economy on daily life (May, 2002). The need for highly skilled and educated employees frequently emerges as a commonality (Williams, 2007).

In 2006, NASA initiated an aggressive campaign in collaboration with numerous colleges and universities to address the future needs and goals of the space agency, and to ensure the national security of the knowledge economy (Taking Action Together, 2006). The International Technology Education Association (ITEA) consists of more than 80 organizations that work to promote stability and growth in the STEM pipeline and to create a prosperous knowledge economy in the U.S. Further, the ITEA works to stimulate interest in STEM fields, and provides information about the workforce to the American public. The participating organizations represent a wide range of specializations and expertise. Recognizable organizations comprise

the 80 member consortium, including: Cambridge University, the Center for the Advancement of Scholarship on Engineering Education, Carnegie Mellon University, the Federal Aviation Administration, the International Society for Technology in Education, Massachusetts Institute of Technology, the Society of Women Engineers, Texas Southern University, and Harvard University (among others). In coordination with the ITEA, NASA ambitiously seeks to make an impact on STEM education, specifically targeting underserved and underrepresented students. Similar to the goals of the ITEA, NASA also aims to attract stakeholders that can inform and educate the American public about STEM. Also largely beneficial to NASA, the ITEA serves in an advisory capacity for the development of engineering and technology curriculum.

Purpose of the Study

Undisputedly, not enough students choose to pursue STEM degrees in the U.S., creating stagnant growth in high-tech fields. For decades, the race to space captivated the American public. Children across the nation yearned to become the next astronaut to defy gravity, instilling a false sense of stability in STEM career fields. Realistically, few newly-graduated professionals possess the capability and expertise today to allow NASA to reach new heights. To address these unprecedented shortages, NASA has initiated a series of programs intended to engage and excite students about STEM (Farmer, 2009).

Since the establishment of NASA in 1958, the agency has existed as a premier space agency in the international community. Despite occasional devastating defeats from global competitors, NASA remains at the forefront of innovation and scientific advancement. However, reaching the next realm of space exploration will require NASA to develop a strategy for recruiting the most talented STEM professionals. As a result, NASA initiated a series of education programs intended to generate interest among U.S. students. The National Science

Foundation (NSF) and the U.S. Department of Education offer the bulk of STEM education programs. Nonetheless, to increase awareness relating to spaceflight initiatives and agency-wide STEM endeavors, NASA also provides education resources for undergraduate students. As the number of STEM professionals nearing retirement increases, the demand for graduates that earn science and engineering degrees will become overwhelming (Quinn, Schweingruber, & Feder, 2008).

Annually, NASA allocates more than \$200 million towards education programs that focus specifically on STEM (Smith, Morgan, & Schacht, 2003). Nonetheless, limited data exists to suggest the most valuable aspects of these programs for underserved and underrepresented undergraduates. Attrition rates for underserved and underrepresented undergraduates in STEM remains significantly higher than that of their counterparts pursuing non-STEM degrees (Yelamarthi & Mawasha, 2008). STEM education programs that provide fulfilling experiences for underserved and underrepresented undergraduates can inspire students to persist in their academic careers, and strengthen the workforce pipeline.

This qualitative study sought to identify factors for persistence in STEM degree fields among underserved and underrepresented undergraduates as student participants of the NASA University Research Centers (URCs) project. The identification of factors for persistence in STEM degree fields can allow NASA administrators to strengthen project components that participating students view as motivational and inspirational. In addition, this study identified deficiencies in the URCs project that may contribute to attrition among underserved and underrepresented undergraduates in STEM degree fields. Further, this study evaluated the perceptions and attitudes of students as participants in the URCs project. The findings can assist NASA administrators in creating programs more appealing to underserved and underrepresented

undergraduates. Face-to-face interviews and document analysis will assist in defining the most significant aspects of the URCs project to underserved and underrepresented undergraduate students at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso.

Minority University Research and Education Program (MUREP)

The Minority University Research and Education Program (MUREP), designated as one of NASA's primary STEM education initiatives, specifically targets underserved and underrepresented undergraduates and graduates. MUREP aims to stimulate interest among "students to continue their studies at all levels of the higher education continuum and earn advanced degrees in these critical fields" (NASA, 2010, para. 1). In addition, MUREP targets Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and other minority universities in an effort to improve research opportunities for students (NASA, 2009a). Under the umbrella of MUREP eight representative projects exist that include the following: 1) Motivating Undergraduates in Science and Technology (MUST), 2) the Harriett Jenkins Predoctoral Fellowship Project (JPFP), 3) the Curriculum Improvement Partnership Award for the Integration of Research into the Undergraduate Curriculum (CPAIR), 4) the NASA Science and Technology Institute for Minority Institutions (NSTI-MI), 5) MUREP Small Projects (MSP), 6) NASA Administrator's Fellowship Project (NAFP), 7) Tribal College and University Project (TCUP), and 8) University Research Centers (URCs). Figure 1.1 illustrates the projects within the MUREP framework as of 2009.

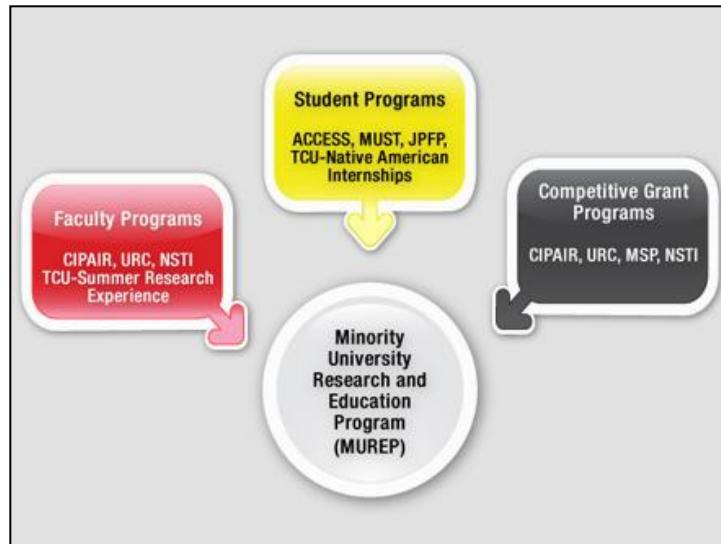


Figure 1.1. Minority University Research and Education Program (National Aeronautics and Space Administration, 2009b).

University Research Centers (URCs)

The NASA University Research Centers (URCs) project selects competitive minority institutions to conduct multidisciplinary research specific to science and/or engineering (Person, 2009). Each research initiative must align with NASA mission directorate objectives and increase faculty and student participation. The universities chosen to receive the funding (not to exceed \$1 million) facilitate research over a five-year period. Of the funding provided, 25 % must be allocated towards the support of undergraduate and graduate students.

The URCs project, established at Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and other minority institutions focus on research specific to NASA (NASA, 2010). URCs include only a select number of institutions. For the 2008 fiscal year, seven minority institutions received funding. California State University in Los Angeles, California (for the development of the NASA University Research Center SPACE Center), Florida International University in Miami, Florida (for WaterSCAPES: Science of Coupled Aquatic Processes in Ecosystems from Space), Howard

University in Washington, D.C. (for the Howard University Beltsville Center for Climate System Observation), Morgan State University in Baltimore, Maryland (for the Center of Excellence in Systems Engineering for Space Exploration Technologies), Prairie View A & M University in Prairie View, Texas (for the Center for Radiation Engineering and Science for Space Exploration), Texas Southern University in Houston, Texas (for the Center for Bio-Nanotechnology and Environmental Research), and the University of Puerto Rico—Rio Piedras Campus in San Juan, Puerto Rico (for the Center for Advanced Nanoscale Materials II) all received funding from NASA (NASA, 2008b). A total of six colleges and universities received funding for the 2009 fiscal year, including the following: 1) California State University in Long Beach, California (for the Center for Human Factors in Advanced Aeronautics Technologies); 2) Delaware State University in Dover, Delaware (for the NASA Optical Sciences Center for Applied Research); 3) North Carolina A & T State University in Greensboro, North Carolina (for the Center for Aviation Safety); 4) North Carolina Central University in Durham, North Carolina (for the NASA Center for Aerospace Device Research and Education); 5) the University of Texas in Brownsville, Texas (for the Center for Gravitational Wave Astronomy); and 6) the University of Texas in El Paso, Texas (for the Center for Space Exploration Technology Research) (NASA, 2009a).

Significance of the Study

The stability of the knowledge economy largely depends on the ability of the U.S. to produce educated workers (Williams, 2007). To remain globally competitive, the U.S. will need an expansive workforce consisting of “symbolic-analytic workers” and “self-programmable workers” (Reich, 1991, p. 231; Castells, 1997, p. 375). These workers will have the capacity to solve existing and new problems to create innovative “knowledge products” (Williams, 2007, p.

512). However, according to a 2005 statement issued by the Business Roundtable, the nation's "scientific and technical capacity is beginning to atrophy even as other nations are developing their own human capital" (Walters, 2005, para. 3). Therefore, the development of more education programs that stimulate student interest in STEM fields can advance the U.S. knowledge economy. When compared to global competition, the U.S. lags behind other more progressive countries in the number of 24-year-olds that hold degrees in natural science and engineering (Guterman, 2001). If this trend continues, the projections become bleak. Current estimates indicate a decline in graduation rates in STEM fields throughout the next decade (Kuenzi, 2008).

Historical Overview

Prior to the advent of NASA, the National Advisory Committee for Aeronautics (N.A.C.A.) assembled in 1913 for the purposes of aeronautical research (Murray & Bly Cox, 1989). N.A.C.A. hardly could receive recognition as an agency, as the organization only consisted of a few research facilities. However, N.A.C.A. proved to be popular with President Eisenhower who desperately sought to entrench the nation's aeronautical research endeavors with the organization following the launch of Sputnik I and II. In April of 1958 President Eisenhower submitted a congressional proposal to allow N.A.C.A. to assume responsibility for aeronautical research in the U.S. By October 1, 1958 the legislation received approval and in the process N.A.C.A. became NASA. Thousands of workers, "three laboratories (now renamed research centers) and two stations, with a total facilities value of \$300 million and an annual budget of \$100 million were transferred intact to NASA" (Bilstein, 1989, p. 31).

Upon the inception of NASA in 1958, the agency quickly established an itemized list of objectives that described the ambitious future of the organization. On July 29, 1958 President

Eisenhower signed the *National Aeronautics and Space Act of 1958* (Public Law #85-568) in response to the launch of Sputnik the previous year, that included provisions (Quinn, Schweingruber, & Feder, 2008) to 1) make all activities conducted in space peaceful and beneficial for mankind, ensure the security of U.S. interests in space activities; 2) develop a civilian agency to manage space activities (excluding military operations); 3) endorse the commercial use of space; 4) expand the public's knowledge relating to planetary sciences; 5) develop safe and efficient vehicles for space travel; 6) perform extensive aeronautical research; 7) assure that the U.S. remains the premier country for space travel; 8) information-share with other federal agencies; 9) encourage collaboration with other space agencies throughout the global community to eliminate the duplication of efforts; 10) emphasize a focus on research and development; 11) advance automobile propulsion systems; and 12) conduct bioengineering research "to alleviate and minimize the effects of disability" (*National Aeronautics and Space Act of 1958*, 1958, p. 3). Among other objectives, the act intended to expand the public's knowledge relating to planetary sciences. As such, the National Aeronautics and Space Act of 1958 provided for an Office of Education to educate the public, K-12 students, and undergraduate and graduate students about STEM.

The NASA Office of Education developed during a time of national uncertainty. After the launch of Sputnik I in 1957, the U.S. realized the political, economic, and societal implications of losing ground to the Soviet Union. As a result of multiple failed attempts to beat the Soviet Union into space, "education was blamed" (McCormick, 2004, p. 19). This one singular landmark event compelled the U.S. to reform science education in the hopes that more students would pursue STEM degrees. For the first time, Americans questioned the academic aptitude of their children. Many feared that inadequate STEM education would equate to

underachieving students. To quell the hysteria of the American public and to strengthen the STEM pipeline, NASA created an Office of Education. The agency sought to bring a renewed sense of global superiority in STEM fields by providing enriching experiences for students throughout the nation.

NASA Office of Education: Organizational Structure

Since the establishment of the Office of Education in 1958, NASA has demonstrated a continuous commitment to STEM education. The initial legislation gave NASA “responsibility for effectively sharing knowledge of the atmosphere and space with the public and ensuring that the U.S. remains a leader in aeronautics and space science technology” (Quinn, Schweingruber, & Feder, 2008, p. 21). The Office of Education has constantly re-structured to improve the educational services provided to undergraduates in the U.S. This assures that undergraduates have access to STEM education resources and programs, and fulfills a larger commitment to the citizens of the U.S. by encouraging scientific literacy.

To ensure effectiveness, “NASA’s Office of Education, Mission Directorates, Centers, the Office of Human Capital Management, the Office of Diversity and Equal Opportunity, and other Mission Support offices” work in close coordination (NASA, 2006, p. 16). Each individual entity works collaboratively to ensure that students receive unique educational opportunities that relate to STEM disciplines and careers fields. Historically, NASA Headquarters in Washington, D.C. managed a large majority of undergraduate education programs (Quinn, Schweingruber, & Feder, 2008). Many undergraduate programs at NASA resulted from research and exploration conducted by the agency. Generally, these NASA undergraduate programs became the responsibility of specific mission directorates. Other more general NASA undergraduate programs focused on agency-wide resources. In addition, colleges

and universities typically managed “mission-embedded projects” with oversight from NASA officials and directorate staff (Quinn, Schweingruber, & Feder, 2008, p. 16). Mission-embedded projects serve an important function. Each mission-embedded project intends to educate undergraduates, graduates, and the general public about the importance of each shuttle mission and align with NASA’s goals, objectives, and outcomes.

Prior to 2001, the Office of Education and Human Resources at NASA worked collaboratively to initiate and fund undergraduate programs. A significant change occurred at NASA between 2001 and 2005 when the Office of Education became autonomous. This elevation in status signified a more influential presence within the organization’s infrastructure. Further, this “promotion” for the Office of Education meant as much organizational recognition as that received by major enterprises like space science, earth science, biological and physical research, and others (NASA, 2006). The re-structured Office of Education sought to communicate the excitement of STEM to the next generation of explorers. Evidence “indicates that many people who grew up during the Apollo era—because they were inspired by the quest to send humans to the Moon—were attracted towards mathematics, science, or engineering” (President’s Commission on Implementation of United States Space Exploration Policy, 2004, p. 41). However, the American Institute of Aeronautics and Astronautics (AIAA) asserts that in more recent years, industry officials have noticed a significant decline in the number of students entering the workforce. Further, much of the STEM workforce now consists of foreign students that have the tendency to return to their home countries following graduation.

In 2005, Dr. Michael Griffin began his term as the new NASA administrator. Dr. Griffin quickly re-organized the infrastructure of NASA to collapse and integrate offices and enterprises in accordance with suggestions made by a post-Columbia review panel in order to increase

organizational effectiveness (Quinn, Schweingruber, & Feder, 2008). Many of the newly organized NASA offices and enterprises would report directly to the NASA administrator. In this new schema, the NASA Office of Education teamed with the Strategic Communications Office, external relations, legislative affairs, and public affairs. In addition, the new infrastructure consisted of four mission directorates (previously science and technology enterprises), including: Exploration Systems Directorate, Space Operations Directorate, Science Directorate, and Aeronautics Research Directorate. Also, many of the NASA centers began to manage education projects once housed at NASA Headquarters.

In an effort to adhere to the newly implemented structure and strategic plan, the NASA Headquarters Office of Education initiated the “education strategic coordination framework” (NASA, 2006, p. 4). The education strategic coordination framework stated, “that NASA is taking a leading role to inspire interest in science, technology, engineering, and mathematics, as few other organizations can through its unique mission, workforce, facilities, research, and innovations” (NASA, 2006, p. 3). This document integrated ideas from the National Aeronautics and Space Act of 1958, and a landmark report issued by the Committee on Prospering in the Global Economy of the 21st Century (National Academies). The 2007 report, *Rising Above the Gathering Storm* made recommendations for attracting and retaining students to STEM fields in the U.S. Among the recommendations made in the report, the Committee on Prospering in the Global Economy of the 21st Century suggested that the creation of scholarships for undergraduates to pursue STEM-related degrees at four-year universities, offering graduate students fellowships in STEM fields (administered by the NSF), allowing for a federal tax credit that would provide scientists and engineers with the opportunity to participate in continuing education, an extension on visas for international students receiving a STEM doctoral degree (to

remain in the U.S. post-graduation to seek employment), the institution of a new “skills-based, preferential immigration option” that allows international students with a STEM doctoral degree to obtain U.S. citizenship through a more lax process, and a provision that allows access to U.S. laboratories for international students and researchers (Committee on Prospering in the Global Economy of the 21st Century, 2007, pp. 9-10). Similar to the recommendations made by the Committee on Prospering in the Global Economy of the 21st Century, NASA emphatically supports the distribution of scholarships from industry officials to support undergraduates pursuing STEM degrees. In addition, NASA actively promotes industry mentors for students and job opportunities. Mentoring programs can contribute to persistence in STEM degree fields (James, 1991).

NASA Office of Education: Management Structure

The NASA Assistant Administrator for Education maintains an essential position within the agency. The Assistant Administrator coordinates and manages all education programs and facilitates annual planning (Quinn, Schweingruber, & Feder, 2008). In addition, the NASA Assistant Administrator presides over the Education Coordinating Committee (ECC) and supports educational efforts that strengthen the STEM workforce of the future (NASA, 2007c). The ECC functions to ensure the fulfillment of strategic goals, and consists of the “the assistant administrator for education, the deputy assistant administrator of education, the executive secretary to the committee, the mission directorate education leads, the education office directors of the centers, and representatives from various other NASA offices” (Quinn, Schweingruber, & Feder, 2008, p. 34). The ECC also troubleshoots programmatic issues that emerge, and assists in critical decision-making. The ECC integrates education programs and creates evaluations.

The NASA Headquarters Office of Education manages all national education programs

and assumes responsibility for compliance with the U.S. Office of Management and Budget (OMB) (Quinn, Schweingruber, & Feder, 2008). NASA also responds to external inquiries and adheres to agency-wide regulations. In addition, NASA implements the strategic framework approach and maintains partnerships with external entities. In 2004, the President's Commission on Implementation of United States Space Exploration Policy suggested that NASA partner with universities to educate the next generation of STEM professionals. Producing scientists, engineers, and astronauts has become imperative for NASA to successfully enter the next realm of space exploration. Partnerships with universities will provide the foundation for NASA to remain at the forefront of innovation. Figure 1.2 represents the infrastructure of NASA's Office of Education.

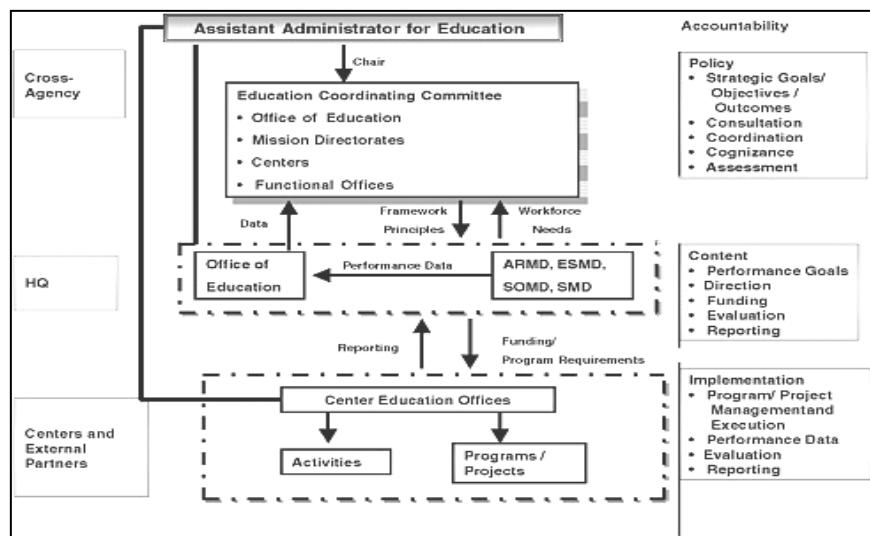


Figure 1.2. NASA education strategic coordination framework (National Aeronautics and Space Administration, 2006).

NASA Mission Directorates

Mission directorates also serve a unique purpose at NASA. Mission directorates develop education projects aligned with NASA research initiatives and flight missions (Quinn,

Schweingruber, & Feder, 2008). Each mission directorate also collaborates with NASA scientists, engineers, and universities to create education projects. Mission directorates generally establish collaborations with other federal agencies with a similar scientific focus. These collaborations increase the impact of STEM educational programs. As such, NASA should solicit the support of the “Department of Education and National Science Foundation—the two other federal government agencies that have ‘education’ in their charter” (President’s Commission on Implementation of United States Space Exploration Policy, 2004, p. 44). On February 22, 2007, NASA signed a memorandum of understanding with the NSF. This MOU will not only allow NASA and the NSF to collaborate on STEM education efforts and combine agency resources, but also more effectively reach underserved and underrepresented students (NASA, 2007b).

All 11 NASA centers manage education programs, including: Johnson Space Center, Stennis Space Center, Marshall Space Flight Center, Kennedy Space Center, Langley Research Center, Goddard Space Flight Center, Glenn Research Center, Dryden Flight Research Center, Ames Research Center, the Jet Propulsion Laboratory, and NASA Headquarters. Each center also works closely with universities “to support the generation and communication of new scientific knowledge and advancements in engineering” (Quinn, Schweingruber, & Feder, 2008, p. 34). Center education offices implement education programs both for NASA Headquarters and for the mission directorates. Further, center education offices coordinate planning efforts and report to center management. NASA Headquarters Office of Education also ensures that each center education office remains accountable for program activities and data collection. Center education offices must remain compliant with agency-instituted reporting systems to receive annual funding.

NASA Office of Education: Goals

In 1992, NASA developed the first agency-wide education strategy. The strategy developed as a result of a mandate from the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) and NASA appropriation legislation for 1992 and 1993 (Quinn, Schweingruber, & Feder, 2008). This strategy suggested “that it is NASA’s policy to use its inspiring mission, its unique facilities, and its specialized workforce to conduct and facilitate science, mathematics, engineering, and technology education programs and activities” (NASA, 1992, p. 5). While the goals for NASA have remained virtually unchanged, the administration within the Office of Education has frequently reconfigured to remain responsive to change. Also, the focus on certain goals has changed to reflect presidential and congressional agendas.

NASA’s most recent education goals include new agency-wide priorities. The first goal established by NASA includes the need to strengthen the workforce of the future (NASA, 2006). To achieve this goal, NASA emphasizes the need ensure the development of skills for the next generation of STEM professionals. In addition, NASA will structure STEM initiatives for underserved and underrepresented students at every level. Another similar goal encompasses recruiting and retaining students in STEM by supporting projects that motivate and inspire students to pursue degrees and careers relevant to NASA’s mission. Further, the agency aims to strategically form partnerships with educational institutions that “will engage students, educators, families, the general public and all Agency stakeholders to increase Americans’ science and technology literacy” (NASA, 2006, p. 4).

NASA Office of Education: Outcomes

All education programs initiated by NASA must fulfill one of three outcomes. The first outcome entails contributing to the STEM workforce in order to meet NASA's strategic goals (Quinn, Schweingruber, & Feder, 2008). The second aspires to retain students in STEM by providing educational opportunities geared towards students, faculty, and teachers. According to Outcome 3, NASA seeks to create partnerships with educational institutions that can promote enriching STEM opportunities and offer information pertaining to NASA's mission. NASA uses a pyramid figure to depict the progression of students participating in education programs. "Inspire, engage, educate, and employ" describes the objectives for students immersed in NASA education programs (NASA, 2006, p. 5). Figure 1.3 illustrates this concept.

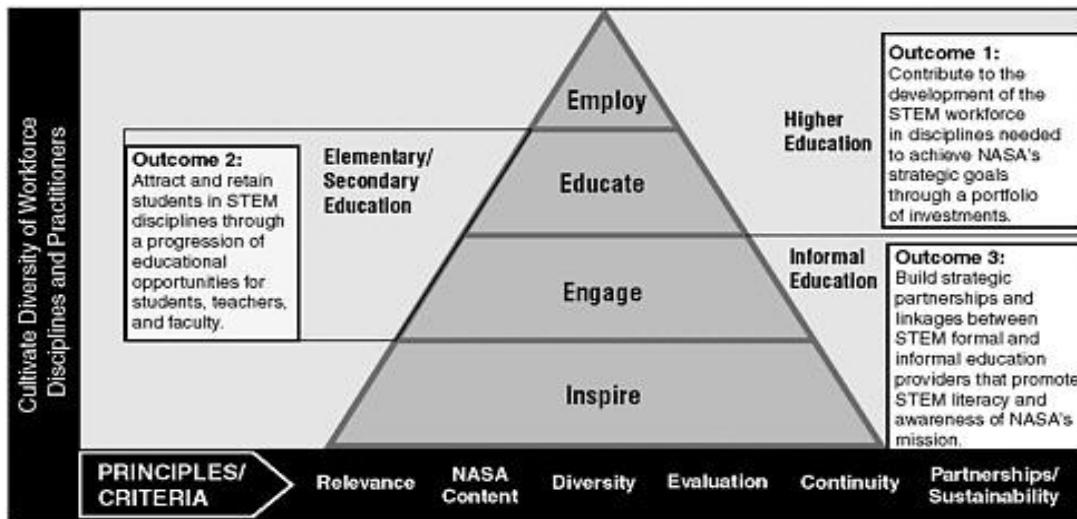


Figure 1.3. NASA education strategic coordination framework pyramid (National Aeronautics and Space Administration, 2006).

As another strategy, NASA's Office of Education integrates the idea of "push and pull" (Quinn, Schweingruber, & Feder, 2008, p. 31). Push and pull refers to inter-office partnerships that encourage elementary education programs to work collaboratively with

upper-level education programs. While the success of this activity remains largely unknown, NASA has started to “track” students to determine the impact of their experience in each program. Tracking also allows NASA to identify students that progress into higher-level education programs and into the STEM workforce pipeline.

A New Era for NASA

A new U.S. president and NASA administrator ushered in an unexpected era of growth and advancement for STEM education beginning in 2009. Upon his designation as the next U.S. President, Barack Obama listed the improvement of STEM education as a primary objective for his administration. In a State of the Union address delivered to Congress on January 25, 2011, President Barack Obama urged the next generation of STEM professionals to support growth in high-tech industries.

Half a century ago, when the Soviets beat us into space with the launch of a satellite called Sputnik, we had no idea how we would beat them to the Moon. The science wasn’t even there yet. NASA didn’t exist. But after investing in better reach and education, we didn’t just surpass the Soviets; we unleashed a wave of innovation that created new industries and millions of new jobs. This is our generation’s Sputnik moment. (Obama, 2011, p. H458)

While still in Congress, Senator Obama co-sponsored the *Enhancing Science, Technology, Engineering, and Mathematics Education (STEM) Act of 2008* in coordination with Representative Mike Honda (*Enhancing Science, Technology, Engineering, and Mathematics Education Act, 2008*). The act, which aims “to improve STEM education coordination among federal and state governments” will “provide federal agencies and states with the infrastructure required to work collaboratively, establish national STEM education goals, and to coordinate STEM education initiatives” (Honda, 2008, para. 2).

Following his inauguration, President Obama continued his drive to ensure STEM education reached the top of his agenda by launching the “Educate to Innovate” campaign on

November 23, 2009 (Office of the Press Secretary, 2009, para. 1). The campaign allocates \$260 million to STEM educational initiatives in a progressive attempt to thrust the U.S. back into the vanguard of global dominance in high-tech fields. The campaign also intends to increase STEM literacy, “improve the quality of math and science teaching,” and “expand STEM education and career opportunities” for underserved underrepresented students (Office of the Press Secretary, 2009, para. 9).

In addition, newly appointed NASA Administrator, Charlie Bolden has indicated an increasing interest for NASA education programs that emphasize STEM (Bolden, 2009b). According to a speech Bolden gave on March 24, 2010, before the House Subcommittee on Commerce, Justice, Science, and related Agencies Appropriations, NASA will invest in climate change research, research and development (R & D) for aeronautics, and STEM education (Bolden, 2010a).

Research Questions

Projects such as the University Research Centers (URCs) have the potential to motivate and inspire underserved and underrepresented undergraduates to pursue STEM degrees. Annually, NASA allocates substantial funding towards the continuation of STEM education projects intended to encourage the persistence of underserved and underrepresented undergraduates in STEM degree fields. Nonetheless, only limited data currently exists to suggest the effectiveness of these initiatives. To further examine the URCs project at NASA, two research questions guided this study. They included the following:

- 1) How do underserved and underrepresented undergraduate students experience STEM in the context of the URCs project; and

- 2) How do underserved and underrepresented undergraduates perceive the URCS project contribute to their success in STEM degree fields?

CHAPTER II:

A REVIEW OF THE LITERATURE

NASA established the Office of Education in an effort to strengthen the STEM pipeline. As such, NASA conceived multiple STEM education initiatives primarily to motivate, inspire, and retain students. As the population in the U.S. became more demographically diverse, NASA began to tailor education programs specifically to meet the needs of underserved and underrepresented students. The competitiveness of the U.S. has become largely dependent on minorities, as they “represent an untapped resource. Although efforts have been made to attract and retain these groups in STEM over the past 25 years, little progress has been made to date” (Burke & Mattis, 2007, p. 7). According to the National Center for Education Statistics (NCES) (2010), underserved and underrepresented students represent only a small portion of students graduating with STEM degrees. As the proportion of underserved and underrepresented students increases in the U.S. these estimates become especially troublesome (Pender, Marcotte, Domingo, & Maton, 2010). During the next decade, growth among underserved and underrepresented students on college campuses will occur exponentially (National Science Board [NSB], 2010). The strength of the STEM pipeline has become largely dependent on the ability of underserved and underrepresented students to persist and graduate in STEM degree fields (Committee on Prospering in the Global Economy of the 21st Century and the Committee on Science, Engineering, and Public Policy, 2007).

The U.S. Department of Education, the National Science Foundation (NSF), and the National Aeronautics and Space Administration (NASA) initiated a series of STEM programs specifically intended for underserved and underrepresented students. NASA developed the

Minority University Research and Education Program (MUREP) primarily to stimulate student interest in STEM. MUREP consists of competitive grant programs, faculty programs, and student programs (NASA, 2009a). Problematically, only limited data exists to indicate the success of MUREP. However, due to internal and external pressures to reform current evaluative practices, NASA has activated progressive efforts to ensure uniformity in data collection.

MUREP receives nearly half of the funding allocated towards STEM education programs at NASA to assist underserved and underrepresented students (Nata, 2007). MUREP offers grant opportunities for Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and other minority institutions. Comprehensively, MUREP provides funding for K-12 curriculum programs that enhance STEM learning through college preparatory courses, awards to colleges, universities, and school districts that improve STEM teaching, and awards to increase STEM degree attainment among underserved and underrepresented populations. Each project within the MUREP infrastructure provides funding to educational institutions not only for STEM preparation, but also to expand scientific research.

Historically, the United States government sought to advance scientific research by apportioning funding through colleges and universities. The allocated funding became a conduit for colleges and universities to become esteemed and elite research institutions. Nonetheless, colleges and universities questioned their ability to remain autonomous from government research interests. The U.S. government offered funding conditionally. Colleges and universities aligned research with mandates from the U.S. government.

The launch of Sputnik I on October 4, 1957, fueled the U.S. government's ambitious drive to remain scientifically superior. In response to Sputnik, the U.S. government initiated the National Defense Education Act (NDEA), intended to prepare the most qualified and talented STEM professionals by offering funding to colleges and universities. In essence, the Cold War became a vehicle “to create a near panic about American education to proffer their own version of educational improvement, many of which had little to do with national defense or the Cold War” (Urban, 2010, p. 4). Further, Congress passed P.L. 85-568 (p. I-1) in an aggressive attempt to ensure stability and retain STEM professionals.

In more recent years, the U.S. continues to encounter difficulty recruiting professionals to the STEM fields. As a result, corporations opt to outsource high-tech jobs to augment the decrease in qualified STEM professionals in the U.S. Further, the U.S. faces the challenge of strategically managing innovative ideas and scientific discoveries to strengthen the knowledge economy, which will expectedly experience sluggish growth due to the shortage of STEM professionals in the near future. However, developing a qualified and capable STEM workforce “is both complex and ambiguous in a global environment characterized by uncertainty, change and heightened competition” (Burke & Mattis, 2007, p. 4). Therefore, educating and retaining the next generation of STEM professionals will become imperative to maintaining U.S. scientific and technological dominance in high-tech fields of the future.

The Evolution of STEM Advancements in the United States

During World War II the U.S. government began to rely on universities for assistance in scientific research. As a result, President Roosevelt developed the National universities Defense Research Committee (NDRC) and the Office of Scientific Research and Development (OSRD) to encourage government and university collaboration (Smith & Karlesky, 1977). After the war,

Congress had to make difficult decisions about the future of federal science policy. Therefore President Roosevelt requested that Vannevar Bush, the director of OSRD, assemble an advisory committee representative of the academic community to create a report that recommended best practices for scientific research.

Vannevar Bush's report, *Science, the Endless Frontier*, captured the importance of advanced research in the sciences following World War II (Thelin, 2004). Bush's report also renewed interest in expanding knowledge relating to the sciences, which eventually led to the creation of a federal agency. Before the establishment of the National Science Foundation (NSF), the Office of Naval Research (ONR) sponsored the bulk of scientific research conducted by universities after World War II (Guston & Keniston, 1994). After the launch of Sputnik I in 1957, the NSF managed scientific research and instituted a system of competitive grants intended for universities (Thelin, 2004; Guston & Keniston, 1994; Flattau et al., 2005). Universities had the opportunity to respond to requests for proposals (RFPs) issued by the federal agency that specified pre-determined scientific research objectives and provided a mechanism for funding. In the years to follow, other federal agencies also began to replicate the activities of the NSF. The Departments of Defense, Energy, Agriculture, Transportation, and Health (Thelin, 2004) similarly developed RFPs to outsource scientific research to universities. Outsourcing offered universities considerable opportunities to advance scientific research at their institutions, and become competitive with peer institutions. Unfortunately, much of the funding funneled to universities for scientific research went to institutions that had already established themselves with the federal government. Universities with minimal experience in preparing proposals for funding consideration often achieved little success when competing against universities with a known and reputable track record. Major research institutions monopolized "the education

industry—organized to gather the lion’s share of social resources available to higher education, and committed to produce the most valued educational products for the most important national markets” (Geiger, 2004a, p. 1). The uneven distribution of funding meant only a select number of institutions became research universities. Disproportionately, research universities graduate an estimated 30 % of students with bachelor’s degrees, train the majority of PhDs and medical doctors, and perform roughly half of basic research at U.S. institutions (Geiger, 2004b, p. xix).

“Big Science” as the “Best Science” became the policy that charged the most talented universities with performing complex scientific research (Thelin, 2004, p. 271). Only a few prestigious institutions received the distinction of becoming a research university, and the financial support to conduct large-scale scientific research projects assigned by the federal government. Research universities began to depend on the cyclic allocation of federal funds for growth. Universities such as Stanford, the Massachusetts Institute of Technology (MIT), Cal Tech, Johns Hopkins, and Berkeley competitively pursued grants issued by federal agencies. Federal agencies also began to identify ideal campus locations for the establishment of research facilities. Cal Tech and MIT both became involved in this venture, providing the Jet Propulsion Laboratory (JPL) and the Research Laboratory of Electronics for government use. The relationship between institutions of higher education and the federal government became increasingly closer. Grants offered universities the opportunity to develop new research priorities. Alternatively, external funding provided the federal government with the opportunity to work closely with a few elite research universities staffed with prestigious academicians. However, consequently, funding provided by the government “was an end to the independence of science, and this became clear fairly quickly” (Gibson, 2009, p. 2). The autonomy that universities once enjoyed rapidly became overshadowed by government mandates. As

universities sought to emerge as leading research institutions, they realized that government funding had “strings” attached. Daniel Greenberg (1999) chronicled these findings in *The Politics of Pure Science*, which examined the erosion of university decision-making in regards to determining scientific research objectives. In addition, Greenberg’s book raised questions about the political and societal implications of science in the U.S. Further, the book became a revolutionary depiction of science in the modern world.

“Social contract science” became the term that referred to the agreement between the federal government and universities (Guston & Keniston, 1994, p. 5). This intangible contract ensured that both the federal government and universities acted ethically in the facilitation of scientific research. This arrangement also contradicted the government’s normal procedures for scientific research. Typically the government only conducted scientific research internally. However, the federal government realized that competitive grants not only expanded scientific research, but created research universities. Competitive grants provided universities with the opportunity to expand their research capacity, while significantly reducing scientific imperatives that government had to accomplish independently. In addition, the stream of funding allocated by the federal government for scientific research stimulated growth at many universities. Further, the federal government hoped that funding for scientific research at universities would cement the U.S. as the global leader in the development of military and medical technologies, commercial products, and more efficient energy. Excellence in innovation became the focus of the grant world (Thelin, 2004).

Federal Funding and Medical Schools

Medical schools received a significant amount of funding from the federal government to conduct scientific research after World War II. During the 1900s, Abraham Flexner (a reformist)

asserted that “medicine needed to be linked to advanced scholarship in the biological sciences, only a few universities had pursued this proposition with much success” (Thelin, 2004, p. 273). In the 1950s, the National Institutes of Health (NIH) began to offer medical research funding for medical schools throughout the U.S. This funding enabled medical schools to include research and publication in the curriculum for future MDs. Medical schools also largely benefited from pre-paid health plans and the Medicare system developed by the federal government that provided financial reimbursement to university teaching hospitals. By 1960, medical schools throughout the U.S. became recognized as the well-funded academic entities at universities.

Despite increased funding for medical research, some institutions became skeptical of the federal government’s intentions and the limitations of accepting such awards. Harvard University President James Bryant Conant initially advocated the fusion of universities with the federal government (Thelin, 2004). Nonetheless, faculty and administrators at Harvard University expressed concerns about restrictions on academic freedom. Essentially this initiated concern “over whether accepting federal research funds compromised the spirit of academic inquiry” (Thelin, 2004, p. 274). However, Harvard University, along with many other institutions realized the potential detrimental impacts of eliminating external funding for scientific research. Universities could not maintain their esteemed status in the science fields without the funding appropriated from the federal government.

Federal versus Foundation

The relationship between universities and the federal government became more dynamic following World War II. Foremost, the federal government became the primary financial resource for universities, quickly eliminating foundations that offered smaller incentives for institutions. In addition, federal research grants essentially “coincided with a relative decline and

withdrawal of some historic foundation from sponsored research” (Thelin, 2004, p. 282). Contributions from well-established foundations including Carnegie temporarily vanished from higher education. Nonetheless, smaller institutions like Ford flourished after 1947, providing considerable funding for universities. However, the federal government scorned foundations for their involvement in scholarly activities considered un-American. Funding allocated for the arts or philosophy became targets for Senator Joseph McCarthy’s House Un-American Activities Committee. Astonished, many foundations discontinued funding. However, by 1954 most foundations had recovered from McCarthyism and remained steadfast in their dedication to support academic and even artistic endeavors.

Foundations differed from federal agencies in their flexibility in funding. If they opted to, foundations could provide financial support to improve one particular university, or multiple academic departments. Uniquely, foundations also had the ability to fund new academic fields by hiring faculty members, building high-tech facilities and laboratories, and developing new curricula (Thelin, 2004). During the 1950s and 1960s, the Ford Foundation sought to focus on the advancement of private institutions and the improvement of social and behavioral sciences. The Ford Foundation allocated approximately \$560 million in 1955 to increase faculty salaries at private institutions (Thelin, 2004). Further, the Ford Foundation sought to make medical schools more efficient in the services they provided and more effective in the instruction they delivered.

Research Implications of Sputnik

On October 4, 1957 the Soviet Union launched Sputnik I, altering the course of history forever and once again increasing federal funding for scientific research at universities. From the decade of 1963 to 1972 the “race to space” accounted for approximately 27% of federal expenditures (Guston & Keniston, 1994, p. 18). Sputnik I weighed only 183.9 pounds (NASA,

2007a), but the satellite quickly became symbolic of superior Russian engineering. Immediately thereafter the American public began to panic. The launch of Sputnik I reflected the inability of the U.S. to succeed in this immense technological endeavor. To add insult to injury, two weeks later the Soviet Union orbited Sputnik II with a dog aboard (Murray & Bly Cox, 1989). This accomplishment revealed the primary intent of the Soviets: to send man into space. The U.S. responded by assembling teams consisting only of the most skilled scientists to develop a concept vehicle capable of traveling into space. These landmark moments in history ushered in new political, military, and scientific ideas in the U.S. (NASA, 2007a). The U.S. government feared the Soviet Union had ulterior motives for creating a space program. Rather than facilitating scientific research, the U.S. suspected the Soviet Union of testing their capability to launch nuclear weapons.

On September 2, 1958, the *National Defense Education Act* (NDEA) became a law that provided widespread federal funding for educational institutions in the U.S. The NDEA aimed to increase the number of undergraduates that pursued STEM fields in the U.S. (Flattau et al., 2005). Further, the legislation aggressively sought to create school systems in the U.S. capable of competing with the Soviet Union, and provided opportunities for teachers to work in collaboration with researchers (Jolly, 2009). The NDEA also offered funding for undergraduates that opted to pursue degrees in STEM fields. President Eisenhower supported the legislation, which intended to supplement already existing education programs sponsored by the NSF and NIH (Flattau et al., 2005).

The NDEA consisted of ten titles. The first two titles articulated the urgency for the NDEA, and the second emphasized the autonomy of educational institutions from federal oversight (Urban, 2010). The remaining titles elaborated on student loans, the enhancement of

science, mathematics, and foreign language, national fellowship programs, “testing, guidance, and counseling,” language development, educational media, science and technology training for underserved areas, the creation of the Science Information Service, and grant funding opportunities for states (Urban, 2010, p. 4). Among the most relevant to NASA, Title III sought to improve science and mathematics education for secondary schools. As well, Title VIII, an extension of the *George-Barden Vocational Act of 1946*, served as a mechanism by which to allocate funding towards technical training for the fields of science and technology in underserved areas. Further, Title IX created the Science Information Service, an administrative arm of the already prolific NSF.

A New Era for Higher Education

By the 1960s, grant-funded institutions became easily recognizable. According to President Clark Kerr of the University of California, institutions of higher education had received nearly \$1.5 billion in federal funding during the 1960s (Thelin, 2004). This remarkable growth occurred because of funding provided by federal agencies which included: the National Institutes of Health (NIH), the Department of Defense (DOD), the National Science Foundation (NSF), the Atomic Energy Commission (AEC), the Department of Agriculture, and the National Aeronautics and Space Administration (NASA). Less than 30 institutions received federal funding in the 1960s. The intense competition for government funding meant that only a few, well-established and reputable universities received financing for scientific research. These selective research universities began to rely on the provided funding to supplement their annual operating budget. However, university administrators struggled to locate funding to support regular institutional functions. Few grant opportunities existed for teaching and other regular operations. Budget constraints also impacted well-funded medical schools. Many medical

schools received federal funding to initiate new scientific research, but had limited operating budgets.

Research institutions that received federal funding established a tight inner circle. The Association of American Universities (AAU), based in Washington, D.C., became an elite organization consisting of exceptional research institutions (Thelin, 2004). Acceptance into the AAU largely became based on the esteem of university doctoral programs and sponsored research. Seeking the same impressive status as their counterparts, many institutions sought grant funding for the first time between 1960 and 1970. Most institutions that had already received external grants opted to remain in the race for funding. Clark Kerr recognized this competitive drive to remain at the forefront of scientific research as “each year a growing number of professors and presidents mused about and then explored their own prospects for landing a subsidized project” (Thelin, 2004, p. 279). Grant funding ushered in a new era at colleges and universities. Each university pursued cyclic funding not only to extend scientific research, but also to increase institutional reputability. Only the most prestigious universities received funding, creating an exclusive inner circle of institutions.

The Advent of Ph.D. Programs at Research Universities

As a result of increased federal funding, many research universities began to initiate new degree programs. Research universities had a special interest in the development of PhD programs that could expand their research capabilities in specific fields (Thelin, 2004). However, research universities nationwide struggled to develop PhD programs with the potential to produce viable and qualified scientists to strengthen the workforce (Guston & Keniston, 1994). Ironically, as the number of PhD candidates increased, the demand for funding to support scientific research did as well. Between 1939 and 1940, only 106,000 students enrolled in

master's and PhD programs. Fortunately the next decade brought more positive indications of growth. By 1950 graduate enrollments had increased to an estimated 237,000 students; mostly at universities that received significant federal funding. Federal funding provided universities with the ability to expand academic programs and research initiatives, recruit only the most reputable faculty, and attract extraordinary students. As an unintended consequence, obtaining grant funding from the federal government became exceedingly difficult. Therefore, in many instances principal investigators had to submit multiple proposals before the federal government approved funding for their scientific research (Guston & Keniston, 1994).

Internal constraints also hindered the ability of universities to offer advanced graduate coursework. Faculty at universities frequently desired to teach more rigorous coursework that equated to smaller enrollments (Thelin, 2004). Faculty began to demand teaching fewer classes and access to high-tech facilities and laboratories. At some institutions, faculty also received permission to take sabbaticals and extended leave to conduct research. In addition, administrators became concerned about university expenditures as doctoral dissertation committees required guidance from tenured or full-time professors. In order to maintain a PhD program, institutions needed to hire highly-qualified faculty that commanded a significant salary. However, universities could easily avoid incurring these tremendous costs if they received funding from the federal government. Funding often subsidized the costs of high-earning faculty members. Federal agencies provided substantial funding opportunities for scientists conducting highly technical research, but had the tendency to neglect other academic fields that did not align with government priorities. Only academic fields designated as "fundable" received an extensive amount of attention and support from university administrators. The federal government's interest in scientific research related more to national defense than the field of

science, however. Through universities, the federal government mandated their research priorities by offering institutions substantial sums of money.

Science Policy and Accountability

Since the country's founding, the science debate has centered on the return on investment for private citizens (Guston & Keniston, 1994). While funding decreased for scientific research at universities during the Great Depression, the federal government realized the importance of science as a public good. Therefore, the federal government ensured the security of the investment by creating a system of accountability. However tumultuous and delicate the relationship between the federal government and universities, the contract between science and society ensured continued accountability.

The federal government developed a peer review system during and after World War II as a means to locate appropriate scientific research endeavors (Guston & Keniston, 1994). The peer review system worked to accomplish two goals. First, the federal government would determine scientific research objectives consistent with the agency's mission. Second, the scientific community would remain independent. The peer review system also provided a mechanism for accountability as proposals had to receive approval from a board of scientists. Generally the peer review system varied from agency-to-agency, but most employed scientists solely for the purposes of proposal evaluation. In addition, federal employees also conducted peer reviews. The peer review system ensured that only the most competitive proposals initiated by universities would receive federal funding. Further, the federal government sought to facilitate research only through universities capable of generating products that would make the U.S. competitive with other global scientific leaders.

Despite efforts to implement a system of checks and balances, the federal government could not always guarantee ethical scientific research at universities. In 1950, President Truman signed the *National Science Foundation Act* that required university professors to sign an affidavit of loyalty (Guston & Keniston, 1994). The legislative and executive branches of government immediately intervened and designated many professors as ineligible to apply for grants due to their involvement or affiliation with questionable organizations. The Department of Health, Education, and Welfare also retracted funding allocated to university professors suspected of participating in un-American activities. Surprisingly few in the scientific community opposed the persecution of their colleagues. These incidents illustrated the ability of the federal government to “strong arm” universities and minimize autonomy.

The federal government also closely monitored the financial activities of universities. Beginning in the 1960s, Representative Lawrence Fountain questioned the fiscal integrity of scientific research programs funded by the NIH (Guston & Keniston, 1994). This “audit” effectively led to increased oversight that caused the NIH to evaluate their accounting procedures agency-wide. In addition, during the 1960s and 1970s, government officials began to question the importance of scientific research. As a result, the NSF received congressional funding to initiate “the Research Applied to National Needs (RANN) Program at the NSF, the War on Cancer at NIH, and the Mansfield Amendment for defense research” (Guston & Keniston, 1994, p. 14). Congress enacted each research directive with social goals in mind. However, these goals did not necessarily align with the research objectives of scientists. Nonetheless, in order to receive funding from the federal government, universities conformed to the objectives. As a result, the ability of scientists to determine their own research objectives became overshadowed by tremendous pressure from university administrators who struggled to attain the status of a

research institution. University administrators needed federal funding to remain competitive with peer institutions. Further, the research mandated by Congress increased the accountability of scientists. Nevertheless, the directives worked. Scientists received the funding they desired in return for assigned scientific research, and the federal government substantiated the need for continued scientific research in the U.S.

In more recent years, “public universities are responding to these external forces by expanding revenues through market-like behaviors, a phenomenon called academic capitalism” (Mendoza & Berger, 2008, p. 1). Building concern about these behaviors has emerged within colleges and universities nationwide as academic capitalism threatens to transform academic culture. With increasing frequency, faculty members succumb to financial incentives offered by corporations that seek to commercialize research. Additionally, as more faculty members choose corporate entities for partnerships, the more vulnerable colleges and universities become to commercialization.

Bok (2003) maintained that corporations began to converge on colleges and universities in the 1980s. The *Bayh-Dole Act*, a congressional initiative “coupled with the sudden rise of the biogenetics industry, set off a surge of corporate funding for campus-based research and a sudden growth of contacts between professors in the life sciences and interested companies” (Bok, 2003, p. 58). This occurrence spawned new apprehension regarding the relationship between corporations and institutions of higher education. Detractors posited that universities would likely withhold research findings to comply with corporate requests. Additionally, critics feared the exploitation of student researchers for commercial gain. Inevitably, corporate involvement hindered the ability of students to make decisions about research interests and inequitably influenced the promotion potential of faculty members that performed research

aligned with corporate interests. Pressure from corporations also elevated anxieties about the focus of research facilitated within colleges and universities. Rather than concentrating on basic scientific research, corporations could persuade faculty members to address research more specific to economic needs. Prophetically, Vannevar Bush's 1945 report predicted the onslaught of corporate influences in university research. Bush recognized the consistent need for basic research that generated revolutionary products and modern medical technologies. In response to this alarming forecast, the U.S. federal government funneled billions of dollars towards the creation of advanced university laboratories, strengthening the nation's scientific prowess. Decades later, the commercialization of universities remains a contentious debate.

Heller and Eisenberg (1998) contended that science exists as an "intellectual common" (p. 698). As an intellectual common, the appropriation of science to corporations ultimately violates the public good. By exclusively restricting the flow of information relating to scientific discoveries and innovations to only corporations, the field of science becomes enclosed. Essentially this diminishes the initial intent of science and of the knowledge economy. This phenomenon of scientific enclosure has the capacity to wreak havoc, as corporations seek profitability from discoveries and innovations with little regard for the public's welfare.

Slaughter and Rhoades (2004) developed a theory of academic capitalism to explain the assimilation of colleges and universities into the market economy. They envisioned "groups of actors –faculty, students, administrators, and academic professionals—as using a variety of state resources to create new circuits of knowledge that link higher education institutions to the new economy" (Slaughter & Rhoades, 2004, p. 1). Universities have now become inseparable from the new economy, as they exist as a large part of development. Knowledge now exists as a "raw material that can be claimed through legal devices, owned, and marketed as a product or service"

(Slaughter & Rhoades, 2004, p. 15). Globalization has significantly increased economic competition, and as a result, research universities have become an invaluable resource in the production of highly innovative technologies.

Research and Development Growth

Considerable growth occurred in research and development in the years following World War II. In 1949 the budget for research and development in the U.S. reached a staggering \$1 billion, and by 1957 the budget had increased to an astounding \$4.4 billion (Gibson, 2009). As a result of federal funding, scientific research made profound advancements that largely benefited the U.S. Today the national budget for research and development has escalated to \$151.1 billion, an increase of more than \$6.8 billion from fiscal year 2008 (American Association for the Advancement of Science [AAAS], 2009). The substantial increase of federal funding for research and development indicates the importance of scientific research in the U.S. Colleges and universities have reaped the benefits from “this development, and they have consistently received the largest share of federal research funds allocated to the support of basic research” (Smith & Karleskly, 1977, p. 3). Figure 2.4 depicts the 2009 R & D appropriations for federal agencies.

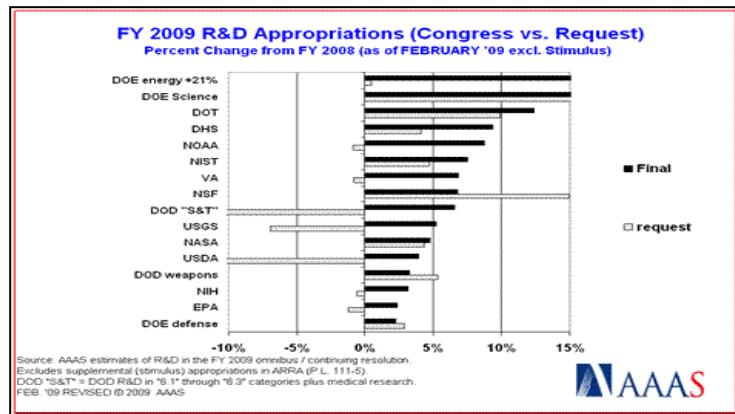


Figure 2.4. FY 2009 R & D Appropriations (Congress vs. Request) (AAAS, 2009).

Government Interest in STEM Education

In response to national instability in STEM fields, the U.S. federal government enacted multiple programs intended to enlist and engage students. According to Kuenzi, Matthew, and Mangan (2007),

a recent study by the Government Accountability Office found that 207 distinct federal STEM education programs were appropriated nearly \$3 billion in fiscal year 2004. Nearly three-quarters of those funds and nearly half of the STEM programs were in two agencies. (Kuenzi, Matthew, & Mangan, 2007, p. 161)

The NIH and NSF received the breadth of funding. Figure 2.5 depicts federal funding allocations per agency for STEM education programs during the 2004 fiscal year.

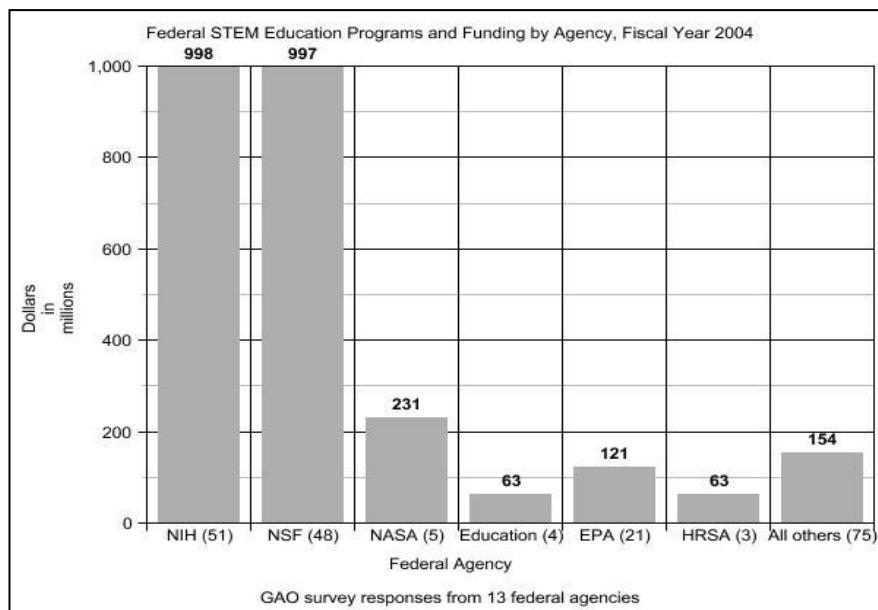


Figure 2.5. Federal STEM Education Programs and Funding by Agency (Government Accountability Office [GAO], 2005, p. 1).

The GAO's findings, compiled in the *Higher Education: Federal Science, Technology, Engineering, and Mathematics Program and Related Trends* report, indicated the urgent need to

increase coordination among federal agencies to improve the effectiveness of STEM education programs (Kuenzi, Matthew, & Mangan, 2007, pp. 162-163). To address these deficiencies, the 109th Congress drafted legislation aimed at promoting economic competitiveness and advancing STEM education. The business and science communities, as well as policymakers, guided the development of the proposals that will expectedly expand outputs generated within the STEM education pipeline. Particularly, the Committee on Prospering in the Global Economy of the 21st Century report, *Rising Above the Gathering Storm*, alerted policymakers of the consequential effects of professional shortages in STEM fields.

During the 2002-2003 academic year, a mere 16% (399,465) of students earned degrees in STEM fields (Kuenzi, Matthew, & Mangan, 2007). An estimated 14.6% of students earned associate degrees, 16.7% of students earned baccalaureate degrees, 12.9% earned master's degrees, and 34.8% earned doctoral degrees in STEM fields (Kuenzi, Matthew, & Mangan, 2007). These statistics reveal stagnation in STEM degree fields. Table 2.1 illustrates the distribution of degree attainment in STEM and non-STEM fields.

Table 2.1

Degrees conferred by degree-granting institutions by academic level and field of study, 2002-2003 (National Center for Education Statistics [NCES], 2005, p.1)

	Associate	Baccalaureate	Master's	Doctoral	Total
All fields	632,912	1,348,503	512,645	46,024	2,540,084
STEM fields, total	92,640	224,911	65,897	16,017	399,465
STEM, percentage (%) of all fields	14.6	16.7	12.9	34.8	15.7

<u>Non-STEM fields, total</u>	540,272	1,123,592	446,748	30,007	2,140,619
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The GAO's 2005 report established the findings by conducting a series of interviews with administrators and educators from the University of California Los Angeles, the University of Southern California, Clark Atlanta University, Georgia Institute of Technology, Spelman College, the University of Illinois, Purdue University, and Pennsylvania State University (GAO, 2005). The selection of these colleges and universities depended on their status as a public or private institution and geographic location. Additionally, the GAO selected colleges and universities based on their status as a minority-serving institution and their service to women. The selected colleges and universities represented high student enrollments in STEM degree fields. Administrators and educators from each respective institution provided the GAO with feedback on factors that encourage students to pursue STEM degrees and careers. The GAO also sought to identify factors for increasing participation in STEM fields. Furthermore, 31 students provided feedback to the GAO via e-mail surveys. Further, the GAO requested the participation of government officials and members of educational associations and organizations to collect data related to STEM education and careers.

Reportedly, the results from the GAO's research indicated that during the 2004 fiscal year, 207 programs received federal funding (GAO, 2005). However, government agencies offered little information pertaining to the effectiveness of each program in improving STEM education and encouraging students to pursue STEM degrees and careers. Of the 207 programs funded by the federal government, 99 belonged to either the NIH or NSF and accounted for approximately \$2 billion of the \$2.8 billion spent in 2004 for STEM education. NASA spent only \$231 million on five STEM education programs in 2004. Costs associated with other

agencies included “\$4,000 for a national scholars program sponsored by the Department of Agriculture (USDA) to about \$547 million for an NIH program that is designed to develop and enhance research for individuals in biomedical, behavioral, and clinical research” (GAO, 2005, p. 3). Each STEM program also listed multiple goals, aimed at diverse populations. Many of the programs researched for the purposes of the GAO’s study also confirmed having routinely performed evaluations. However, several programs in existence for many years have not yet undergone evaluations.

Interviews with administrators, educators, and others yielded crucial information about the inclination of students to pursue STEM degrees and careers (GAO, 2005). According to the respondents, early preparation (during K-12) in STEM emerged as a factor in students’ decisions to pursue STEM degrees and careers. Additionally, mentoring for women and minorities usually contributed to students’ decisions to pursue STEM degrees or careers. Further, difficulty obtaining a visa made pursuing a STEM degree or career in the U.S. difficult for many international students. The GAO’s report suggested increased flexibility in visa requirements to attract more international students to colleges and universities in the U.S. Students also provided unique insight about their individual experiences in STEM education at the selected colleges and universities. These suggestions centered around four areas designated by the GAO, including “teacher quality, mathematics and science preparation and courses, outreach to underrepresented groups, and the federal role in STEM education” (GAO, 2005, p. 5). Overall, most students emphasized the need for better mathematics and science preparation. While the GAO substantiated the need to address these student concerns in the report, the agency also recognized the need to internally evaluate the effectiveness of current STEM education programs. Similarly, NASA seeks to define project components that make STEM education efforts effective for

underserved and underrepresented students. At the cusp of a new and more competitive era in STEM, NASA will need to make accurate determinations regarding the ability of education projects to motivate and inspire the next generation of students. However, little data exists to suggest factors for retention in STEM degree fields among underserved and underrepresented students. Thus, this study yielded data specific to underserved and underrepresented undergraduates that identify factors for persistence and factors that contribute to success in STEM degree fields as a result of participation in the NASA University Research Centers (URCs) project.

Science, Technology, Engineering, and Mathematics (STEM) in the New Millennium

Concerns relating to the competence of Americans in STEM significantly increased since the terrorist attacks of September 11, 2001 (Rochin & Mello, 2007). The revolutionary report issued by the Committee on Prospering in the Global Economy of the 21st Century in 2007, *Rising Above the Gathering Storm*, quickly heightened awareness regarding the competitiveness of the U.S. in STEM fields (Foshay, 2006). Leading academicians from colleges and universities nationwide, as well as representatives originating from various STEM-related organizations, collaborated on the compilation of this report. The report has gained considerable recognition from the federal government and educational entities alike since the initial release. While economists from the Alfred P. Sloan Foundation and the Urban Institute refute the findings by the Committee on Prospering in the Global Economy of the 21st Century (Monastersky, 2008), the report intensified the campaign to improve STEM education.

The STEM Crisis

Rising Above the Gathering Storm predicts the gradual decline of the U.S. in the global market economy. According to the Committee on Prospering in the Global Economy of the 21st

Century (2007), the U.S. has entered a pivotal point in history. The nation has successfully contributed to research and development at colleges, universities, corporations, and within government agencies during the past 50 years. However, the consistent outsourcing of STEM jobs from the U.S. to other nations has created economic distress. The vitality of the U.S. economy “is derived in large part from the productivity of well-trained people and the steady stream of scientific and technical innovations they produce” (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 1). Ultimately the absence of innovations and high-tech advancements could potentially have devastating effects. According to the Committee on Prospering in the Global Economy of the 21st Century, the lack of STEM enterprises can lead to economic downturn and reduce the quality of life for American citizens. Reportedly, 85% of economic growth (per capita) in the U.S. relates to technological change. Americans contend with their global counterparts for employment. Workers capable of performing the same high-tech tasks as Americans frequently accept lower wages. Further, technology permits corporations to locate these workers in countries like Ireland, China, India, and Finland with just a mouse-click.

In a proactive attempt to lessen the impact of outsourcing in the U.S., the Committee on Prospering in the Global Economy of the 21st Century (2007) established several recommendations. Recommendation C, “Best and Brightest in Science and Engineering Higher Education,” stated the following:

Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world. (Committee on Prospering in the Global Economy, 2007, p. 9)

Under Recommendation C, the Committee on Prospering in the Global Economy of the 21st Century suggests several actions. Action C-1 urges an increase in the number of four-year

scholarships (by 25,000) awarded to U.S. citizens pursuing degrees in “the physical sciences, the life sciences, engineering, and mathematics” (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 9). The Undergraduate Scholar Awards in Science, Technology, Engineering, and Mathematics (USA-STEM) would cover up to \$20,000 of tuition for students in STEM disciplines. Each state would receive funding for the USA-STEM scholarships based on congressional representation and performance on governmentally mandated national examinations.

Action C-2 recommends the annual creation of 5,000 new fellowships for graduate students in STEM fields. The NSF would manage the fellowships in synchronization with other federal agencies to fully address national needs. In addition, these fellowships would help ensure a sufficient supply of STEM professionals, and the availability of more STEM jobs, post-graduation. Each fellowship would include a generous \$30,000 stipend and \$20,000 for tuition and fees. Action C-3 encourages a federal tax credit for employers to allow for continuing education, specifically for STEM professionals. This would allow for enriching educational opportunities that lead to the continued development of highly innovative technologies and new scientific discoveries. Beneficially, this would also allow STEM professionals to acquire advanced skills for a fluctuating job market. Actions C-4 and C-5 advise for more flexibility for international students that require visas to study in the U.S. Action C-4 suggests lenience for international students and scholars to attend scientific meetings and other academic events. Similarly, Action C-5 would provide a visa extension (of approximately one year) for those international students that earn degrees in STEM disciplines to seek employment opportunities in the U.S. According to Action C-5, students should receive the opportunity to pass a screening test (for security purposes) that would allow for “automatic work permits and expedited

residence status. If students are unable to obtain employment within 1 year, their visas would expire” (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 10). Comparable to C-5, C-6 proposes a “preferential immigration option” to allow individuals possessing doctoral level degrees in STEM to receive priority in obtaining U.S. citizenship (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 10). The Committee on Prospering in the Global Economy of the 21st Century recommends annually offering 10,000 H1-B Visas to curb economic stagnation in STEM fields. Employers would have the ability to also offer additional visas for individuals that earn STEM degrees from a U.S. university. According to Action C-7, the Committee on Prospering in the Global Economy of the 21st Century advises lessening restrictions on international students and researchers. The report maintains that providing access to U.S. facilities, equipment, and information “will reform the current system of deemed exports” (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 10). However, the Committee on Prospering in the Global Economy of the 21st Century suggests the exclusion of access to information and facilities deemed security-sensitive.

These incentives would reasonably encourage more students to pursue STEM degrees and careers. However, the recommendations made by the Committee on Prospering in the Global Economy of the 21st Century do not encompass immersive STEM experiences for undergraduate students. Primarily, the report’s recommendations urge the creation of more financial incentives to motivate students to pursue STEM degrees. Further, the report specifies the need to establish more flexible visa procedures for international students that obtain STEM degrees. Removing many constraints for immigrants undoubtedly has the potential to stimulate job growth in STEM fields.

Staggering Statistics

The recommendations developed by the Committee on Prospering in the Global Economy of the 21st Century (2007) resulted from recent statistics indicating significant losses in STEM fields. Annually, 67% of undergraduates in Singapore receive degrees in natural science or engineering, followed closely by the Chinese (50%), and the French (67%) (Committee on Prospering in the Global Economy of the 21st Century, 2007, p. 16). Only a mere 15% of American undergraduates earn natural science or engineering degrees on an annual basis. Further, foreign-born students earn 34% of doctoral degrees awarded in the U.S. in the natural sciences (including earth, ocean, and atmospheric science, and biological and physical science) and 56% of doctoral degrees in engineering. The STEM workforce also consists of foreign born workers (38%). This statistic reflects high attrition in STEM disciplines on behalf of American students. Today nearly one-third of American students withdraw from engineering majors prior to graduation. In the years that preceded the launch of Sputnik I in 1957, the proportion of students that obtained STEM degrees in the U.S. reached a national high. Today, the U.S. struggles to produce STEM professionals. Friedman (2005) forecasts a plateau effect occurring in the U.S. economy due to recent technological advancements that allow for increased outsourcing. He also cites inadequate preparation of students in the U.S. as a reason for the diminishment of U.S. superiority in STEM fields. What Friedman terms the “quiet crisis,” symbolizes the progressive creep of other global nations with the capacity to rival the U.S. economy in STEM (Friedman, 2007, p. 326).

The Knowledge Economy

Based on innovative ideas and concepts, the knowledge economy has become a highly competitive global phenomenon that threatens to subvert the U.S. economy (Shulman, 1999). To

remain competitive in the global market economy, the U.S. will have to protect ideas and concepts to promote economic stability and growth. The proliferation of high-tech skills, the generation of scientific concepts, and the formation of ideas in the U.S. can boost global leadership in STEM.

In 2008, the Bush Administration released a statement intended to address the fears of Americans. The statement, articulated by the RAND Corporation (and sponsored by the Department of Defense) deviates from recent concerns that allege the decline of U.S. dominance in STEM. According to the RAND Corporation, "Our review of the data suggests that the United States is not close to the brink of losing its leadership" (Monastersky, 2008, para. 2). This assertion boldly contradicts *Rising Above the Gathering Storm*, which indicates a growing threat in STEM fields by the global community. The RAND report substantiates this claim by providing evidence of U.S. superiority in STEM. Nearly two-thirds of STEM-related publications originate in the U.S. As well, approximately 70% of Nobel Prizes have resulted from American innovation. Additionally, 30 of the world's top 40 universities reside in the United States.

The RAND report also refutes any indication of stagnation in the STEM fields. Researchers discovered U.S. investment in STEM fields has increased when compared to global growth. The RAND Corporation iterated, "We find that the United States leads the world in S&T and has kept pace or grown faster than the rest of the world in many measures of S&T" (Monastersky, 2008, para. 6). Further, researchers conducting this study found little evidence to suggest dearth in STEM fields. This supports recent findings of several labor experts from the Alfred P. Sloan Foundation and the Urban Institute whose testimony before Congress in 2007 astonished many. Both labor experts insisted that the shortage of STEM workers would not

become a national crisis. Rather, the report concludes that the lack of funding from federal agencies and difficulty in hiring specialized STEM professionals has contributed to the hysteria.

Additionally, the RAND report finds the strengthening of knowledge in other areas of the world less than troublesome. Rather, researchers adamantly maintain that knowledge as a global good can benefit everyone. Nonetheless, Norman R. Augustine, chairman of the National Academies' committee, negated the findings when presented with the RAND report. Augustine, whose committee produced the *Rising Above the Gathering Storm* report, predicts the deterioration of STEM fields in the U.S. His projections emphasize the need to continue growth in STEM fields to prevent the loss of competencies unique to the United States. Augustine asserted, "If you look at the current situation, it's very easy to go to sleep because the U.S. is very strong in science and technology, primarily because of investments made 10 years ago" (Monastersky, 2008, para. 15). But looking toward the future, he said, "the U.S. is losing its leadership position at a fairly good rate" (Monastersky, 2008, para. 15).

Strengthening the STEM Pipeline

Between 1994 and 2003 employment in the STEM fields increased by 23%, while employment in non-STEM jobs experienced a respectable growth of 17% (Pantic, 2007). Additionally, the Bureau of Labor Statistics projects consistent growth through 2014 with specific interest in those who possess specialized expertise in the life sciences, environmental sciences, and engineering (Pantic, 2007). Further, the average salary of most workers employed in the STEM fields equates to an estimated 66% more than non-STEM workers. However, future projections also predict significant and potentially detrimental losses in the number of STEM professionals the U.S. graduates annually. During 2006, the United States "graduated 70,000 engineers, but China graduated 300,000 and India, 150,000" (Pantic, 2007, p. 25).

Moreover, many engineers in China and India elect to remain in their own countries, post-graduation, contributing to the rapid depletion in the U.S. of highly-skilled professionals. This occurrence has become a factor in the insubstantial U.S. knowledge economy.

The enrollment of U.S. citizens in STEM academic programs hardly compares to the number of international students that pursue the same degrees (Kuenzi, 2008). The 2003 *National Science Foundation Survey of Earned Doctorates* determined that foreign students earned one-third of all doctoral degrees conferred by colleges and universities. More specifically, approximately 44% of foreign students earned a doctoral degree in either computer science or math, and 35% earned a doctoral degree in a physical science. Additionally, doctoral degrees in engineering accounted for more than half of those awarded during 2003 to foreign students.

Underserved and underrepresented students in STEM fields can assist the U.S. in remaining competitive in an increasingly diverse economy (Ward & Wolf-Wendel, 2011). To strengthen the STEM pipeline, Merkel (2001) suggested that underserved and underrepresented students need research integrated into their curriculum as undergraduates. Reports such as the Boyer Commission Report in 1998 substantiated Merkel's assertions. The Boyer Commission Report insisted that colleges and universities should incorporate research as part of regular curriculum (Hunter, Larsen, & Seymour, 2006). Funding agencies especially have recommended that colleges and universities include more research opportunities for undergraduates (Hunter, Larsen, & Seymour, 2006; National Research Council, 2000; National Science Foundation [NSF], 2003). Inevitably, research opportunities have the potential to heighten engagement among underserved and underrepresented students, and the campus-wide community (Bauer & Bennett, 2003; Hunter, Larsen, & Seymour, 2006; Lopatto, 2004; Russell, 2005; Seymour,

Hunter, Laursen, & DeAntoni, 2004; Zydny, Bennett, Shahid, & Bauer, 2002a, 2002b). While educational research in the past has consisted of efforts to retain and promote STEM for underserved and underrepresented students, little data exists to indicate the effectiveness of immersive research programs (Adhikari & Nolan, 2002; Barlow & Villarejo, 2004; Hathaway, Nagda, & Gregerman, 2002; Hunter, Larsen, & Seymour, 2006; Nagda et al., 1998).

STEM Literacy Initiatives

Building a STEM-literate society has become more important than once realized (Riccards, 2009). However, the implementation of STEM education sometimes appears reminiscent of vocational programs used decades ago. Others in academia assert that the challenging curriculum presents problems for many students. To counteract these beliefs, institutions of higher education link STEM education and the economy to emphasize the need to improve both. Improvements in education have become more widespread. . For reform in education to occur in the U.S., “ultimate success is more than just educating key constituencies about their cause and goals” (Riccards, 2009, para. 3). To adequately prepare students for the workforce of the future, stakeholders will become crucial to student success. Many policymakers acknowledge shortages in the next generation of STEM professionals. Nonetheless, these policymakers have difficulty defining a strategy for addressing these predicted shortages, and therefore the STEM pipeline has the potential to weaken.

To reverse this trend, Pantic (2007) suggested strengthening the weakened STEM pipeline in the U.S. by initiating programs with the potential to stimulate interest beginning in the primary years of education that continue into secondary and post-secondary education, and eventually translate into a career within the STEM workforce. Research facilitated by the NSF indicates that exposure to STEM at an early age, superlative training in science and mathematics,

and collegiate-level programs that effectively retain students in STEM disciplines, contribute to the potency of the U.S. STEM pipeline. The integration of hands-on, interactive STEM programs in the classroom and in informal learning environments can elevate understanding of critical concepts, generate excitement about STEM, and can provide information pertaining to careers in STEM fields.

While much of the RAND report research challenges current findings, the report does acknowledge the academic deficiency of American students. The report cites the mediocre performance of high school students in science and mathematics, as well as their lack of tenacity to pursue careers in science and engineering, as largely problematic. Significant literature exists that suggests the accuracy of these assertions. The 2005 *Nation's Report Card* indicated acutely insufficient student preparation for STEM-degree programs. The proficiency level of high school seniors has become less than stellar, with only 23% purportedly possessing adequate mathematics skills. The Trends in International Mathematics and Science Study (TIMSS), released in 2003, "shows U.S. 4th- and 8th-graders lagging behind their international counterparts in both math and science preparation (in 12th and 15th place in math for 4th and 8th graders, respectively, and 6th and 10th places in science)" (Pantic, 2007, p. 25).

Texas and Massachusetts have addressed these national deficiencies by developing STEM-intensive curriculum that prepares students for the rigors of collegiate-level academic work (Pantic, 2007). Further, many schools orchestrated partnerships with institutions of higher education and private and public organizations to allow for the collaboration of resources, funds, and expertise. The Texas Engineering and Technology Consortium includes colleges and universities, private and public organizations, and the state of Texas. The consortium works proactively to increase the number of STEM graduates by initiating highly-innovative outreach

and retention programs. The state of Texas allocates approximately \$5 million annually to this effort, in addition to funding received from the federal government and various participating organizations.

Theories Relating to STEM Education

In a study using the Cooperative Institutional Research Program (CIRP) and the *National Longitudinal Survey of Youth*, Leslie, McClure, and Oaxaca (1998) concluded that critical variables that correlated to the attainment of a STEM degree included “the student’s self-concept, self-confidence in STEM capability, commitment to the goal, and the influence of high school peers” (p. 35). They assert that interest in STEM usually develops early in life. Influential factors including socialization and behaviors that manifest during adolescence usually contribute to this interest. However, self-concept and self-efficacy prevail as two of the most important factors that contribute to the development of student interest in STEM. According to Leslie, McClure, and Oaxaca (1998), self-concept and self-efficacy affect the achievement level of underserved and underrepresented undergraduates (although only limited literature exists to prove this assumption). General self-concept exists at the highest level “of the self-concept hierarchy; positive, subordinate self-concepts generally contribute to positive general self-concepts, although the former may be complementary rather than complimentary” (Leslie, McClure, and Oaxaca, 1998, p. 246). Frequently children possess a stable self-concept, but this perspective usually weakens with age due to situation-specific experiences that influence confidence.

Self-Concept Theory

According to Marsh and Shavelson (1985), students have the innate tendency to compare their academic aptitude to their peers. This external process of evaluating individual ability to

peer ability often contributes to the formation of self-concept. Also, students internally analyze their ability to perform well in one subject against other subjects. Further, Bandura (1986) hypothesized that belief in oneself influences individual abilities, perhaps more than actual aptitude. The self-concept construct acts as mechanism that influences the individual's perceived confidence when performing a task. Theorists that have researched self-concept "have argued that an individual's self-concept mediates the influence of other determinants on subsequent performance and is the stronger predictor of that performance when those determinants are controlled" (Pajares & Miller, 1994, p. 194). Bandura (1986) contended that if an individual cannot exert any control over a situation, they have less anxiety.

Pajares and Miller (1994) facilitated a study that discovered a strong correlation between self-concept and math performance. The study consisted of 350 undergraduates enrolled in classes in the College of Education at a public university. A Self-Description Questionnaire (SDQ) consisting of "course-specific self-concept items" assisted in making determinations about the self-concept of college students in mathematics courses (Pajares & Miller, 1994, p. 196). The study concluded that a student's self-concept usually developed during the primary years of education. As such, Pajares and Miller (1994) suggested early individual assessments of students. These assessments can allow early interventions that restore confidence and eliminate erroneous self-concepts.

Social Cognitive Career Theory (SCCT)

Social cognitive career theory (SCCT) describes career development (Isaacson & Brown, 2000). Four variables influence career-related behavior, including: "self-efficacy beliefs, outcome expectations, and goals" (Mau, 2007, p. 235). Self-efficacy allows individuals to direct their "cognitive, behavioral, and social skills to a task" (Mau, 2007, p. 235). Additionally, self-

efficacy determines individual action. Essentially self-efficacy influences the ability of an individual to focus on a task, exert the effort to address the task, and to persevere despite failure. Mau (2007) employed SCCT as the conceptual framework for a study that encompassed understanding career aspirations and persistence for underserved and underrepresented students. Understanding career aspirations and persistence will become crucial to providing interventions for individuals from diverse cultures.

Conceptual Framework:

Self-Efficacy Theory

Self-efficacy frequently predicts behavior (Maddux, Norton, & Stoltenberg, 1986). Social scientists use the self-efficacy theory to describe student outcomes as they relate to science and engineering (Leslie, McClure, & Oaxaca, 1998). Bandura's (1977) self-efficacy theory explains that human behavior occurs through cognitive processes. Self-efficacy theory also explicates that performance-based experiences materialize as the most important of cognitive process. As students learn more about themselves as individuals, they evaluate "differential consequences" (Leslie, McClure, and Oaxaca, 1998, pp. 246-247). More specifically, this involves the evaluation of personal information. Learning consists of performance accomplishment (based upon mastery), vicarious experiences (making social comparisons), verbal persuasion (widely used, but not necessarily useful), and emotional arousal (the stimulation of behaviors). Performance accomplishment asserts that if an individual experiences repeated successes, this can potentially heighten self-confidence that can assist in overcoming future challenges and obstacles (Brand & Wilkins, 2007; Zimmerman, 2000). Described as "positive encounters in social models" vicarious experiences allow students to see "oneself in others and their struggles can improve personal perceptions of inadequacies" (Brand

& Wilkins, 2007, p. 299). Verbal persuasion elevates self-confidence through affirmations that motivate individuals. Reinforcing individuals using verbal affirmations can lead to increased participation in classrooms, and can strengthen actual academic aptitude. Emotional arousal refers to the elimination of “negative emotional proclivities” that can reduce stress (Brand & Wilkins, 2007, p. 299). Fostering positivity within classroom environments can increase student concentration and focus. Each of these elements contributes to student success in STEM degree fields. Self-efficacy ultimately determines if students overcome challenges that arise to persist in STEM degree fields, or resign (Hackett & Betz, 1989; Marra, Rodgers, Shen, & Bogue, 2009). Bandura (1977) asserted that self-efficacy affects “strength of conviction,” and the ability of a student to persevere or even exert effort towards addressing the challenge (p. 247). Predictably, self-efficacy can accurately forecast performance 85 % of the time.

In addition, Bandura’s (2003) Social Learning Theory contends that self-efficacy largely determines an individual’s pursuits, the duration that the individual has the ability to persevere despite obstacles, whether the individual’s thoughts motivate or deter, and how much effort the individual will expend towards achieving a desired outcome. Self-efficacy specifically “refers to individuals’ beliefs in their causative capacity to control a *given attainment*, such as learning geometry, writing an English paper, or running a marathon. This self-belief becomes an innate motivator of behaviors” (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007, pp. 213-214). Self-efficacy has become a well-recognized term within the field of psychology. However, those external to the field of psychology usually relate self-efficacy directly to self-confidence within a “specific context” (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007, p. 214). Individuals may possess self-confidence, but may not have strong self-efficacy relating to specific knowledge and skills.

Tinkering and Technical Self-Efficacy

Tinkering self-efficacy explains the confidence individuals have relating to their manual abilities. Generally if individuals participate in “manipulating, assembling, disassembling, constructing, modifying, and breaking and repairing components and devices” their confidence increases (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007, p. 218). Thereby, providing hands-on interactive experiences for undergraduate students in STEM degree fields can potentially increase self-efficacy. Similar to tinkering self-efficacy, technical self-efficacy asserts that self-confidence depends on an individual’s ability to “learn, regulate, master, and apply technical academic subject matter” (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007, p. 219). Analogous to tinkering self-efficacy, in order to strengthen technical self-efficacy, undergraduate students must receive numerous opportunities to master skills specific to STEM fields.

Factors Influencing Self-Efficacy

As with any academic or personal endeavor, commitment largely determines success (Leslie, McClure, & Oaxaca, 1998). As such, self-efficacy and peer influence often impact goal commitment. Self-efficacy that relates to STEM usually initiates during a student’s primary years. Families also have the tendency to overshadow a student’s decisions to pursue degrees and careers in STEM. Often students in STEM degree fields have a higher probability of persisting if they have a parent(s) in a STEM occupation. Further, Leslie, McClure, & Oaxaca (1998) identified student desire to gain employment in a STEM field by the age of 35 as a strong predictor of student success. In this particular instance, financial outcomes and career aspirations can create strong commitment for students in STEM degree fields.

According to Hackett et al. (1992), self-efficacy emerges as a more reliable predictor of student cumulative GPAs than interest, stress, and expectations for undergraduate engineering majors. However, “few studies have been done to examine the effect of science classroom experiences on self-efficacy” (Fencl & Scheel, 2005, p. 20). Baldwin, Ebert-May, and Burns (1999) found that the integration of alternative pedagogies (such as cooperative learning) in the classroom increased student self-efficacy in undergraduate biology coursework. Fencl and Scheel (2004) also concluded that collaborative learning positively impacted students enrolled in undergraduate physics, physical sciences, and chemistry courses. Congruently, Samiullah (1995) deduced that increased student interactions improved attitudes and classroom environments in undergraduate physics courses, and Fencl and Scheel (2005) determined that actively engaging students in coursework can lead to a better understanding of science fields. As such, encouraging student interactions and allowing students to creatively explore curriculum can potentially boost self-efficacy.

Strengthening Self-Efficacy

Margolis and McCabe (2006) have provided several strategies for effectively strengthening student self-efficacy. Margolis and McCabe (2006) maintained that tasks assigned to struggling students should present at least a moderate challenge in order to strengthen self-efficacy. However, tasks should not provoke fear or frustration. Ideally, the assigned task should promote higher-level thinking from the student. In addition, Margolis and McCabe (2006) suggested the use of peer models. Students have the ability to acquire academic skills by observing their peers capably perform on assigned tasks. Peer models consist of “mastery or coping models. Mastery models flawlessly demonstrate a targeted skill or learning strategy, whereas coping models demonstrate how to learn the skill or strategy and how and when to apply

it” (Margolis & McCabe 2006, p. 221). Coping models may have a particularly strong impact on students with especially low self-efficacy. These models teach students how to overcome challenges, often encouraging students with low self-efficacy. Margolis and McCabe (2006) also advocated the use of learning strategies for struggling students. Initially, instructors must identify student deficiencies and then assign an appropriate learning strategy to address the problem. Instructors can assist students by teaching them when to employ the learning strategy (or strategies). Essentially this enables students to utilize specific learning strategies when working independently. Allowing students to choose their own assignments or pursue academic interests can also engage those with low self-efficacy. Instructors can capitalize on student interests to stimulate learning. Finally, Margolis and McCabe (2006) proposed the use of interventions for students with low self-efficacy. Interventions can include commending students “for effort, persistence, (i.e., working longer on moderately challenging tasks), and correct strategy use; providing extrinsic reinforcers” and “negotiating behavioral contracts for working longer, accomplishing more,” and properly using strategies (Margolis & McCabe, 2006, pp. 222-223).

Underserved and Underrepresented Students in STEM

Underserved and underrepresented students, especially, require early exposure to STEM (Pantic, 2007). A report issued by the NSF indicates that underserved and underrepresented students continue to fall behind their White counterparts in the number that earn STEM degrees (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007). Generally underserved and underrepresented students earn fewer STEM degrees than their population proportion. For this reason, researchers, employers, public policy makers, and educators have tried to define predictors for STEM interest. Currently, the U.S. needs qualified, capable, and highly-skilled

workers in the STEM fields (Smyth & McArdle, 2004). However, the number of underserved and underrepresented students that enter the STEM workforce remains scarce (Leslie, McClure, & Oaxaca, 1998).

The Higher Education Research Institute (HERI) Cooperative Institutional Research Program (CIRP) studies student career interests. A study by Smyth and McArdle (2004) used CIRP data, combined with data from the students' college transcripts and characteristics of the institutions to test for gender and ethnic differences among students graduating from selective institutions with a STEM degree using a series of hierarchical linear models. (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007, p. 35)

Smyth and McArdle's (2004) research indicated that students attending highly-selective institutions that grouped low-performing students (based on scores) had a lower probability of completing a STEM degree. The analysis also revealed that majority students typically had higher success rates in attaining STEM degrees than underserved and underrepresented students. Only 37% of Hispanic students and 47% of African American students pursuing STEM degrees persisted after four years (Smyth & McArdle, 2004). The persistence rates for Whites and Asian Americans represented substantially higher proportions. Among White students, 61% persisted after four years in STEM degree fields. Asian American students pursuing STEM degrees persisted at 67% after four years (Asian Americans typically possessed a stronger inclination to pursue STEM degrees than their equivalents). Smyth and McArdle (2004) estimated that relatively few American Indians pursue STEM degrees or enter the STEM pipeline.

Astin and Astin (1992) contended that preparedness consistently predicts a student's inclination to pursue science degrees and careers. Whereas many Asian American students receive early exposure to mathematics (Fullilove & Treisman, 1990), underserved and underrepresented students rarely have the same opportunities (Bowen and Bok, 1998; Duntzman

et al., 1979; Elliott et al., 1995; Fullilove and Treisman, 1990; Ramist, Lewis, and McCamley-Jenkins, 1994). From 1991 to 1993, Seymour and Hewitt (1997) conducted 335 ethnographic interviews with students to determine variables for persistence and attrition in STEM degree fields at seven, four-year institutions. The researchers tracked a cohort of freshmen for four years to determine patterns for changing majors and persistence. The analysis deduced that capable students (whether male or female or classified as a racial or ethnic minority) frequently switched from STEM major to non-STEM major. Those students who continued to pursue a STEM degree usually developed a strategy for success and had the ability to overcome difficult challenges. Many of the students considered capable of earning a STEM degree, who switched to a non-STEM major, often became overly focused on teaching methods that sought to eliminate less indomitable students.

Another study used data from the Integrated Postsecondary Education Data System (IPEDS), as well as CIRP freshmen pre-surveys and follow-up surveys to establish variables for minority entrance into STEM majors (Bonous-Hammarth, 2000). The study also analyzed variables for minority exit from STEM majors. Conclusively the findings revealed that minority students with previous academic achievement in STEM, or personal interest in STEM, usually persisted at a greater rate. Female African-American, Native American, and Hispanic/Latino students had the highest attrition rates in STEM majors, followed closely by male students classified within the same demographics.

Zhang, Anderson, Ohland, and Thorndyke (2004) analyzed data from the Southeastern University and College Coalition for Engineering Education (SUCCEED) to determine factors for graduation in engineering. SUCCEED developed and maintained a database consisting of longitudinal data representing nine institutions. Calculated using a multiple logistic regression,

the authors determined engineering graduation rates, and estimated the time students took to complete engineering coursework. Among the nine institutions studied, ethnicity emerged as a viable predictor of graduation rates for seven engineering programs.

Besterfield-Sacre, Atman, and Shuman (2007) attempted to identify attitudinal shifts in freshmen engineering students to improve retention. By accurately predicting these attitudinal shifts, universities have the ability to develop more effective means of retaining underserved and underrepresented students through improvement programs. During the 1993-1994 school year, Besterfield-Sacre, Atman, and Shuman (2007) administered pre-surveys (prior to student immersion in engineering coursework) and post-surveys (following student immersion in engineering coursework) at the University of Pittsburgh. Regression analysis identified attitudinal variables that predicted performance and attrition. The results from the study indicated that a strong correlation existed between student attrition rates in engineering, and high school achievement. Those students considered successful in high school, but that never developed a strong interest in engineering, rarely persisted in engineering majors. The authors surmise that these high-achieving students that switch majors, may have opted to pursue an engineering degree to fulfill parental expectations. On the contrary, students that performed poorly in engineering usually indicated that they chose to pursue an engineering degree because of the financial benefits, post-graduation.

Adelman (1998) analyzed data from a group of sophomore students pursuing engineering degrees in 1982. The study tracked this cohort of students for approximately 13 years (beginning in 1982) to determine student motives for pursuing engineering degrees. The data indicated that a relationship existed between students that enrolled in advanced science and mathematics courses in high school and their inclination to pursue an engineering degree. Those students

considered academically successful in high school, usually pursued an engineering degree at a higher rate than their lower performing counterparts. Research previously conducted, “identified strong mathematical skills, higher academic performance, and personal motivations to study science as positive factors in students' pursuing STEM degrees” (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007, p. 36).

Factors Affecting Persistence

Educational attainment (years of education or earned degrees) “serves an indirect role by mediating the influence of an individual's background resources” (Pascarella & Terenzini, 2005, p. 373). An individual's background subsequently impacts income and occupational status. Second, the role of education in status attainment can occur directly, without regard to socioeconomic status. In addition, Pascarella and Terenzini (2005) asserted that the attainment of a baccalaureate degree largely determines income and occupational status. However, the comprehensive student experience at a college or university also frequently effects attainment. Pascarella and Terenzini (2005) defined persistence as “the progressive reenrollment in college, whether continuous from one term to the next or temporarily interrupted and then resumed” (p. 374). Persistence “can legitimately be considered a necessary, if not sufficient, condition for degree attainment” (Pascarella & Terenzini, 1991, p. 370). Students persist in various ways (Leppel, 2001). Students can persist by continuing to pursue a major at a college or university, change majors, or “they can transfer from one university to another, but continue in the educational system” (Leppel, 2001, p. 328).

Astin (1993a) identified family and faculty as the two most paramount issues that effect student persistence. However, Seymour & Hewitt (1997) have contended that generally underserved and underrepresented students have ineffectual relationships with STEM faculty. In

addition, underserved and underrepresented students have different learning styles than generally offered in mainstream STEM coursework (Sunal, Wright, & Day, 2004). However, Sunal, Wright, & Day (2004) asserted that difficulty in STEM coursework usually emerges due to the lack of educational socialization. In a series of interviews conducted with students that attended minority high schools, most conveyed that they overwhelming preferred the pedagogical techniques of their high school teachers, rather than STEM college professors (Seymour & Hewitt, 1997). Frequently high school teachers have the ability to inspire students to attend college. However, underserved and underrepresented students become reliant on their teachers for assistance during high school, and as a result, rarely interact with peer study groups (Sunal, Wright, & Day, 2004). Subsequently, when these students enter college they expect to develop the same dependent relationship on their STEM professors. Frequently teachers sought to motivate “students by using a rewarding effort, as well as performance, with good grades, and their students carried this expectation into college” (Sunal, Wright, & Day, 2004, p. 159). Thus, students largely perceive the grading system implemented by their STEM professors as discriminatory. Further, as students become accustomed to receiving individual attention from their high school teachers, they typically have trouble adapting to highly-competitive STEM coursework. Consequently, underserved and underserved students have low self-esteem as they initially enter STEM academic programs.

Several factors effect student persistence at institutions of higher education. Building close relationships with peers and participation in campus activities positively contributes to student persistence. Additionally, if students perceive that their institutions genuinely care about them individually, persistence increases. Persistence among African American students also has the tendency to increase for those that attend Historically Black Colleges and Universities

(HBCUs), opposed to students that attend predominantly White institutions. Other factors can deter students from persisting. The consistency of enrollment “(for example, by transfer from one four-year institution to another) appeared to inhibit educational attainment” (Pascarella & Terenzini, 2005, p. 375).

Tinto (1997) emphasized the need for students to amalgamate with their peers, socially and academically. If students receive the opportunity to integrate socially and academically,, “the more likely the student is to persist until degree completion” (Leppel, 2001, p. 327). Additionally, Bean and Metzner (1985) have upheld that a student’s inclination to remain enrolled at a college or university depends on their ability to acclimate psychologically and academically. Further, Bean and Metzner (1985) contended that a student’s desire to remain enrolled also depends on their capacity to adjust to their environment. Variables such as finances, encouragement (from family, peers, etc.), work hours, stress, familial obligations, contentment, and goal commitment all effect student persistence.

According to Leppel (2001), academic majors also influence student persistence. The persistence rates for students with profession-specific majors differ from those with non-specific majors. Students who opt to pursue degrees in engineering, business, or education (for example), generally persist at higher rates if they have knowledge relating to benefits of their chosen field. These students may have a stronger goal commitment. Nonetheless, despite understanding the monetary benefits of a profession-specific major, if a student has difficulty developing an interest in their chosen field of study, attrition increases.

Persistence in STEM Degree Fields

A declining interest in engineering education at colleges and universities nationwide has provoked many questions in academia (Ohland, 2008). Underserved and underrepresented

undergraduates consistently choose to pursue other majors leaving a growing deficiency in the field of engineering. This deficiency increases between the first and second year of studies (Fleming, Engerman, & Griffin, 1998). According to Astin (1993a), “engineering produces more significant effects on student outcomes than any major field” (p. 371). Generally, students that major in engineering exhibit strong analytic and career skills. Nonetheless, these same students often experience dissatisfaction with curriculum and instruction, “diversity orientation,” and the overall college experience (Astin, 1993a, p. 306). As such, the majority of research related to engineering “focuses on finding ways to retain students in the undergraduate engineering major” (Ohland, 2008, p. 259). These studies seek to discern students with the ability and motivation to persist in engineering education. By identifying these students, institutions of higher education can more readily develop engaging pedagogies that encourage the completion of engineering degrees (Felder et al., 1998; Knight, Carlson, & Sullivan, 2007).

Most research on persistence in STEM has concentrated primarily on students enrolled in engineering. Further, “enrollment and tracking of engineering majors may be two key factors related to the restricted scope of these studies” (Mendez, Buskirk, Lohr, & Haag, 2008, p. 57). Frequently students that major in STEM fields change to another STEM field within the same academic college. Tracking may differ for those students pursuing STEM degrees, and those that pursue engineering majors; however, persistence for both has become exceedingly low. Variables relating to cognitive and non-cognitive functions “previously shown in models predicting graduation persistence in general STEM fields has been largely unexplored in the research literature up to this point” (Mendez, Buskirk, Lohr, & Haag, 2008, p. 58). Non-cognitive variables (e.g., self-concept) and the recognition of racism play a more instrumental role in student persistence than cognitive factors (Tracey & Sedlacek, 1987). Racism especially,

accounts for discrepancies in academic performance between White and underserved and underrepresented students (Loo & Rolison, 1986; Suen, 1983). Further, racism encumbers cognitive development, thereby isolating underserved and underrepresented students from faculty, peers, and other campus activities (Fleming, 1984; Hurtado, 1994; Smedley, Myers, & Harrell, 1993; Smith, 1992).

Attrition rates among underserved and underrepresented students have also increased due to a lack of academic preparation and financial hardship (Pender, Marcotte, Domingo, & Maton, 2010; Schneider, 2000; Vetter, 1994; Elliot, Stretna, Adair, Matier, & Scott, 1995; Villarejo & Barlow, 2007; Tyson, Lee, Borman, & Hanson, 2007). As many underserved and underrepresented undergraduates have deficient academic preparation upon entering college, few succeed in prerequisite coursework in STEM degree fields (Villarejo & Barlow, 2007). Often underserved and underrepresented students have the tendency to enroll in less challenging STEM coursework in high school, inhibiting their ability to succeed in STEM degree fields in college (Tyson, Lee, Borman, & Hanson, 2007). Financial hardship also can create difficulty for underserved and underrepresented students and can delay graduation, ultimately lowering inclination to persist (Pender, Marcotte, Domingo, & Maton, 2010). Seymour and Hewitt (1997) asserted that even the most gifted students rarely persist when confronted with financial hardship. Furthermore, underserved and underrepresented students largely resist financial aid to reduce debt, post-graduation (Porter, 1990). An array of studies has indicated a significant relationship between academic preparation, financial hardship, and persistence (Barlow & Villarejo, 2004; Building Engineering and Science Talent [BEST], 2004; Maton & Hrabowski, 2004; Pender, Marcotte, Domingo, & Maton, 2010; Summers & Hrabowski, 2006).

In 2000, a national retention study found that a mere 35% of students that begin majors in STEM actually graduate (House, 2000). Numerous studies have found that self-belief often reliably predicts academic outcomes. In addition, the perception of academic aptitude “and drive to achieve were found to be significantly correlated with persistence for two years in college while expectations of graduating with honors were significantly related to persistence in college for four years” (House, 1992, p. 7). Often self-belief predicts grade performance in STEM coursework, but typically interest in the field and personality traits have more influence. The intent of students to persist in STEM degree fields emerges as the strongest predictor of persistence.

The STEM Professor’s Role

Treisman (1992) has recommended assembling study groups to improve student persistence. Peer collaboration can increase persistence and improve students’ self-perception (Daniels, 1994). Further, this strategy assists underserved and underrepresented students succeed in exceedingly large classrooms (Sunal, Wright, & Day, 2004). Also, as many underserved and underrepresented students rarely develop relationships with STEM professors, they often miss the opportunity to ask questions pertaining to assignments and tests. If STEM professors assign these study groups, underserved and underrepresented students have the chance to network with their peers that they would otherwise not approach. These study groups also benefit underserved and underrepresented students as they feel less isolated, and therefore have the potential to become more successful in STEM coursework. Small study groups provide underserved and underrepresented students with the occasion to ask questions, discuss ideas, and build friendships.

The lack of support on behalf of professors can increase attrition among underserved and underrepresented students (Astin, 1993a, 1993b, 1993c; Hayes, 2002; Hong & Shull, 2010, Moller-Wong & Eide, 1997). STEM professors can assist underserved and underrepresented students succeed in rigorous coursework by observing classroom dynamics, integrating applicable life experiences into the classroom, and providing role models (Sunal, Wright, & Day, 2004). As many STEM professors deliver lectures to large classrooms, they often encounter difficulty reaching every student. Therefore, modifying the classroom dynamic can ensure student participation. To encourage student participation in the classroom, professors can allow a “wait time” before selecting a respondent. Additionally, professors can solicit the help of their colleagues to assure students receive an equal opportunity to participate in classroom discussions. Professors can also incorporate contributions to STEM fields made by minorities. This will essentially make underserved and underrepresented students feel included in the discussion and increase confidence. As colleges and universities become increasingly more diverse, underserved and underrepresented students will become invaluable to classroom discussions. Regularly the applicability of theories can become difficult for STEM professors to explain. However, underserved and underrepresented students can offer real-world examples that assist their peers in understanding difficult concepts. Further, not only can professors present research conducted by minorities, but also can invite guest lecturers that reinforce the importance of diversity in STEM fields. Finally, Sunal, Wright, and Day (2004) have suggested that colleges and universities hire diverse faculty members that can serve as role models to underserved and underrepresented students. Faculty members can instrumentally provide support and act as role models and advocates (Tapia, 2009). In addition, these faculty members exemplify the possibility of success for underserved and underrepresented students. The need to

attract and retain STEM faculty has become imperative to student success. However, STEM faculty “who are minority are barely visible, regardless of field—less represented at the highest ranks and less likely to be tenured” (Chubin, May, & Babco, 2005, p. 81). Astoundingly, African Americans and Hispanics represent only three percent of faculty in engineering, and less achieve status as an associate or full professor. The majority of African American professors classified as either tenured or tenure-track, work in architectural engineering. However, only one percent of African Americans work as professors in computer engineering. Conversely, Hispanic professors have achieved the most success in computer engineering, but lag behind their African American counterparts in architectural engineering.

Colleges and universities will continue to encounter difficulty recruiting and retaining underserved and underrepresented students without more diverse faculty representation. As such, Chubin, May, and Babco (2005) recommend the formation of campus-wide working groups to address shortages of underserved and underrepresented faculty. The working groups would consist primarily of faculty, and would involve conducting site visits at peer institutions to devise a strategy for the effective recruitment of these populations. Essentially, visits would offer the “opportunity to meet with minority graduate students and to flesh out a structure where peer institutions can recruit neophyte Ph.D.s outside their institution to academic appointments” (Chubin, May, & Babco, 2005, p. 82).

Building a Diverse STEM Workforce

In 2001 George, Neale, Van Horne, and Malcom released a report for the American Association for the Advancement of Science (AAAS) in collaboration with the NSF that described tactics for building a diverse workforce. The report entitled, *In Pursuit of a Diverse Science, Technology, Engineering, and Mathematics Workforce: Recommended Research*

Priorities to Enhance Participation by Underrepresented Minorities, projects the shortage of qualified STEM workers in the U.S. Attributed to restrictions on H1-B Visas for guest workers, and a sharp decline in the number of White, non-Hispanic men in the workforce, the report forecasts reduced productivity in high-tech fields because of these factors. In 1995, White males in the workforce averaged 36%. However, White males now will comprise “26% of the overall workforce, while in 1997 they represented nearly 70% of the STEM workforce” (George, Neale, Van Horne, & Malcom, 2001, p. 2). As such, George, Neale, Van Horne, and Malcolm (2001) recommend the recruitment of underserved and underrepresented populations to the STEM fields to sustain productivity and fill gaps left by White men. According to the report, STEM education programs have only incrementally impacted underserved and underrepresented populations. To determine factors for this occurrence, the AAAS invited 70 of the most esteemed STEM educators and researchers to participate in this study, which commenced in 2000. Conjointly the group examined 150 research efforts pertaining to the selection of a STEM major, retention in STEM majors, academic mentoring, the choice to pursue a doctorate in STEM, and faculty positions. As a result of the study, the consortium identified three research priorities that included: improving methodology, improving research linkages, and exploring new research areas.

In order to build a robust STEM workforce in the U.S., “it is imperative that this nation understand how to encourage and develop the STEM talent of all U.S. citizens, including all racial/ethnic groups” (George, Neale, Van Horne, & Malcom, 2001, p. 3). However, the study concluded that underserved and underrepresented populations drop-out of college during their undergraduate years because of financial difficulties, a lack of early STEM preparation, inadequate college teaching, low expectations, and rigorous curriculum. To improve retention

among underserved and underrepresented students, George, Neale, Van Horne, and Malcom (2001) suggested providing STEM academic support services. Many colleges and universities that have initiated these support services have reported increased retention rates in STEM.

Funding Concerns for STEM Federal Education Programs

Programs that support underserved and underrepresented students that pursue STEM degrees can increase retention rates. Allocations for STEM programs represent only a small percentage of all federal funding, nonetheless, “science programs for minority-serving institutions are at the forefront of a debate over the role of these colleges and how best to prepare more students of color for science, technology, engineering, and math STEM careers” (Dervarics, 2010, p. 6). In 2011, the Obama Administration plans to merge several smaller STEM programs located within HBCUs and other minority-serving institutions, into one larger STEM program in an attempt to heighten awareness regarding STEM education. However, this plan has become a contentious debate in higher education, as predominantly White institutions also will gain the eligibility to apply for these grants (if they graduate a high percentage of underserved and underrepresented students). Questions loom about the distribution of funding for these colleges and universities. The absence of line-item budgeting in the Obama Administration’s 2011 budget plan means many HBCUs, HSIs, tribal colleges and universities, and other minority institutions will become increasingly competitive with one another. A cadre of NSF programs will feel the effects of this proposed plan, including: “HBCU Undergraduates Program (HBCU-UP), The Louis Stokes Alliance for Minority Participation, the tribal colleges and universities undergraduate program (TCUP), and the Hispanic-serving institutions program” (Dervarics, 2010, p. 6). Collectively these programs receive an estimated \$89 million annually. The new plan entails replacing each program with the Comprehensive Broadening Participation

of Undergraduate Institutions in STEM. This program would initially receive \$103 million in funding from the federal government.

The Comprehensive Broadening Participation of Undergraduate Institutions in STEM program would also include a component that encourages minority institutions to collaborate with majority institutions. This would essentially increase the visibility of STEM education, and perhaps attract interest from other federal agencies, the private sector, and national laboratories (Dervarics, 2010). Purportedly this plan to centralize STEM education programs will accelerate growth among underserved and underrepresented populations. However, the plan also has received criticism. According to Texas Representative Eddie Bernice Johnson, the plan will prevent many HBCUs, HSIs, and tribal colleges and universities from receiving funding dedicated specifically to programs that provide opportunities for underserved and underrepresented students. While the United Negro College Fund (UNCF) supports the president's agenda, the organization will request that federal funding continue to support small STEM education programs until the new program initiates in three to four years.

STEM Education

Academicians began to explore new approaches for transforming STEM education as early as 1999 (Narum, 2008). These approaches primarily emphasized learning and assessment in STEM at colleges and universities. Each emerged as a result of a 1999 National Research Council Report, *How People Learn: Brain, Mind, Experience and School*. The report details the need for “development of academic cultures where deep understanding about how students learn determines how courses and curricula are planned, technologies selected, spaces designed, and faculty recognized and rewarded” (Narum, 2008, p. 12). The report also provided a framework for shaping STEM cultures.

More than a decade later, most conversations central to STEM education converge on the capabilities that students acquire at a college or university (Narum, 2008). The Association of American Colleges & Universities (AAC & U) has become integral in facilitating discussions involving community members about student preparation for a transitional and technology-driven world. Many colleges and universities now articulate student learning goals on their websites. In recent years, Miami Dade College verbalized their STEM student learning outcomes in a public announcement, becoming “one of the most recent and most visible examples of the mainstreaming of attention to setting and assessing student learning goals both within and beyond STEM fields” (Narum, 2008, p. 15). The assembly of campus leadership teams to compile student learning outcomes as set forth by the AAC & U and other professional organizations can establish a vision for the future.

Pedagogies of Engagement for STEM Learners

Edgerton (2001) coined the term “pedagogies of engagement,” which explains how students in STEM disciplines learn, and includes: Just-in-Time Teaching, Student-Centered Activities for Large Enrollment Undergraduate Programs, and Problem-Based Learning (para. 1). Just-in-Time Teaching (JiTT) involves the interaction between students, as well as students and their instructors outside of the classroom (Narum, 2008). Most of this connectivity occurs through various technologies. JiTT pedagogy engages students through pre-instruction and web-based warm-up lessons. Students initially develop individual answers, and then electronically submit their perspectives to the instructor, prior to the beginning of class. This provides the instructor with sufficient time to integrate student ideas into the classroom discussion. The brevity of warm-up lessons also allows for stimulating and thought-provoking discussions. This pedagogical concept has two benefits. First, by submitting warm-up assignments, students

become more inclined to participate in classroom discussions as they have more ownership over the issue. Additionally, warm-up lessons have added value as they prepare students to interact in pertinent classroom discussions. According to Gregor Novak, a pioneer of JiTT, creating unity and team camaraderie have become essential to ensuring student success in STEM. As such, faculty and students work collaboratively to ensure students not only pass classes, but also learn the knowledge and skills necessary for STEM professionals of the future.

Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) contends that students need hands-on, interactive experiences that simulate real-world scenarios (Narum, 2008). Students have the tendency to become intimidated in exceptionally large and impersonal lecture halls that offer little peer interaction, and few opportunities to develop relationships with instructors. Uniquely, SCALE-UP uses “cooperative learning pedagogical techniques” for significantly smaller classes (not to exceed 100 students) and emphasizes teamwork (Narum, 2008, p. 16). Beneficially, students become immersed in a highly technological classroom environment that integrates both the lecture and lab. The research indicates remarkable improvements in student understanding of STEM disciplines, student attitudes towards STEM disciplines, and an increased capacity to comprehend and retain complex STEM concepts among participating students.

Uniquely problem-based learning (PBL) offers a “theoretical framework for learner-centered active instructional experience that relies on collaboration, critical thinking, and hands-on interaction with resources” (Kenney, 2008, p. 386). Using PBL involves the collaboration of multiple students to define a problem, the identification of unknown information, and determining potential sources of information. By facilitating PBL, students learn to think

critically, learn how to effectively collaborate, gain the ability to solve real-world problems, develop enhanced communication skills, and discover appropriate sources of information.

Each pedagogy of engagement represents the opportunity for students to gain valuable experience as a STEM practitioner (Narum, 2008). Further, these advanced practices enrich student perspectives and enable students to more readily appreciate and identify with professionals in STEM fields. Most importantly, these pedagogies also strengthen student confidence in STEM disciplines by allowing for recurrent student interaction with professionals within the STEM community. As students repeatedly associate with STEM professionals, they gain a realization of the importance of collaboration within their fields. Instilling a shared sense of purpose in undergraduates creates permanence and stability in the STEM pipeline.

While these pedagogies of engagement have proven effective in stimulating STEM learning opportunities for undergraduates, institutional culture often has the ability to impede progress. According to Henderson and Dancy (2007), STEM faculty admitted shortcomings with traditional instructional practices. Nonetheless, these instructors resist the integration of new pedagogies in “mainstream instruction” because of barriers (Henderson & Dancy, 2007, p. 1). Barriers including the management of sizable classrooms, administrative mandates to cover an extensive amount of classroom content, and the lack of student experience in active learning, all have the potential to hinder the ability of faculty to introduce and implement new pedagogies (Narum, 2008).

Pedagogies of engagement ideally provide pragmatic real-world experience for undergraduate students. However, faculty still may encounter difficulty in the transition. Many of these practices have not received wide acclaim from the academic community. As such, these practices may remain idle at many institutions, thereby denying students ample exposure to

authentic STEM experiences. While colleges and universities may meet opposition in adapting to newly-introduced pedagogies, federal agencies possess the resources necessary to create and initiate highly-interactive and immersive STEM programs that invite students to participate in germane and applicable real-world experiences. These STEM programs managed by the federal government may lack the intensity of collegiate-level coursework. Nonetheless, as many colleges and universities opt to avoid pedagogical modifications in STEM disciplines, federal programs will become increasingly vital to real-world STEM exposure for students.

STEM Federal Education Programs

Annually, the U.S. federal government allocates approximately \$3 billion towards the initiation and continuation of STEM K-12 and higher education programs. However, the consensus on their viability and utility remains largely unknown. A recent report issued by the federal government indicates the need for increased accountability among the agencies that manage STEM programs (Cavanagh, 2008). Additionally, the federal government has begun to proactively campaign for more cohesiveness between agency initiatives. Only minimal coordination presently exists, sometimes creating duplicate (or similar) federal STEM education programs.

According to a 2007 report originated by the Academic Competitiveness Council (ACC) and mandated by Congress, 105 STEM education programs housed within 11 federal agencies received \$3.12 billion in 2006 (Cavanagh, 2008). In 2006, the ACC conducted 115 evaluations of these programs to determine their effectiveness. Only four federal STEM education programs proved to have a positive impact. In 2007, Congress approved the America Competes Act, which allocated funding towards the improvement of instruction, educational research, and teacher training. Further, according to the House Committee on Science and Technology, K-12

and undergraduate education received an estimated \$840 million. Advocates of STEM education have pledged to continue to support increased funding for programs that advance interests in high-tech fields, and stimulate student knowledge pertaining to careers. Yet even those who advocate substantial spending for STEM education realize the necessity of reforming the current system to ensure programmatic effectiveness.

The ACC found that most federal STEM education programs fail to address changes in student achievement. Instead, federal agencies tend to focus more on attitudinal shifts (as a result of immersion in programs) and instructor participation. As a result, uncertainty looms regarding the impact that federal STEM education programs have on student achievement. To remediate the system currently employed by federal agencies to evaluate program effectiveness, the ACC recommends facilitating more advanced and rigorous educational research. These studies would evaluate students and/or instructors that participate in federal STEM education programs against a group of students and/or instructors that do not receive exposure to federal STEM educational programs. This strategy can potentially assist federal agencies in identifying specific components of programs and curriculum proven particularly effective. However, the ACC acknowledges the significant cost of such an endeavor.

Adhering to the recommendations issued by the ACC, the federal government requested that STEM agencies provide plans for improved program evaluation (Cavanagh, 2008). Since the ACC's report, the NSF has aggressively sought to address STEM program deficiencies. The NSF's Division of Education and Human Resources, which funds a multitude of STEM programs, already requires evaluations. Increasingly, the NSF has facilitated independent studies on many of these programs to determine their effectiveness. Further, in a progressive effort, the agency has also performed studies to determine why specific program components worked

effectively, while others produced poor results. Joan Ferrini-Mundy, Director of the NSF's Division on Research in Formal and Informal Settings, suggests that evaluations will become critical to the advancement of STEM education in future years (Cavanagh, 2008).

The National Science Board also produced a report analogous to the ACC's (Cavanagh, 2008). As an independent advisory panel to the NSF, the National Science Board recommends increased coordination among STEM agencies. Additionally, the National Science Board promotes the creation of a national council on STEM, with the ability to oversee educational efforts at the local, state, and federal levels of government. In the report, the National Science Board indicates the duplication of STEM educational program efforts. Further, the National Science Board identified numerous innovative STEM education programs that remain in relative anonymity. As such, the panel suggests that federal agencies network to exchange information relating to STEM education programs. In this capacity, the agencies could isolate specific components that make programs either successful or unsuccessful.

Conclusion

Despite collaborative differences, "over the past five decades, a dynamic partnership between the federal government and the scientific and engineering community has fostered unprecedented progress in scientific research and education in our nation" (AAAS, 1998, para. 1). The research conducted by universities has altered our perspectives and changed our understanding of science. In addition, funding and support provided by the federal government has allowed for the continuation of extensive university-based scientific research.

The need to proliferate and advance scientific research caused the federal government to offer substantial funding opportunities for research universities. Although federal funding had significant limitations, universities rapidly expanded research initiatives to accommodate

government demands. Most government research initiatives reflected the urgency of the U.S. to eliminate global scientific competition. As the Soviet Union began production on vehicles with the capacity for space travel in the late 1950s, the U.S. felt compelled to respond to such an immediate and potentially devastating scientific development. The U.S. feared that the Soviet Union possessed the capability to not only send a man into space, but also the capability to manufacture nuclear weapons. The race to space commenced leaving the U.S. in a desperate position to maintain national security and scientific superiority. Universities became an ideal venue for the U.S. to facilitate scientific research and to compete with the scientific advancements of the Soviet Union.

During the past 50 years, the U.S. has achieved phenomenal success in scientific discoveries and technological advancements. However, the complacency of the U.S. in the STEM fields may eventually lead to a decline in the number of high-tech workers that can capably assume jobs. Imparting confidence in students pursuing degrees in STEM fields and offering interactive and immersive opportunities will become fundamental to ensuring student preparedness for future generations. Additionally, adapting pedagogical techniques for undergraduates will increase student engagement and stimulate interest in curriculum.

The Academic Competitiveness Committee (ACC) facilitated research in 2007 to determine the effectiveness of federally-funded STEM education programs. The report discovered that few federal STEM education programs had an impact on participating students. Aside from the ACC's report and inconsistent evaluations conducted by the federal government, only scant data exists that indicates the success of each program in encouraging, inspiring, and retaining students in the STEM pipeline. Further, a lack of peer-reviewed literature regarding NASA undergraduate programs prohibits a more extensive investigation of previous research.

NASA continues to emerge as a viable provider of STEM opportunities. Programs such as the Minority University Research and Education Program (MUREP) provides undergraduates with career-specific STEM opportunities that aim to enhance learning. While each respective project within the MUREP infrastructure has the potential to encourage and motivate undergraduates to continue their academic and professional career in a STEM field, little literature exists that investigates the effectiveness of these projects. This study examined the University Research Centers (URCs) project to substantiate or delineate from any preconceived assumptions relating to the effectiveness of these initiatives.

CHAPTER III:

RESEARCH METHODS

This qualitative study examined one NASA educational initiative to determine the capacity of the project in encouraging persistence, and contributing to the success of underserved and underrepresented undergraduate students in STEM degree fields. The University Research Centers (URCs) project, part of the Minority University Research and Education Program (MUREP) configuration, intends to primarily address the needs of underserved and underrepresented students in STEM degree fields. While the URCs project has longevity within the NASA infrastructure, insufficient data indicated the need to further examine the effectiveness of this initiative. The identification of factors that contribute to the enrichment of underserved and underrepresented undergraduates in STEM may increase student persistence and increase motivation.

Frequently NASA attempts to collect and analyze data pertaining to each STEM education program within the agency. However, constant variation in reporting systems led to a lack of continuity. In October 2008, NASA launched the Office of Education Performance Measurement (OEPM) system to standardize data collection. OEPM has been structured to manage instruments for data collection, “including survey questions for participants, and data summary collection forms for project managers and grantees” (ExpectMore.gov, 2008, p. 1). The OEPM system was activated after the elimination of other similar tracking systems including the NASA Education Evaluation Information System (NEEIS), the Performance Outcome and Student Tracking System (POSTrack), and the Consortium Management Information System (CMIS). The OEPM system, NASA’s newest tracking system, still has

considerable flaws. For one, NASA continues to update and modify the system, making OPEM unfriendly to managers. Additionally, NASA plans to continuously integrate new “elements” into the OPEM system in the future. Although beta-testing will occur preceding the roll-out of the new system, operational efficiency has already been questioned.

Methodology

Identifying factors that contribute to increased self-efficacy among underserved and underrepresented undergraduate students can assist administrators in developing programs that stimulate interest and instill confidence to prevent attrition in STEM (Zhang, Anderson, Ohland, & Thorndyke, 2004). Conducting qualitative research allowed for the characterization of these factors. Qualitative research allows for “the collection and analysis of textual data...and by its emphasis on the context within which the study occurs” (Borrego, Douglas, & Amelink, 2009, p. 56). Qualitative research generates “thick” description, providing significant details relating to each project (Borrego, Douglas, & Amelink, 2009, p. 56). Additionally, qualitative research designs strengthen understanding relating to human behaviors, not possible when employing randomized controls (Koro-Ljungberg & Douglas, 2008). Koro-Ljungberg and Douglas (2008) also indicate the need within the academic community to conduct rigorous qualitative research, especially in engineering education.

Site Selection

NASA originally consisted of four centers that included the Lewis Research Center in Cleveland, Ohio, the Ames Research Center near San Francisco, California, Edwards High Speed Flight Station in the Mojave Desert, and Langley Research Center in Hampton, Virginia (Murray & Bly Cox, 1989, pp. 12-13). Today 11 nationwide centers represent the NASA organization including the following: Johnson Space Center, Stennis Space Center, Marshall

Space Flight Center, Kennedy Space Center, Langley Research Center, Goddard Space Flight Center, Glenn Research Center, Dryden Flight Research Center, Ames Research Center, the Jet Propulsion Laboratory, and NASA Headquarters. Collectively, each NASA center manages education programs focused specifically on STEM. Therefore, management of the URCs project (within the framework of MUREP) occurs through multiple NASA centers. Recipients of URCs awards coordinate all internships and research activities through an assigned NASA center. I focused on Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso as these institutions have experienced significant success in facilitating high-tech research with the funding provided by NASA. Site selection was also based on specific criteria. Only 13 institutions currently have funding from NASA for URCs project. Of these 13 colleges and universities, Prairie View A & M University (classified as an HBCU), Texas Southern University (classified as an HBCU), and the University of Texas at El Paso (classified as a HSI) were selected for their status as minority serving institutions.

Prairie View A & M University

In 1981, Prairie View A & M University received recognition as an independent division from Texas A & M University (Prairie View A & M University, 2009). Today, Prairie View A & M University, a Historically Black College or University (HBCU), enrolls more than 8,000 undergraduates and 2,000 graduates. Students attending Prairie View A & M University originate from throughout the U.S. and the world. The institution conferred more 5,000 undergraduate and 2,000 graduate degrees during the past five years. Since the establishment of the institution nearly 130 years ago, Prairie View A & M University has awarded more than 46,000 academic degrees.

In 2008, Prairie View A & M University received the distinction of becoming a NASA University Research Center (URC). With the funding allocated by NASA, Prairie View A & M University initiated the Center for Radiation Engineering and Science for Space Exploration (CRESSE). The research center, “with the infrastructure to investigate the scientific and engineering challenges faced by NASA and the international space community caused by space radiation,” focuses specifically on space radiation research related to astronaut health during lunar and Martian missions (NASA, 2008a, p. 5). The study encompasses experimental and theoretical radiation modeling. Additionally, student and faculty researchers use particle accelerator facilities located at the NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory, the Proton Synchrotron at Loma Linda University Medical Center, and the Los Alamos Neutron Science Center (LANSCE) at Los Alamos National Laboratory. Within these test facilities, student and faculty researchers simulate highly radioactive environments by building an experimental test bed. The researchers also use methods including: space radiation environment modeling, Monte-Carlo radiation transport modeling, space radiation instrumentation and dosimetry, space radiation effects on electronics, and micro-composite fabrication using in-situ materials. The study intends to “maximize the technical readiness level of radiation instrumentation for human and robotic missions, optimizing the return value of CRESSE for NASA exploration” (NASA, 2008a, p. 5). However, most importantly the study seeks to elevate STEM learning opportunities for underserved and underrepresented students and increase the number of these students pursuing advanced degrees in STEM fields. More specifically, CRESSE aspires to increase the number of underserved and underrepresented students that obtain a Ph.D. in electrical engineering.

Texas Southern University

The 50th Texas Legislature established Texas Southern University on March 3, 1947 (Texas Southern University, 2010). Texas Southern University (previously Texas State University for Negroes when owned by the Houston Independent School District) became essential to offering higher education opportunities for African American students. Additionally, Texas Southern University became the first state-supported institution of higher education in Houston, Texas. Texas Southern University's academic programs include: law enforcement, health, public works, city planning, environment, business and education. Today, Texas Southern University exists as a premier institution for African American students and enrollment has swelled from just over 2,000 undergraduate and graduate students to an estimated 9,000 (Texas Southern University, 2010).

In 2008, Texas Southern University received grant funding from NASA to establish the Center for Bio-Nanotechnology and Environmental Research (C-BER) (NASA, 2008a). The NASA C-BER multidisciplinary initiative seeks synergistic collaboration with private and public sector professionals in order "to train and educate students and postdoctoral fellows" (NASA, 2008a, p. 6). The research facilitated by Texas Southern University students and faculty focuses on the integration of chemical and biochemical analysis, molecular biology, bio-nanotechnology, and bioinformatics, in an effort to control for variables that may affect the health of astronauts during exploratory missions. Therefore, researchers from Texas Southern University attempt to isolate harmful microorganisms and other stress factors by developing countermeasures.

NASA C-BER aligns with the NASA Exploration Systems Mission Directorate (ESMD), but also parallels other NASA mission directorates (NASA, 2008a). This project will benefit NASA as the research includes multiple strategies to enhance technologies, develop new

inventions, and decrease overall costs. Specifically, the research conducted by Texas Southern University will primarily benefit astronauts in long duration space missions. Further, this project intends to strengthen the STEM workforce of the future, improve collaborative opportunities and partnerships for Texas Southern University, advance healthcare for astronauts, increase technology transfers, and enrich the quality of life.

University of Texas at El Paso

The University of Texas at El Paso, classified as a Hispanic Serving Institution (HSI), offers more than 80 baccalaureate degrees, 65 master's degrees, and 16 doctoral degrees. Further, the University of Texas at El Paso received the honor of becoming a National Science Foundation Model Institution for Excellence (MIE), and received \$5 million from the Carnegie Corporation to initiate the Teachers for a New Era (TNE) program. In addition, the University of Texas at El Paso became one of ten institutions to receive funding from the Office of the Director of National Intelligence to establish the Intelligence Community Center for Academic Excellence. The University of Texas El Paso reported in 2011 that total research spending equaled approximately \$60 million (University of Texas at El Paso [UTEP], 2011, para. 4).

In 2009, the University of Texas at El Paso received funding from NASA to found the Center for Space Exploration Technology Research (cSETR) (NASA, 2009c). With the funding allocated by NASA, cSETR aims to improve “green propulsion and in-situ resource utilization” in order to produce valuable propellants (NASA, 2009c). Overall, the center facilitates research on exploration technologies and increases the participation of underserved and underrepresented students in the aerospace sciences. Additionally, cSETR provides a multidisciplinary approach to the aerospace sciences, supports research conducted by students, and offers a series of outreach activities specifically for K-12 teachers and students. To ensure the sustainability of

cSETR in future years, the University of Texas at El Paso secures partnerships with other institutions, NASA centers, NASA contractors, and the Department of Defense.

Data Collection

Data collection converged on the inclusive experience of underserved and underrepresented undergraduate students in the URCs project. Selected institutions served as the unit of analysis, and data collection occurred through a series of interviews. Interviews occur as “conversations in which a researcher gently guides a conversational partner in an extended conversation” (Rubin & Rubin, 2005, p. 4). Data was also extracted through document analysis. However, the primary means of data collection occurred through 30 face-to-face interviews with underserved and underrepresented undergraduate student participants in the URCs project.

Purposeful sampling, a form of non-probability sampling, guided the selection of participants. This form of sampling “Purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned” (Merriam, 2009, p. 77). As such, “information-rich cases” were selected for this study, which yielded significant information relating to the most effective aspects of the URCs project for underserved and underrepresented students (Patton, 2002).

Specific selection criteria allowed the researcher to identify appropriate participants for this study. Participants were primarily selected based on their participation in the URCs project, and were undergraduate students pursuing a STEM degree at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso. Participants selected for interviews also had at least one semester of internship experience at their institution that involved STEM-related research. African American females participating in the URCs project and pursuing STEM degrees were emphasized and consisted of 8 of the total 30 interviews.

Historically, African Americans have been underrepresented in STEM fields (Perna et al., 2009). Incremental growth has occurred during the past 20 years in STEM fields among this population, nonetheless African Americans still represent the smallest proportion of the population graduating with bachelor's degrees in STEM (5.6%) (Hill & Green, 2007). In 2004, African Americans earned a mere 3.3% of master's degrees and 1.3% of doctoral degrees in STEM degree fields.

Further, the proportion of African American females that pursue STEM degrees is significantly lower than African American males (Perna et al., 2009). Research establishes "the relationship between self-efficacy and education attainment in STEM fields, especially for women and students of color" (Perna et al., 2009, p. 4; Colbeck et al., 2001; Lent et al., 2005; Leslie et al., 1998; Rayman & Brett, 1995; Zeldin & Parajes, 2000). The largest deficiencies exist in engineering. In 2001, African American females earned only 36% of the total number of engineering degrees awarded to African Americans (NSF, 2004). As such, colleges and universities must become more proactive, and "do more to promote attainment in STEM degree fields, particularly among African American women" (Perna et al., 2009, p. 2). As such, this study examined this specific population to determine the effectiveness of the URCs project in stimulating interest in STEM and encouraging African American females to persist in STEM degree fields.

Annually, NASA makes projections relating to the number of students impacted by programs such as MUREP. This study focused on a sample of underserved and underrepresented undergraduate students that annually participate in the URCs project to determine its effectiveness in encouraging persistence in STEM degree fields. Further, this study determined factors within the URCs project that contributed to the success of underserved and

underrepresented undergraduates in STEM degree fields. NASA also tracks students to determine the number that enter jobs within the agency, with NASA contractors, or at colleges and universities following participation in the URCs project. Table 3.2 depicts student employment following participation in the URCs project in 2010.

Table 3.2

Student Employment Following Participation in the URCs Project (2010)

Employment	Number of Students
NASA	12
Aerospace Industry	38
STEM Academia	102
STEM Industry	6
Non-STEM	8

Prior to data collection, a proposal for this study was submitted to the Institutional Review Board (IRB) at the University of Alabama for approval. Once approval was received, interviews commenced with students at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso. Informed consent forms were distributed to student participants. The informed consent forms included a synopsis of the research, provided comprehensive information relating to the researcher's background, and described benefits and risks of the study (Rubin & Rubin, 2005). A total of 30 face-to-face interviews were conducted across the three study sites to ascertain the effectiveness of the URCs projects. Information relating to each URCs project, posted via university websites, was also analyzed to determine the effectiveness of the provided information.

Interviews

Interviews served as the primary instrument for gathering data relating to the URCs project. The researcher employed responsive interviewing. This interviewing model is comprehensive and “relies heavily on the interpretive constructionist philosophy, mixed with a bit of critical theory and then shaped by the practical needs of doing interviews” (Rubin & Rubin, 2005, p. 30). Responsive interviewing stresses the importance of recognizing ethical obligations as a researcher. This model also emphasizes the need to develop an understanding of the respondents’ situational awareness.

Prior to contacting the principal investigator at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso to request interviews with students, I contacted the NASA Office of Education to ensure awareness of my study. I then contacted each principal investigator at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso to request their assistance in locating students willing to participate in interviews. Principal investigators provided e-mail distribution lists of students that met the criteria, as detailed. An e-mail was drafted and distributed to students that provided information about interviews and requested their voluntary participation.

Students selected for the purposes of this study met specified criteria. Students were current participants of the URCs project, or had recently participated in the URCs project in coordination with NASA and the institution that they attend. Of the 30 students that participated in interviews, 19 students were African American and 11 students were Hispanic. In addition, 17 of the students that participated in interviews were male, and 13 student participants were female. As the URCs project exists at institutions nationwide, students at Prairie View A & M

University, Texas Southern University, and the University of Texas at El Paso were also selected based on their proximity.

Interviews allowed for the collection of extensive information pertaining to each student's experience as a participant in the URCs project. Prior to identifying themes in the data, I notated significant segments of data, using open coding. Definitions were created as a measure to consistently identify similar codes within the data. In addition, using an outline procedure allowed me to hierarchically delineate specific codes (Rubin & Rubin, 2005). Main topics were designated using roman numerals, and subtopics were designated with roman letters. The outline for this study was created only after extensive review of each transcript. This coding scheme allowed me to recognize relationships that existed within the data. Assigning codes to data allowed for categories to emerge (Merriam, 2009).

Interview protocol was developed by identifying prevalent themes throughout the literature utilized for the purposes of this study. These themes encompassed the inclusive experiences of underserved and underrepresented undergraduates in STEM, and factors that detracted from persistence in STEM degree fields. Further, literature relating to self-efficacy was used to develop questions relating to hands-on and technical challenges. These questions encouraged students to provide specific examples of challenges that they experienced as participants of the URCs project that strengthened self-confidence and self-concept.

An audio recording device documented interactions with student participants. Essentially, the audio recording device allowed me “to keep a record of what was said for later analysis” (Rubin & Rubin, 2005, p. 110). Following the facilitation of each student interview, interviews were transcribed using a transcription service. Following transcription, each interview was thoroughly reviewed to ensure accuracy and identify variations in individual

responses. Interviews also allowed the researcher to discern body language and recognize fluctuations in the verbal tone of respondents.

Document Analysis

NASA frequently utilizes websites and other marketing materials to recruit students to participate in the URCs project. In addition, faculty and students alike receive information pertaining to the URCs project through university websites. NASA also makes application information available via the NASA Office of Education web portal and through agency-wide press releases. Further, NASA markets student participation in the URCs project through attendance at conferences and forums. For the purposes of this study, these marketing strategies were evaluated to determine their effectiveness in attracting students to the URCs project. Moreover, interview questions queried students about the URCs project marketing materials and websites to determine the effectiveness of documents used to recruit student participants. Students were asked to describe the most appealing features of the URCs project documents to determine the importance of the information provided by NASA. Students were also asked to identify aspects of the project advertised in documents that were not offered.

Data Analysis

A constant comparative process was employed throughout the duration of this study, as data analysis occurred concomitantly with data collection (Merriam, 2009). This provided me with the opportunity to adapt interviews to ensure a comprehensive study. Unique to the constant comparative method, similarities between portions of the data are compared “with another to determine similarities and differences” (Merriam, 2009, p. 30). Previous interviews were consistently reviewed to isolate imperfections in the interview protocol. For the purpose of clarification, questions regarding tinkering and technical self-efficacy were revised to ensure

understanding. Students were asked to provide explicit examples of problems that they encountered while conducting research that illustrated both hands-on and technical challenges. Rudimentary analysis also occurred as data was continuously collected.

Atlas.ti software was used to assist in analyzing the student interviews. After transcription, coding permitted the researcher to identify comparable themes. The coding of data allows for “the formal representation of analytic themes” (Marshall & Rossman, 2006, p. 160). Coding was assigned according to the relevance to the study (Merriam, 2009) and resulted in the identification of 58 codes.

The conceptual framework, self-efficacy, influenced the development of themes. Themes were based on a student’s inclination to persist in STEM degree fields, the ability of the URCs project to stimulate interest in STEM degrees and professions, and the capacity of the URCs project to improve the knowledge, skills, and self-confidence of student participants. These themes were identified through the literature and relate to self-efficacy and STEM education for underserved and underrepresented students.

Following the coding of data, interpretation began (Marshall & Rossman, 2006). Interpretation allowed the researcher to assign meaning, develop linkages, determine significances, and make conclusions about each theme. Defining themes also allowed the researcher to better understand the collected data. The final product resulted from collected data and conducted analysis (Merriam, 2009). Thus, data analysis provided answers to the stated research questions.

Limitations

Time existed as the largest constraint for this study. Preferably this study would be longitudinal, allowing the researcher to track students post-participation in the URCs project to

establish their predilection for entering the STEM workforce following graduation. Also, as many students have not completed their participation in the URCs project, they encountered difficulty evaluating the total experience.

Access to students also was a limitation of this study, as many institutions participating in the URCs project are located out-of-state. Predictably, recruitment for interviews became difficult, as the researcher was external to these institutions. Therefore, interviews were restricted to students attending universities in Texas. Students were requested to participate in interviews based upon their involvement in the URCs project. I thereby relied on the contacts provided by the NASA Office of Education, and the principle investigator associated with the URCs project at each university. Students were contacted through campus e-mail to request individual interviews.

Role of the Researcher

Responsive interviewing encourages the researcher and interviewee to “develop a relationship within a *conversational partnership* that influences the interviewing process” (Rubin & Rubin, 2005, p. 79). Therefore, my occupational experience proves relevant to the study. For approximately four years I worked as a Government Professor at two community colleges in the Houston/Galveston, Texas area. My role within each institution encompassed the development of course materials and providing assistance to students enrolled in introductory level courses. I also worked as a Research Analyst in the Office of Research and Institutional Effectiveness (ORIE) at a regional community college. As the Research Analyst for ORIE, I maintained institutional data for annual submission to the Integrated Postsecondary Education Data System (IPEDS).

For the past four years, I have had the opportunity to work at NASA Johnson Space Center. First, in my capacity as the Grants Development and Management Coordinator for the Aerospace & Biotechnology Academy, I initiated grant proposals for submission to federal agencies and various foundations. With the funding received, I created STEM programs intended for students pursuing secondary or post-secondary education. In addition, I also supported the NASA Reduced Gravity Student Flight Opportunities Program, or Microgravity University. Microgravity University competitively invites undergraduates and graduates to perform scientific experiments aboard a C-130 aircraft. Further, I drafted and edited the annual Reduced Gravity Student Flight Report for submission to NASA Headquarters and participating colleges and universities in 2007.

Currently, I am the Educational Administrator for the NASA Human Research Program Education and Outreach project at Johnson Space Center. In my role, I assist colleges and universities in the development of grant proposals. If approved, funding is utilized for the implementation of NASA education materials that focus on increasing student participation in STEM. I also regularly make presentations for professional organizations at state and national conferences to provide information pertaining to NASA student and educator opportunities, and manage a series of STEM education programs. I also work to establish new programs, unique to NASA. In 2009 I was responsible for initiating a virtual conference in collaboration with the Smithsonian Institution focusing on the societal contributions NASA has made since its inception in 1958. The conference reached more than 3,000 people throughout the global community.

Further, I am one of four Authorized Organizational Representatives (AORs) for Johnson Space Center. My position as an AOR enables me to submit grant proposals on behalf of the

agency. For the past two concurrent years, I have also represented NASA Johnson Space Center as a member of the University of Houston—Clear Lake Teacher Certification Council (TCC).

As an industry representative for the TCC, I assist in reviewing modifications to the teacher certification program at the institution, and ensure alignment with state mandated regulations.

Additionally, I am a member of the Lee College Geographic Information Systems (GIS) Advisory Committee. As an advisory committee member, I assist Lee College in locating employment opportunities in industry for students after the completion of GIS certification.

Since 2008 I have also served on the Nike Jordan Fundamentals Review Panel. The Nike Jordan Fundamentals foundation provides funding for predominantly low-income schools. In my service to the Nike Jordan Fundamentals foundation, I regularly work with school administrators, Nike executives, underserved and underrepresented students, and various communities to cultivate enriching education programs. As a member of the Nike Jordan Fundamentals Review Panel, I also make determinations about funding allocations for grant proposals received by the foundation.

Although I work at NASA Johnson Space Center, I do not manage or coordinate any of the education activities related to the URCs project. The NASA Human Research Program Education and Outreach project is external to the NASA Office of Education and exists under the Exploration Systems Mission Directorate (ESMD) and Space and Life Sciences Directorate (SLSD), providing me with only occasional access to activities facilitated by Minority University Research and Education Program (MUREP) managers. Additionally, I have not interacted with students who have participated in past or present URCs projects.

Trustworthiness

Lincoln and Guba (1985) asserted that trustworthiness improves a study's credibility.

Qualitative research emphasizes the need to build trust, preserve good relationships, respect "norms and reciprocity," and ensure ethical behavior (Marshall & Rossman, 2006, p. 78).

Merriam (2009) describes "eight strategies for promoting validity and reliability" in qualitative research that consists of: triangulation, member checks, adequate engagement in data collection, researcher's position or reflexivity, peer review/examination, audit trail, rich, thick descriptions, and maximum variation (p. 229).

Triangulation of Data

The triangulation of data integrates several sources of data to explain a specific point.

Several sources of data "can be used to corroborate, elaborate, or illuminate the research question" (Marshall & Rossman, 2006, p. 202). After IRB approval was received, interviews were conducted with student participants from the URCs project. These interviews were instrumental in summarizing student experiences in the URCs project. Document analysis also provided unique insight into the utility of NASA marketing tools. By reviewing these documents, the researcher gained knowledge pertaining to the intended use of marketing materials, and their efficacy (Marshall & Rossman, 2006). These methods thereby increased the validity of this study.

Lincoln and Guba (1981) suggested the audit trail as a method to authenticate a study by following the researcher's trail. In qualitative research, an audit trail essentially describes the data collection process, discusses the derivation of categories, and explains decision-making implicit in the study (Merriam, 2009). As such, the researcher consistently maintained a journal that illustrated questions, decisions, and ideas that emerged during the study. These reflections

were embedded in the methodology section of the study, and detailed a sequence for the conducted research. Further, the audit trail influenced the dissemination of data for this study. As data was analyzed, the audit trail assisted in making collective determinations about the meaning of statements made by student participants in the URCs project. As questions in the interview protocol often prompted students to make similar statements about their participation, I used the audit trail to categorize commonalities. Essentially, this strategy allowed themes to emerge through the data.

Rich, thick description “refers to a description of the setting and participants of the study, as well as a detailed description of the findings with adequate evidence presented in the form of quotes from participant interviews, field notes, and documents” (Merriam, 2009, p. 227). Rich, thick descriptions originate from the researcher’s first-hand experiences and enhance data synthesis (Rubin & Rubin, 2005). Main questions, probes, and follow-ups were used to ensure in-depth detail for this study. I used main questions to query student participants about primary topics to assure a comprehensive interview. Additionally, probes allowed me to further investigate reactions to interview questions. Also, follow-up questions allowed the student participants to elaborate on statements viewed as important.

CHAPTER IV:

RESULTS

The U.S. continues to encounter difficulty recruiting underserved and underrepresented students into the science, technology, engineering, and mathematics (STEM) pipeline. Recognizing a growing national deficiency, NASA created an array of STEM educational initiatives to stimulate interest among underserved and underrepresented students. The University Research Centers (URCs) project offers undergraduates with the opportunity to facilitate high-tech research aligned with NASA's agency-wide research objectives at Historically Black Colleges and University (HBCUs), Hispanic Serving Institutions (HSIs), and tribal colleges and universities. While the URCs project offers unique opportunities, only limited data currently exists to indicate the effectiveness of the initiative on the persistence of underserved and underrepresented undergraduates in STEM degree fields. To further address the persistence of underserved and underrepresented undergraduates in STEM degree fields, this study analyzed factors that contribute to self-efficacy. More specifically, this study examined how the NASA URCs project contributes to the success of underserved and underserved students in STEM degree fields. Literature suggests that strong self-efficacy frequently prevents attrition among underserved and underrepresented undergraduates in STEM degree fields (Leslie, McClure, and Oaxaca, 1998). If underserved and underrepresented undergraduates have the ability to overcome challenges, they become more likely to succeed in STEM degree fields.

The findings below represent the most pertinent aspects of the URCs project. Initially, this study examines the benefits of the URCs project. Thereafter, this study analyzes data derived from interviews to ascertain the benefit of internship opportunities, academic challenges that emerged during participation, the importance of faculty support, and the influence of

mentors. The five themes encompass the comprehensive experiences of students in the URCs project. Students reflected on the benefits garnered as a direct result of their participation in the URCs project. Students also discussed the internship opportunities they received within the URCs project at their institutions, at NASA, and at other STEM-related industries. In addition, students articulated their concerns about academic challenges presented within the URCs project. However, faculty support often provided students with the reinforcement necessary to progress in the URCs project. As well, mentors often positively influenced students in the URCs project, and contributed to their persistence in STEM degree fields.

Benefits of the URCs project

As one of NASA's premier educational initiatives, the NASA URCs project provides generous funding opportunities for minority serving institutions throughout the U.S. to create new technological concepts, "expand the nation's base for aerospace research and development, develop mechanisms for increased participation by faculty and students of MIs in mainstream research, and increase the production of socially and economically disadvantaged students" (NASA, 2009d, para. 2). The allocated funding not only allows colleges and universities to conduct research, but provides a stipend for student participation. Additionally, NASA allows flexibility in the management of programs. As such, each university creates distinctive programs that differ from other funded institutions.

Entry into the URCs project at Prairie View A & M University (Center for Radiation Engineering and Science for Space Exploration or CRESSE), Texas Southern University (Center for Bio-Nanotechnology and Environmental Research or C-BER), and the University of Texas at El Paso (Center for Space Exploration Technology Research or cSETR) has become a highly-selective and competitive process. Students must maintain a stable GPA and have demonstrated

a strong interest in their chosen STEM degree field. Faculty affiliated with the URCs project and principle investigators determine the appropriate participants following a series of interviews that evaluate a student's academic and personal aptitudes. Students invited to participate in their institution's URCs project work up to 40 hours a week in university laboratories, often in coordination with their peers.

NASA URCs project denotes success by the aggregate experiences of their students. For the purposes of this study, students at three institutions (Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso) provided feedback on the benefit of their experience. Jeff, a male African American senior chemical engineering major discussed his experience in the URCs project.

Initially I wanted to be at NASA so I got to see the culture, but you know, ten years from now I'll remember what a great experience it was no matter where I am. I'm seeing different aspects of research I can go into.

Mary, a female African American junior biology major, recalled realizing the importance of her experience. She stated,

I was just in class the other day - my biology seminar class, it's over maybe 70 or 80 students in the class. The speaker asked the students how many people have gone on internships. I was the only one out of 70 or 80 students that raised their hand.

Sean, a male African American senior mathematics major, suggested that the support provided by faculty and students motivated him to continue his pursuit of a degree. He stated,

The professors run a great program here and you know, even at times when I'm feeling down from the semester because of all the work...I sit with the [Center for Bio-Nanotechnology and Environmental Research] scholars or with the C-BER mentors. You know, it gives me that extra juice I need to keep going, so it's a wonderful program.

Sean also emphasized that the C-BER project at Texas Southern University had reinforced his self-confidence, motivating him to pursue his Ph.D. in mathematics. Kara, a female African American senior electrical engineering major also suggested that the URCs project had provided

her with the skills to excel in graduate school. Other students confirmed that the URCs project allowed them to overcome self-perceived inadequacies. Jessica, a female Hispanic senior mechanical engineering major explained that

As a student you think [University of Texas at El Paso] is not a well-known university like Purdue or MIT or something like that. The first summer I went to do my internship you feel here are all these students with all these really well-known universities...you tend to underestimate your capabilities and you are like, how can you compete with these people? You realize, especially with all the work I have done here...there is really no difference between them and me and what we are capable of and our expertise.

The URCs project provided perspective for students in their individual STEM degree fields. In addition, students found associating with their peers and professors as largely beneficial in overcoming challenges. Further, multiple students suggested that participation in the URCs project strengthened their self-perception and ultimately increased their belief in their capabilities.

Academic Benefits of the URCs Project

Frequently underserved and underrepresented undergraduates become paralyzed by rigorous academic coursework. With little or no support, many of these students opt to change majors or withdraw from their institution. Thus, the number of underserved and underrepresented undergraduates qualified to enter the STEM pipeline continues to decline. The URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso offer opportunities intended to ignite interest in STEM degree fields, and to equip students with the necessary academic skills to succeed in demanding coursework. As a result, students in the URCs project tend to develop a heightened sense of ability. According to Steven, a male African American senior biology major,

A lot of times, a lot of my peers right now will come to me and ask questions whether they know what I do in a lab or not...they know I have exposure to some of the things

they are recently just getting exposed to in the lab. Whether it is cell counting, I have done it a dozen times so I can explain the details about it and they understand why it is necessary to do a cell count. So it helps out in lab courses. It helps out in my other courses as well.

Elizabeth, a female Hispanic senior mechanical engineering major, quipped that she could readily communicate with NASA personnel in her field because of her participation in the URCs project. She stated,

I learned all the technical boards. I remember people at NASA would say “LOX.” My friends would ask me, “What is that?” I would say, “It’s liquid oxygen.” And when I get to communicate with people from NASA, I already know what they’re talking about. I know this stuff already!

Student participants in the URCs project also benefit from working on research projects conjointly. Oscar, a male Hispanic senior mechanical engineering major, described a scenario that allowed him to work with his peers to solve a complex problem. After trying multiple tests, he realized that the concepts his team applied did not relate to what they had previously learned in the classroom. The experience he gained with his peers allowed Oscar to realize that classroom learning differed from real-life experiences. “That was probably the most important thing that I’ve learned.”

Many students had the opportunity to participate in other university-based STEM programs. Melissa, a female African American senior biology major, expressed her satisfaction with the URCs project:

I have to say that I think this is the best program...science program that I have been in yet. I have been a part of another program, I don’t want to name names, but...it was nothing compared to the NASA C-BER. This is just way broader and informative and everything. I’m really learning.

When confronted with challenges, students often relied on their peers for academic support. Moreover, they realized their fortitude to overcome these challenges. Additionally, students

became more cognizant of their potential as participants of the URCs project, feeling more self-confident because of their acquired knowledge.

Undergraduate/Graduate Collaboration

As a mechanism to assist underserved and underrepresented undergraduates succeed in STEM degree fields, institutions initiated collaborations between undergraduate, master's, and doctoral students. This collaboration not only ensures the comprehension of difficult research-related concepts, but provides mentoring for undergraduates. In addition, this collaboration allows undergraduates to gain perspective on graduate programs in STEM degree fields. David, a male Hispanic senior mechanical engineering major, explained how the process works. "We split up the work. We've got Ph.D. students and master's students involved in there. We split up the work and we'll work together to get whatever we have to do right by the deadline."

As a result of collaboration between undergraduates and graduates within the URCs project, students develop strong communication skills. These relationships allow students to interactively collaborate on research and other academic pursuits, and promotes problem-solving with peers. Jessica, a female Hispanic senior mechanical engineering major, described the relationship she maintained with her peers. She stated,

I think it is funny how most of us are not just like co-workers, we are all just friends now since we spent so much time with each other. We have a family thing going on. Every group is separated and has maybe one undergraduate student, a master's student, and a Ph.D. student. So usually the Ph.D. students are the leaders of the group. We don't just stay with our group. There are a lot of collaborations between groups actually.

The ability to collaborate with her peers also enabled Jessica to resolve difficult tasks that emerged in her research. She asserted that

You are always going to get challenged by stuff you have never done before. It is never something too hard that you can't do or can't ask someone to help you with and usually people are really good with that. I can't say there has been something that was

“Oh my God I can’t do this.” There is always ways to figure it out and we have the means and the right people to ask.

Further, Max, a male Hispanic senior mechanical engineering major, contended that as a group, students can accomplish more and can “trouble-shoot things a lot easier.” Charlie, a male Hispanic electrical engineering major, also suggested that working collaboratively with graduate students provided him with more insight. “Most of the students that I have shared ideas or work with are masters or even Ph.D. students and that’s helped me a lot because master’s students or Ph.D. students are more experienced.” As most graduate students possess extensive experience in research, collaboration can permit undergraduates to acquire skills necessary for success in STEM degree fields. Graduates also have the ability to stimulate interest in STEM degree fields, increase knowledge, and promote the attainment of advanced degrees among underserved and underrepresented undergraduates. As such, graduate and undergraduate collaboration appears a valuable component of the URCs project.

Problem-Solving with Peers

Faculty encourage student problem-solving with peers in the URCs project. Inevitably, this provides students with the opportunity to build relationships and to determine probable solutions for research projects. Michelle, a female African American senior mechanical engineering major, identified similarities between peer problem-solving and problem-solving facilitated within the engineering industry:

I have been under a grad student so it really has been a team effort and as simple as that might sound, I found teamwork to be essential in the engineering industry. You have to know how to work and to allow someone else to come in and teach you and train you to gain more information. That’s one thing that I really have learned and it’s a big part of me now.

Further, Elizabeth discussed more specific benefits of problem-solving with peers. As a participant in the URCs project, Elizabeth worked collaboratively with her peers to construct an

injector. While she lacked prior experience, her peers compensated for her novice skills. According to Elizabeth, “everyone’s been very helpful, and they have more experience.” In addition, Max cited the close proximity of student offices as beneficial for problem-solving. “I know a good majority of all the students just because all our offices are together, if someone is discussing something about your project, input is welcome and you always get people like ‘oh, well have you thought about this’ or ‘what can you do about that?’” Weekly scheduled meetings also allowed participating students to understand the intricacies of other projects. These meetings promoted information-sharing and problem-solving. As Max explained, “We always have a certain meeting every Monday and we all come together and I guess we discuss issues and we work on...talk about future plans and work on different projects and stuff like that.”

Problem-solving with peers can largely benefit students. Nonetheless, some students that prefer to work independently struggled to adapt to group dynamics. Sean described working with his peers as challenging. “Collaborative efforts for research...having not done that before, you know that’s an obstacle I have had to overcome, but I think I’m doing quite well overcoming that.” He acknowledged that he preferred only to work with his mentor on research projects. However, because of the URCs project, Sean has learned to work effectively with his peers. “Learning how to work in a group to achieve a research goal is another skill set that I’ve been able to acquire.”

Peer Collaboration

The URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso requires students to participate in high-tech research that correlates with NASA agency-wide objectives. Frequently, undergraduate students within the URCs project worked with graduate students to develop an enhanced understanding of multi-

faceted issues in assigned research. Joseph, a male African American junior electrical engineering major, discussed his work with graduate students:

I've also been assisting various graduate students with their actual project. I will of course, do my own project, you know, down the line, but so far with the center I kind of just assisted with other people's projects and, I've done one of my own smaller projects. But again, we do a lot of collaboration.

Michelle also benefited from peer collaboration with graduate students. "Anything that I was given - if I did have trouble or couldn't find the answers, they were always right there to help me." Moreover, Katherine, a female Hispanic junior mechanical engineering major had a comparable experience. "It's a good program. Sometimes the undergraduate students will explain different topics to each other. Sometimes the master's or Ph.D. level students will explain it to the undergraduates." Further, Jessica described her relationship with the mechanical engineering department at the University of Texas at El Paso as a "family."

The URCs project selects only the most competitive and accomplished students to participate. As a result, many students have positive experiences collaborating with their peers. Mary described her involvement with her peers as fulfilling. "In my classes, I think - it doesn't seem like students study as much or work as hard. With this program, they pick the best, so it's nice to associate myself with other students like myself." Jessica also found the structure of the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso helpful in resolving challenges. She contended that students avoided becoming overwhelmed because of collaboration. "I think the center and just the way things are run, and the set-up of having the undergraduate, graduate, and Ph.D. students in the groups kind of keeps that from happening too much."

Conversely, other students found peer collaboration frustrating. Oscar recalled feeling estranged while working on multiple projects with his peers:

At first I thought it was weird and I didn't like it because I thought like I'm just here and I'm not contributing and my team here has their projects and they're working on stuff, it seems really cool and I would help them you know...here and there, but I didn't have like a full project of my own that I could like, "well that's what I'm working on," you know.

Analogous to other students in the URCs project, he often found peer collaboration an obstacle.

As Oscar generally worked individually on his academic coursework, he found difficulty adjusting to collaborative research required in the URCs project at the University of Texas at El Paso.

I usually study on my own. When I'm reviewing for a test it's usually by myself or it's real quiet and there's nobody around, you know? When you go to work it's not like that. You don't work in your little office and your little space where it's quiet, you work in a group, and you almost always do everything in a group.

While Oscar initially resisted working collaboratively with his peers on research projects, his experience likely will result in better outcomes as he enters the STEM workforce pipeline.

Similar to Oscar, other students within the URCs project regularly conferred with their peers on research and academic coursework. This collaboration resulted in students identifying solutions to problems and overcoming challenges.

Collaborative Experiences

Aside from rigorous research facilitated within universities, student participants in the URCs project frequently have the opportunity to become immersed in the NASA culture. Students often visit various NASA centers and facilities in an effort to provide realistic working experiences, and interface with professionals in STEM fields and other students pursuing STEM degrees. These site visits not only offer hands-on interactive experiences, but allow students to gain insight into careers at NASA centers throughout the United States. Sean reflected on his experience at NASA Ames Research Center in Moffett Field, California:

At the end of this summer when we had the research experience out there in NASA Ames, I mean that entire experience was hands-on. We got to visit the facilities out

there at NASA and see the supercomputer...that was very cool. We had a lot of meetings and luncheons and also social barbecues even...to get to know each other and the program coordinators as well. You know, I had an opportunity to meet people from all over the world.

Elizabeth also valued the collaborative experiences at NASA that focused on teamwork. "I've used a lot of teamwork and experiences that I learned within NASA, and with the center."

Elizabeth's teamwork skills have translated into other aspects of her life. "I've been in extracurricular activities like Eco Shell, and doing stuff like that. You get to work with other people." However, she suggested modifying the structure of research projects within institutions to ensure more effective collaboration.

Everyone's doing their own thing, you know...just work with your team. Maybe have more of the ability to move around and be like, "oh, I've just been working this project, and I want to move to that one." Or if someone's interested in working in our project, for them to move this way.

Other students viewed the assemblage of participants as conducive to productivity. Oscar, although initially hesitant to collaborate with his peers, explained the camaraderie he felt after working with the same students repeatedly:

I probably see these guys maybe like 15, 20, 30 hours a week. It's great because I've known them...I either had them for class or I've just known them from around or know them through friends within the department. You start to see the same people. There comes a point where you start having classes and it's the same group of people, but then you get to become friends with them and you get to know them and it's really great. So by then you know, with these guys I had already known them for maybe like a year and a half or so, and then we started working together and then built that relationship and then all three of us went to [Johnson Space Center] for the summer so then we built that strong relationship.

Collaborative experiences allowed student participants of the URCs project to gain invaluable insight into STEM fields, and develop relationships with peers and STEM professionals.

Otherwise introverted students learned to effectively interface and work with their peers, professors, and STEM professionals. Students also received unique opportunities to meet other

students from URCs projects housed at varying institutions, and strengthened existing relationships with their peers from Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso.

Personal Benefits of URCs Project

Institutions that receive funding from NASA not only create research opportunities for students, but strive to create an environment that reinforces student self-confidence. Students carry this self-confidence over to careers within the STEM pipeline, or in graduate school. Kara described the personal benefits of the URCs project. “I can go out into the workforce and say “You know what? I have so much to offer. I know the potential inside of me, I just have to let it out.” In addition, she explained, “it’s making me a more well-rounded person.” Kara also expressed her enthusiasm for entering the workforce as a result of her participation in the URCs project. “All the possibilities I’ve been in, it’s just telling me, that look...you don’t have to limit yourself to this space right here. You can go here, you can go there.” Matthew, a male African American senior mechanical engineering major viewed the experience he received via the URCs project as a way to strengthen to his résumé. “With the résumé, just to see that I have that experience on there has really paid dividends for me.”

For many student participants, the URCs project also provided valuable insight relating to graduate school. For Elizabeth, the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso made her more inclined to consider graduate school.

When you’re in a project, “oh, my God, I have a deadline,” and you have to think about this and you have to think about that. You really start developing those skills that you really don’t get in a classroom. So I really feel that it should be important. And it just motivates you to keep going. Like, yeah, I was just thinking I’m just going to get a bachelors and that’s it, you know? And it’s like, “oh, you know, master’s...hmm.”

As a result of their participation in the URCs project, some students received more advanced job assignments. Charlie detailed his role within the cSETR project at the University of Texas at El Paso:

I'm working with them as a System Administrator right now, and I'm considered the main guy for computers, so in the past I had to work by myself as the System Administrator, you know, and I think working with them at cSETR,...it has been helpful for me, because I have learned a lot of things and I have been actually in charge of computer labs in the center.

Other students appeared less convinced that their work within the URCs project would become personally beneficial. Melissa hesitantly conveyed her feelings regarding the “rewards or benefits” of the URCs project. “Uh, rewarding? I guess it’s a reward. I’m being...I’m a part of something. I take that as being rewarded. Um, but I’m like still...like working on stuff. I have to work towards their goals to get those; I guess achievements...certain achievements and awards.”

Personal benefits of the URCs project consisted of students developing time management skills critical to achieving success in STEM degree fields. In addition, students acknowledged that the URCs project influenced their maturity. However, other students insisted that the URCs project only provided minimal personal benefits. Rather, some students contended that the URCs project only focused on the achievement of goals specific to the institution.

Influence of URCs Project on Degree Completion

The URCs project appears to encourage many underserved and underrepresented undergraduates to aspire to loftier goals. However, few student participants recounted becoming more inclined to complete their degrees because of their participation. In fact, most students maintained that the URCs project had little influence on their decision to complete a STEM degree. Mike, a male African American senior computer engineering major reported little

difference in his decision to persist. “I mean, I think I would have finished regardless, you know? I wouldn’t say like, it was a reason why, but maybe a little bit. I’ve seen some of the different areas out there. And, what they tried to interest me in, doesn’t interest me.” Jeff also seemed reluctant to credit the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University with his accomplishment. “I would say that I was pretty much on the path. I don’t think I was going to be, I guess deterred to finish my degree.” Rather, Jeff explained that CRESEE instead allowed him to locate a new internship opportunity when economic downturn caused another to close. “So being in it and being able to see that I can lose an internship and be able to gain another one with the same great opportunities kind of reassures me that I need to be where I am.” Melissa also suggested that she would have likely completed her degree without the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University. “It inspired me, but I was going to complete my degree with or without it.” Similar to Melissa’s assertion, Steven stated, “I am already motivated. So I’m sure it helps somewhere but I was already even before C-BER...I was already committed to completing my degree. So in a way I would say ‘yes.’ It did help. But I already have that discipline.” David also admitted that he would likely finish his degree without his participation in the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso. However, David claimed that cSETR provided “extra motivation.”

Nonetheless, students like Michelle became encouraged by her peers that received job offers following their participation in CRESSE. After a short hiatus, Michelle detailed her experience transitioning back into school at Prairie View A & M University:

To come back and get back into school and get back into the school mind frame...at the time I still had, you know, hadn’t had any experience and I’m seeing my, you know,

my friends doing all this. So being able to get a hold of this actually gave me some applications to all of this studying and everything that I've been doing. I . . . I greatly appreciate the hands-on that it's provided me.

In addition, Elizabeth cited financial incentives for completing her degree, rather than her participation in cSETR. Elizabeth presumed that a degree had become necessary to securing a well-paying job. Without her degree, Elizabeth feared that she would receive significantly less compensation from her future employer.

Financial Incentives to Participate in the URCs Project

In return for their participation in the URCs project, most students received a stipend to subsidize the cost of tuition. The stipend allowed students to remain on-campus to concentrate on research projects and coursework, rather than locating a job off-campus. As many students struggled to maintain an off-campus job and coursework, funding provided by NASA helped to alleviate stress for students like Michelle.

This research has given me the opportunity to be able to work, because I do have finances that I do have to cover outside of school such as housing and, you know, bills of that sort. So that allows me to actually still be on-campus. I don't have to worry about that extra travel, to Cypress to keep looking for a job. And on top of that they really do understand the fact that you are in school.

Sean also acknowledged the importance of receiving funding from NASA as a student. As a full-time student, Sean depended on the provided funding to subsidize his personal and academic expenses.

What the funding is able to do -- unfortunately I'm not a rich man, at least not one apparently so. I don't know if I will be able to study this mathematics so vigorously but for the funding. And so I -- I'm certainly delighted to have the funding...what's available so that I would be able to completely study math, as opposed to study the math and go and work for someone else so I might make the money I need to support myself.

Brad, a male African American junior biology major described funding as an initial motivating factor for his participation in C-BER at Texas Southern University.

I have matured a lot. At that time, I probably wouldn't have done it. Now that I am in the program and I actually see like, I'm actually like doing great things. If you get out you're only hurting yourself. I'm not greedy or nothing...I appreciate what we do get because it does help a lot. Everyone has financial hardships, and I'm one of them.

Financial hardship compelled Katherine to seek a position within the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso. However, Katherine described the experience that cSETR provided as fulfilling.

It was definitely a motivating factor. I'll tell you that much. I signed a 12-month lease so getting paid is certainly very helpful. But, I think getting involved in that sort of research...it was a good opportunity to begin with. So, even if it, even if the compensation wasn't that good, I probably would have accepted it and then tried to find another job to pay for whatever other expenses.

Other student participants in the URCs project contended that the stipend did not prompt their participation. For Nick, a male Hispanic senior aviation science management major, working with NASA meant much more than just receiving a paycheck. "Once you say NASA, NASA's such a big name out there and, when people hear about that, they want to jump towards you. I can get into doors with anyone." Further, some students volunteered for the URCs project. Steven described his inclination to participate in C-BER at Texas Southern University as a volunteer. "I think I was in C-BER for almost a year with no compensation. So it wasn't a factor. I just wanted to be part of it." Likewise, Oscar maintained that financial adversity did not influence his decision to participate in cSETR:

It didn't influence my decision. Like I think maybe it helped in the respect that you know, I do live by myself and I do have to pay rent and I have a car payment and my cell phone bill, and all these things that may be not every other student has to worry about. The fact that it included a stipend was a plus. I probably would have worked here anyway, but I would have just had to continue working outside of school.

Jessica implied that financial compensation improved the performance of students within cSETR. She reflected on her position within cSETR:

I worked outside of the university for the first couple of semesters but it gets hard afterwards just trying to work around the schedule. So it was a big factor. Although the opportunity of doing research is great sometimes, I mean you have to work so it was actually a big factor...it motivates people more to do a better job since it is not just they are researchers, it is your job.

Additionally, many students opted to pursue an opportunity with the URCs project to conduct research closely aligned with their respective fields. Students that work off-campus seldom can locate employment related to their degree field. Max, a student at the University of Texas at El Paso, recalled his position in sales:

I used to work at a T-Mobile store. I used to be assistant manager and I'm like "This isn't helpful in regards to engineering. I'm like, might as well try to find something, find something at school, and at least, I'm learning something."

Although provided funding became an attractive incentive for students to participate, most asserted that they sought internships opportunities within the URCs project to gain experience in STEM-related research. Nonetheless, for many students funding eliminated the additional burden of locating employment external to their institution. Therefore, working on-campus allowed students to intently concentrate on research and academic coursework.

Inclination to Enter the STEM Pipeline

Student participants of the URCs project receive preparation to enter the STEM pipeline, post-graduation. Nonetheless, many students opt to pursue advanced degrees in order to enhance their knowledge and expand their career opportunities. Heather, a female African American senior mechanical engineering major expressed her intention to enter the STEM workforce. "If I could go into the industry and figure it out that thing that I'm the most passionate about, I'd be more than willing to come back to school." Michelle deliberated about her decision to immediately enter the STEM workforce. "I was really open to, of course, going straight into the

workforce just for experience, but I'm fighting between going straight into my master's or going out. . .going into the industry and then possibly coming back for my master's."

Mary considered working at NASA as a springboard for admission to medical school. In addition, Oscar explained that he would seek admission into a graduate engineering program, but would work at NASA if he could not acquire funding to pursue an advanced degree. Max, also a student at the University of Texas at El Paso had recently secured a job with NASA Johnson Space Center in Houston, Texas and planned to enroll in two graduate-level classes.

Interest in STEM

Crafted to stimulate interest in STEM among underserved and underrepresented students, the URCs project fosters an environment conducive to innovative learning. However, prior to their participation in the URCs project, students' early individual experiences shaped their interest in STEM. Kara attributed her interest in STEM to working in the healthcare industry as a teenager. However, she also received early exposure to STEM from her father and sister; both engineers.

My dad used to always say that I would put together things, and break things, and put them together, and where there was technologies, I always tried to figure out how stuff just operates, and it works. So I was like, well, I'm going to have to do this. But I grew-up in a household full of technology and engineers. My father's background is engineering. My sister graduated with - from here - in engineering.

Students like Heather participated in NASA on-line educational programs in sixth grade that incited her interest in STEM. However, she also seemed to possess an innate interest in STEM.

I wanted to build the first flying car. If you call my Mom she will tell you that I was really upset when I figured out that they already built one. It affected my whole dream and my life vision was gone. But uh...that -- that was it. I liked to figure out how things worked. So if that's using CAD drawings, or actually getting in there with my hands itself; it is just that.

As a result of her father's frequent hospitalization, Mary developed an interest in STEM. Mary recalled her experience as a child:

I always wanted to be a doctor. I've always wanted to be a doctor because my father, he was always in-and-out of the hospital so I wanted to know "Why?" I would try to figure out what was wrong with him. I would research, I would go to WebMD. I had to figure out what was wrong with him, and I liked what I was learning.

As a freshman at Prairie A & M University, Michelle became interested in STEM. A demonstration by several mechanical engineering majors at the institution intrigued Michelle enough to learn more about the program at Prairie View A & M University.

My freshman year they - the mechanical engineers had a project and that project was to build an airplane. And I thought that was so fascinating. And, you know they had to build a model and do the calculations of this and the other and it just really shook my interest and that's what really pulled me into mechanical engineering.

In the latter part of his life Oscar became interested in STEM as he had the opportunity to regularly interface with mechanical engineers. According to Oscar:

I was always really interested in how things work and why things happen the way they happen and I would actually see a lot of shows on TV like the History Channel, Discovery Channel, and just seeing programs about you know...they would show how things were made or how things work or the manufacturing process. I always thought it was really interesting and I used to work in a restaurant, well I had worked in restaurants since forever and I started noticing that people are really talking to you or like I would always ask "Man yeah, that sounds like the coolest job, what do you do?" They would always say "Well, I'm an engineer." I was like "What are you doing in El Paso?" And they're like "Oh we're doing this and this for you know, for Lockheed Martin or like Boeing." Delphi's another big company in El Paso and I'd say "well it seems super cool," like that's actually really what I'm interested in.

For many students, interest in STEM developed during early childhood. Students became motivated by parents, their peers, NASA interventions, and even TV shows. Thus, the URCS project offered students the opportunity to explore their interests in STEM further.

Interest in NASA

As a NASA-funded initiative, the URCs project must focus on research objectives as established by the agency. Preferably, the research conducted by individual institutions will rouse interest not only in STEM, but also in NASA for underserved and underrepresented undergraduates. The success of NASA has become contingent on the ability of colleges and universities to produce the most skilled and qualified STEM professionals to fill positions left vacant by the “baby boom” generation. Without the next generation of STEM professionals, NASA will lag behind international competition. The crux of the problem has become reaching the most crucial population of students that have received adequate preparation and training to lead NASA into a new era of innovation and excellence.

Kevin, a male African American junior biology major described his desire to work for NASA. “Well, being at NASA is just like -- it's NASA. Like to me, I'm all into NASA. To work at NASA it would be very surreal, I wouldn't mind at all.” Kevin continued, “Well, I guess -- I don't know if I'm like a sci-fi fan, but it's like NASA kind of feels that kind of way. So when I see the labs, like the Neutral Buoyancy Laboratory and things like that, it's like wow.” Other students envisioned NASA as rigid agency lacking character and culture. Jeff acknowledged his misconceptions of the agency:

I learned that - when I first went into NASA I thought - my original my perspective, was that it was very...I was going to go and there was going to be a lot of top-notch science, technology, engineering majors - and there are...don't get me wrong, but that the environment wasn't going to be as comfortable as it was. I was pleasantly surprised at how open they were at NASA.

Other students articulated facts about NASA they found interesting. Steven perceived the recruitment of underserved and underrepresented students in STEM fields at NASA as astounding. “I was actually surprised at how much effort they first put into trying to recruit

underrepresented minorities in this career field. I was very surprised about that.” Nick conveyed his excitement about having the opportunity to view a shuttle launch. “When they take-off you feel the - when they did the first - the sonic boom, you can feel the heat, even though it's like three or four miles away. I was like ‘Wow!’ I feel like Jesus everywhere I go, it's like, ‘yeah, you know, I've seen a NASA launch.’” Katherine discovered that working at NASA would enable her to combine her passion for biomedical engineering, rocketry, and space. Upon making this realization, Katherine decided to work vigorously to increase her GPA in the hopes of receiving an internship at a NASA center. Additionally, Jessica recognized NASA’s contributions to society:

At first and a lot of people think “Oh well, NASA just goes to space.” No. There are so many other things. “Do you know why you have power tools at home? Thanks to NASA.” So many things that people use in their everyday lives they do not even know why they exist. It is because of NASA coming up with space-related applications.

Internships at NASA often provided exposure for students that lacked knowledge and understanding of the agency. Tours of NASA facilities and access to shuttle launches increased student interest in NASA. Further, these internship opportunities required students to maintain a respectable GPA. As a result, students became more motivated to excel in their STEM degree fields to receive consideration for NASA internships.

Conclusion

The NASA URCs project offers an array of benefits for participating underserved and underrepresented undergraduates. Despite sometimes overwhelming hourly requirements, students have the tendency to advance both academically and socially in the URCs project. The URCs project also advocates for collaboration between undergraduates and graduates. While some students resisted collaboration, they gradually adjusted; learning to work productively with their peers. Undeniably, collaboration allows for more fruitful and rewarding research. In

addition, students had the proclivity to problem-solve when they worked collaboratively with their peers. The relationships that developed during collaboration often lead to positive experiences. Students that worked together at their respective institutions, frequently worked together on internships at NASA centers located throughout the U.S., creating solidarity.

As a result of the URCs project, students also benefited personally. Many students interviewed reported an increased sense of self-confidence. Students described overcoming intense feelings of anxiety to develop a strong sense of individualism. However, most students rejected the suggestion that the URCs project encouraged persistence and the completion their degrees. Numerous students asserted that they would have likely succeeded, regardless of the URCs project. Nonetheless, the URCs project inspired many students to seek more fulfilling experiences in their academic and future professional careers.

Financial incentives also enticed students into participation. Most students acknowledged the need to work to pay for housing, tuition, and other bills. As such, students sought opportunities that would accommodate their busy academic schedules, while still offering compensation. The URCs project provided compensation in exchange for student research. However, most students found the time they allocated towards research strenuous.

Following the completion of their undergraduate degrees, numerous students divulged their uncertainty about pursuing additional education, or immediately entering the STEM workforce pipeline. Student loan debt emerged as a determining factor. Thus, students often opted to seek a professional career, while attending graduate school. Nonetheless, some students felt a loyalty to their university which ultimately motivated them to consider graduate school.

All students professed their interest for STEM and NASA. The URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso each

fostered learning through an interactive and hands-on environment. Students appeared receptive to the opportunities offered, which unavoidably sparked interest in STEM and NASA. In addition, many students received the unique opportunity to work or visit NASA centers. These experiences engaged, encouraged, and excited many participating students.

Internship Opportunities

Students participating in the URCs project often received financial assistance to conduct research at their respective universities. In addition, many students had the unique opportunity to interview for internship positions at a NASA center. These internships provided students with the ability to network with STEM professionals, participate in research, and seek employment opportunities, post-graduation. Michelle explained the benefit of her internship at NASA. “I hadn’t had any internship experience so this really has been my experience to get a taste of, you know, what I would be doing as a mechanical engineer, as an engineer out in a prominent company such as NASA.” Similarly, Shannon, a female African American junior biology major perceived her internship as valuable. “Just this summer I interned at NASA at Johnson Space Center, so you know, it really opens up like how it is in the real field actually...and how the field is progressing. So it’s opened up many new doors.” Jessica detailed her internship experience at the Marshall Space Flight Center in Huntsville, Alabama, which compelled her to pursue a graduate degree.

I did a couple of internships my sophomore and my junior year at the Marshall Space Flight Center so they do a lot of propulsion there and I thought it was really interesting. I thought oh, they have that at the university. And I talked to [a faculty member] and this was when the center was converting into the URC. He just explained to me what they had. It was really interesting to me so I decided to apply as an undergrad to do research. You talk to other students from other universities what research they have...and they do not usually have these kinds of opportunities. Especially as undergrad student to work with the kind of stuff that I get to do. I guess it had a lot to do with the fact that I wanted to stay for grad school just because there’s really cool stuff to do here. That is why I

decided to stay here. My research right now is for hydrogen peroxide to be used as a mono propellant.

In addition, Jessica found that her internship closely resembled a job she might expect to find in industry. “It feels like we are actually doing a real job. I guess that helps a lot with the transitioning.” Students like David expounded on the uniqueness of internships offered through the URCS project:

Really getting the hands-on experience through an internship...the work that we do is, it's quality work, right? It's different than most of the research assistant positions here on campus. You really get an exposure to rockets and combustion and all that so it's really helped me apply what I learn, right?

For Oscar, his internship fulfilled his ambition to work for NASA:

I started at community college then transferred here to the [University of Texas at El Paso] and I started getting closer to getting more upper-level classes and I started seeing all this stuff, internships and I'm like “well I'll apply and probably not,” so when I got it...for me it really was a big deal and to be able to work there you know...long-term is what I really want to do.

Many internships at NASA centers aligned with students' STEM degree fields. However, several students voiced concerns about the applicability of research to their majors. Kevin discussed his internship. “I was interested in science more. I'm actually a biology major, but when I was at the NASA internship, I was doing a computer science internship.” Kevin elaborated, “I said there were a couple problems I had with my internship, the math that was above my skill level.”

Skills Acquired

The acquisition of skills that make students more viable in the STEM workforce can allow the U.S. to remain globally competitive. According to the Prairie View A & M University Center for Radiation Engineering and Science for Space Exploration (CRESSE) website: “CRESSE is committed that Prairie View A&M University will provide a dependable,

academically prepared and technically competent pipeline of highly-trained advanced degree-holding graduates ready to fill NASA's future workforce needs" (CRESSE, 2009, para. 1). Michelle evaluated the training she received using machinery as a student participant in CRESSE. "The diamond saw, the compression, the mechanical testing. I was able to have the opportunity just to go to Loma Linda, California to where we did the radiation testing. That was exciting for me." Sean also enthusiastically discussed his use of Computer Vision, which utilizes technology to simulate vision. Shannon described the development of research skills. "It taught me a lot of research skills, stuff that you can't learn in the lab, or you know, at school. I told my friends like I learned this, and they're like 'Oh wow!'" Jessica emphasized the importance of hands-on experiences:

I think just the hands-on experience. And it is with everything. You pretty much don't really learn anything until you actually do it. It is just somewhere in your brain. It is a lot different than going to the classroom to the actual application of - not everything is nice and simple like the way it is in the classroom. You have to simplify it to make it the way it is in the classroom. I think that has been probably the strongest...I guess the biggest benefit from being here aside from all the networking and everything else.

Other student participants in the URCs project conveyed the relevance of personal skills they acquired. Heather, a senior at Prairie View A & M University listed time management as an essential skill:

You're going to have to learn how to manage your time differently than you would in class. You know? It's kind of a different assignment. So just, you know if you need help...even if you need help, we're all here. They want to see if you can set your own goals and your own timeline, and see if you can do it.

Many students encountered difficulty creating a balance between their internship requirements and coursework. Brad also recognized the importance of time management in his academic career:

The reason I say time management is because I'm an out-of-state student, so I have to work, unfortunately. That takes a lot of time away from studying, and a lot of time away

from being in the lab. So during the day I don't have time to just come and play here. Once I get out of school it is either straight studying or going straight to the lab.

For many students, the URCs project encouraged the acquisition of skills. These skills encompassed learning time management. Adequately managing time allowed students to address research and academic requirements within mandated deadlines. Also beneficial, students acquired hands-on and technical skills. Learning fundamental and advanced hands-on and technical skills contributed to student success in STEM degree fields, and increased self-confidence.

Networking

Critical to building relationships, networking allowed students to interface with STEM professionals, their peers, and students participating in URCs project at different institutions. Joseph discussed his networking opportunities during his participation at the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Texas Southern University:

You don't get a lot of exposure sitting in the room back here. But off to the places I've been and the things that I've done, I've gotten plenty of . . . plenty of contacts that, you know I met...high-up people such as [a NASA education administrator] and stuff like that. You know, I can't see those not being valuable to the future.

According to Kara, "You never know who you are going to meet. You never know what information they're going to have. And so, this is just the best opportunity, I think, to network." Jeff related networking to locating gainful employment. "That was one of the biggest things...it's who have you talked to and the ability to network with them that will come back to you in the future." Sean developed a long-term friendship with his mentor from NASA Ames.

She was able to give me information to help me to make decisions, that's preparing me to pursue a Ph.D. in mathematics, so I mean again that feeling, I cannot describe it, but it's -- it's certainly an awesome feeling and, you know I hope to help others to feel the same way.

Mary also described sustaining relationships she developed within the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University and at NASA Ames Research Center:

The professors here I got to know them more on a personal basis. And then at NASA, my mentor, he was a professor at the University of California at Santa Cruz, and he was also a professor at Stanford. Then I'm still in contact with my other - a lot of people that I worked with at NASA Ames. And then I'm also talking to grad students, cause before I didn't really know any grad students, but now I do.

David also found support from NASA personnel that visited the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso. "We've been able to network with people from NASA directly right. I mean, they come and check how we're doing like the projects, and we've been able to meet them and talk with them and they give us advice." In addition, many students within the URCs project make an effort to work with their peers at other institutions. Jessica explained an opportunity she received while interning at the Marshall Space Flight Center.

We went to Kennedy Space Center and they had a bunch of students from the other URC universities and it was really nice...like workshops, and we got to see the shuttle on the launch pad and stuff like that. We got to talk to, not just network with NASA people, but network with a lot of the other students and professors from the other universities that are part of the URC. So that was really nice.

However, students like Mike did not have ample opportunity to participate in networking. "Actually I can't really say I've done that in this program. Yeah, it'd be nice, but I can't really say that at this particular point I have been able to do that."

Technology Use for Networking

To maintain and expand networking, students within the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University must create Facebook, Twitter, and MySpace pages. These pages, updated frequently, detailed student progress on

research projects. In addition, student pages provided institutional information on speakers and other guests that visited C-BER.

One of the things that they have encouraged is to have a Facebook account and a Twitter, so a lot of our followers are actually workers or staff members. Even during the seminars that we have, like every other week...even during the meetings, they encourage us to Tweet about what we're...what the speaker's talking about, what different NASA centers are doing, so they really encourage that.

Nick explained how he utilized social networking. "We keep our status on Twitter, what's going on today...this is what I'm doing. Any science-related stuff we like to keep posted on there."

Melissa used Facebook to seek answers about her research. Further, Melissa networked with individuals who could provide relevant information pertaining to the biology field. Students at other centers, such as cSETR at the University of Texas at El Paso, have also started to use Facebook to communicate with participants at URCs institutions throughout the country.

Jessica, a senior at UTEP, perceived the creation of a Facebook page as necessary to exchanging ideas and developing meaningful relationships:

We even created a Facebook group of URC students. We are trying to keep the networking going. I know they are trying to make some sort of meeting every year with the URC groups just so everyone knows what everyone is doing. Also maybe we can somehow collaborate with each other. Maybe they have an expert in something we can use...have that accessible to each other. I think that is really nice.

Technology has revolutionized social interaction. Recognizing the potential of technology to virtually connect students with each other, and with other URCs projects nationwide, many institutions (like Texas Southern University) require students to maintain social networking sites. These sites allow students to provide updates on research and other events, expanding the URCs project network.

Experience Acquired

Students must possess skills applicable to the STEM workforce in order to receive competitive opportunities, post-graduation. Erica, a female African American senior chemical engineering major interned at NASA in both the space radiation analysis group and radiation lab, obtaining valuable real-life, hands-on experience. Erica cited her internship as highly beneficial. “It has given me a chance not having any experience before, and I had never worked in a wet lab before.” Elizabeth also depicted her experience within the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso as educational:

Well before...I really didn't know about rocket science. You know...during your classes it's really, you know, just broad. So when you get into this, it's different. They start talking about different things, different components, and I was really like, “Oh, my goodness, like what is this, you know?”

As a student participant in cSETR, Max learned fundamental and advanced concepts significant to the field of mechanical engineering. He planned to continue his research upon beginning his career at NASA Johnson Space Center.

Especially with the research that I'm doing right now, there's not that many people that are able to work with - especially the chemicals that we're working with. It's something that I can add-on and even going into JSC...I don't think there's that many people who have worked with, hydrogen peroxide, or anything like that.

Oscar conveyed his feelings about gaining independent research experience at NASA Johnson Space Center. “I actually really like that aspect a lot too, is that you're kind of left alone to do your stuff. Yeah I experienced that a little bit at [Johnson Space Center].” He continued, “when you're done you come with your results or you know, if you need help then you come for some help, so I really like that aspect of it.” Further, Oscar implied the complexity of the process for initiating a research project:

Even something really small that you think is really simple you know, you have to go through all these kind of things to make sure that it's gonna be safe and make sure that no

one is gonna get hurt and make sure your design is set-up right and sometimes you think it's easy to manufacture something, and its not that easy to manufacture it. So that experience has been really beneficial.

Experiences offered through the URCs project provided students with the ability to expand their knowledge in STEM and prepare for a future in the workforce. Furthermore, student participants of the URCs project frequently had the opportunity to access high-tech facilities, and delved into research relevant to NASA. This pragmatic exposure stimulated student interest in STEM degree and career fields by simulating real-life practices and procedures.

Opportunities Offered by Faculty

Students often remain unaware of constructive and beneficial experiences available through their institutions. Thus, faculty become instrumental in providing information on internships and scholarships which can off-set the sometimes crippling costs of tuition.

Heather recalled receiving information about a \$5,000 scholarship opportunity from a faculty member within the CRESSE at Prairie View A & M University. As a mechanical engineering major at Prairie View A & M University, Michelle discussed how a professor encouraged her to research the program. “He just stopped me one day in the hallway and he asked me if I was interested in actually working for the URCs. And I jumped on it because at the time I hadn’t had internship experience. And they - the research as a whole sounded, like, really in touch with me.” Brad reflected on the relationship he valued with a biology professor at his institution. As a result of his friendship with his professor, he received information about the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University.

I was having a lot of financial issues and me and him developed a relationship. And I asked him “Do you actually know somewhere where I can get a job?” He said “let me see what I can do.” He came back to me in a few days and he was like, “Are you interested in doing research?” And I’m like “of course I want to do research, but I don’t know how to do research.” And he said “the school here has a program.” And I’m like

“okay, it has been under my nose this whole time and I didn’t know.” He actually introduced me to a few kids in the program and I’ve been here since last January.

Many professors also consistently relayed information relating to the availability of internships within external companies to students. Jacob described information he received from a professor within C-BER pertaining to an internship with Kellogg, Brown, and Root (KBR):

I just got a scholarship from KBR. So it was something that I really didn't know too much about and they just called me up and told me, “Hey, there's a scholarship application, you know, that's going on for technology, you know, apply for it, you know.” So, they got me - got the recommendation letters, you know, I did the essays and what not. So, they you know, of course they were totally behind me.

In addition to information provided by faculty members within URCs project, websites maintained by institutions also offer information pertaining to the availability of scholarships.

According to Texas Southern University’s website:

The NASA C-BER University Research Center at Texas Southern University (Lead), with collaborations at University of Houston, Norfolk State University, Jackson State University, University of California Santa Cruz, Stanford University and Texas A & M University, is offering undergraduate and graduate scholarships to qualified students. The C-BER is supported with capital funds from NASA's Office of Higher Education. The CBER provides undergraduate, graduate, and postdoctoral research training for selected students who are seriously pursuing a career in the fields of Science, Technology, Engineering and/or Mathematics. The NASA C-BER scholars program will expose undergraduate participants to current research and careers in the STEM fields throughout the year. The program includes a provision for students to attend a national meeting. Students selected to this Program will receive a stipend (Center for Bio-Nanotechnology and Environmental Research [C-BER], 2011, para. 1).

Frequently, student participants of the URCs project reported receiving information from faculty members relating to internship opportunities. Few, however, implied that they had received a brochure or pamphlet describing the URCs project. Institutions have become more dedicated to maintaining websites that provide information about the URCs project and scholarships. Nonetheless, faculty members have become most essential to attracting and recruiting students for the URCs project at participating institutions.

Time Allocated for Participation

Despite receiving unique and fulfilling opportunities through the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso, students discovered difficulty in finding sufficient time to manage job responsibilities and challenging coursework. Jeff attributed his lack of time to the demands of the program:

So I will tell you that an obstacle of being part of the program is that making sure that, "Okay, I know I have to go to Texas A & M or it's Corpus Christi this weekend, so I'm studying for this exam now." But you know, it's with anything - if you're in an organization, time management is always an issue.

As a full-time student majoring in biology at Texas Southern University, Brad also found time management largely problematic. Brad recognized his continuous conflict between school and work:

One of my biggest issues is I don't like the fact that I have to go to school and work. I'm stressed every day. I have a routine. I know by 5 o'clock I have to get my schooling done, go to the lab, go to the meetings. So the fact that I think working like a large amount of time you know, I have to do this, I have to do this. But you know if I didn't have to do this you know I'd be working on my studies.

Jacob, a senior at Texas Southern University, articulated his concerns regarding time. Similar to many students, Jacob found that working a full schedule complicated his involvement with other organizations on-campus.

I'm a quite dedicated student and I have other obligations, you know, organizations...at Texas Southern University. I have probably about two organizations that I'm the president for. And I don't have a vice-president, so, you know. I guess it takes a lot of my time...I really don't have a social life, not much, but, you know. I'm at this meeting, then the next meeting, you know, it takes a lot out of you, cause you know, I'm supposed to be here from eight to six every day.

Anxiety regarding working on-campus, off-campus, and managing as a full-time student in mechanical engineering became difficult for Oscar:

I immediately knew I wanted to work here and you know, I'm like, it was expected that we were gonna have you know put in so much time. So initially I had a really tough time just kind of figuring out like how am I gonna do this, how does it work out with my classes, I was taking a full load so even between classes I didn't have a lot of time. You know, so trying to figure out a schedule. I would be at school from pretty much you know, eight in the morning until you know one or two in the afternoon and then after that, and then knowing that I had to go to work at five at a restaurant and kind of like those two hours in-between I should be going to work here at the center but I kind of wanted to go home and take a nap or you know, or go study or go do some homework or do something.

Steven described time constraints he encountered during his participation within the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University.

Possessing technical expertise, C-BER professors often overly-relied on Steven for his assistance. According to Steven, “I’m taking a lot of hours and studying for the MCAT at the same time, and somehow managing to - I am highly technical so C-BER relies on me a lot and sometimes it can be very challenging.” Students like David expressed feeling overwhelmed due to rigorous mechanical engineering coursework and an extensive work schedule. Nonetheless, he also asserted that he received substantial support from the professors within the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso. Likewise, Max implied that his schedule often became problematic. Nonetheless, he found support from his peers in the cSETR program which ultimately compelled him to persist in mechanical engineering.

Research Challenges

In addition to prolonged work hours, research projects presented challenges for students. Many student participants of the URCs project alleged that research projects became too difficult and too overwhelming. Further, other students charged that they lacked experience critical to facilitating a successful research project. Mike described his experience learning to use equipment and materials in the laboratory as challenging. In addition, Michelle verbalized her

difficulty with assigned research projects. Nonetheless, Michelle gradually learned to embrace research challenges as she progressed in her academic career.

I guess you could say the research as a whole. Research is a lot different from the typical, you know, book-study-do your homework-and turn it in...you're actually having to diligently go in and actually research...and, you know, look at different articles - pull from this article, pull from that article. And that was, like, a little struggle for me, I guess because of the transition, but, now I really do enjoy it.

David encountered similar challenges while conducting research related to methane within the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso:

When we started we had to work...we're working with liquid methane for a particular project from our group and we had to basically investigate all there was in liquid methane...and there's not much information on that. And so that was a very hard project. After we did a paper on it, we had to come up with our own Excel spreadsheet and plug in the equations, see if they worked, and they worked fine...but it was a very time-consuming job, but we learned a lot though.

Sean found the manipulation of new software programs challenging. "That Computer Vision program...it wasn't so much of an easy task starting out." In addition, Nick conveyed his frustration working with another student in a different STEM degree field on a collective presentation. Nonetheless, Nick and his counterpart learned to effectively merge ideas to make the presentation successful:

I'm not really like familiar with...like with the post-docs. I have an aviation background...so I'm doing a lot of research on that and trying to get a grasp of what they did...trying to explain it on the paper, it was like, "wow." That's something totally different. Yeah, that was a real challenge right there, cause it was me and also the other guy that graduated already...we're doing the same thing.

Oscar struggled to find direction in his research project and identify a relevant topic. "I have a problem finding a specific topic to research." Admittedly, he capably performed the research in coordination with his peers once he understood the intent:

Initially there was a little bit of confusion as far as who was gonna work on what and we had two projects going on with our team and one was oxygen production from lunar soil and the other one was using lunar soil to make structural material to make building materials. But for like a month and a half I had no clue what I was, what I was gonna do, where my research was going, what I was going to focus on, so I felt very, like I wasn't doing anything.

Research challenges often emerged during internships within the URCs project. Students facilitating research gained practical and hands-on knowledge relating to STEM. Importantly, students also learned to amalgamate ideas with their peers in different STEM degree fields. While the fusion of ideas did create some apprehension, this approach provided insight into different STEM fields.

Conclusion

Students receive internships at NASA centers based largely on their GPA and their inclination to pursue a career in the STEM workforce pipeline following graduation. Internships provide students with the occasion to work at NASA centers and “shadow” professionals in their fields. URCs project internships also provide students with insight on procedures for conducting research, and promotes team-building. During internships, students acquired various skills, applicable to their future careers. Some students became noticeably frustrated by research assignments that they felt lacked relevance. In addition, students verbalized their unease towards research assignments that failed to align with their interests and specializations.

Beneficially, most students had the opportunity to network with STEM professionals and students from other universities during their internships. Frequently, students maintained their relationships with mentors and peers following the completion of internships. Uniquely, the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University utilized social networking sites including Facebook, Twitter, and MySpace to strengthen networking opportunities. These sites allowed students to network, while posting

notifications of their progress on research. Students also posted information regarding speakers, and other notable visitors to Texas Southern University.

Internships also allowed students to acquire hands-on experience working in NASA facilities, and with NASA personnel. Many students received information relating to these opportunities from faculty members in URCs project. While most students appreciated the enriching experiences offered by each URCs project, several communicated their apprehension relating to the staggering hours worked in university laboratories. Other students articulated concerns about challenges related to research. However, the majority of these students also successfully addressed these problems in coordination with their peers. Research challenges encompassed working with foreign materials and chemicals, collaborating with peers on research, and isolating appropriate research topics.

Academic Challenges

Underserved and underrepresented undergraduates sometimes become overwhelmed by challenging academic coursework and research projects. As a result, these students become difficult to retain in STEM degree fields. Many students sought the assistance of faculty within the URCs project to reduce anxiety related to academic challenges. Joseph described his experience within the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University. He fully recognized the advanced nature of the research conducted within CRESSE, lessening his trepidation. “The work that the center is doing is actually way over my head. Being an undergraduate is a reason, but I don’t have to learn everything. You know, it’s still a learning process.” Similarly, Elizabeth communicated that initially she had difficulty understanding complex STEM concepts. Despite this challenge, Elizabeth persevered.

It was really hard for me at the beginning. They teach a space-space systems class, and I didn't take it so I'm like, "oh my God, I'm so lost right now." So that was really hard for me, but I really learned. I find it very rewarding that I learned all of that stuff. I can just put it on my résumé; I know about rocket science.

Mike surmised that asking for help alleviated much of his unease. "I mean it's difficult if I don't ask for help, but a lot of times it's pretty manageable." In addition, Sean explained how he turned his challenge into a positive experience. He initially expressed hesitation about his participation in the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University. In retrospect, however, he felt fulfilled because of the challenges presented within CRESSE:

I love a challenge so that's why I'm here. Although it was a challenge for me starting out with this program, it was a welcome challenge which makes it makes it one of those good challenges, you know? It's definitely made me a better person as a result, also a better programmer. Like I said, I have that skill now.

Due to a lack of knowledge, Jacob revealed that mathematics and technology had proven challenging for him. Jacob invested numerous hours researching these unfamiliar topics in order to improve his understanding. Comparable to other students in the URCs project, Max became overwhelmed by time constraints. However, he found solace with his peers. "Pretty much any type of obstacle, just being in school in general and trying to make the time to work and complete everything...but just because we have our offices there, everyone is always working together so it's a lot easier, in regards to getting things done on time."

Other students confessed to feeling conflicted about their involvement with other campus organizations. According to Katherine, her participation in a sorority detracted from her ability to focus on coursework. Moreover, she implied that her association with other organizations had become detrimental to her GPA.

I would have to say when you get yourself into a GPA hole it's really difficult to climb out. I'll tell you that much. First of all because I don't know if this is common at other

institutions, but sometimes when professors see that you've done terribly in a previous course...they think that you're struggling in that particular course for the sole reason that you're either not cut out to be an engineer...or in my case I'm a member of a sorority and they think it's all about the sorority.

The persistence of underserved and underrepresented undergraduates in STEM degree fields frequently hinges on the ability of students to overcome challenges. Many students interviewed could appreciate challenges. Conversely, others became overwhelmed by the academic expectations of the URCs project. However, most students suggested that they received adequate assistance and support from peers and professors within the URCs project.

Self-Efficacy

Self-efficacy describes the capability of an individual to overcome an obstacle and succeed. Commonly, underserved and underrepresented undergraduates lack self-confidence, which consequently prevents success in STEM degree fields. Initiatives such as the URCs project promotes self-confidence through the facilitation of research and internship opportunities. Due to academic difficulties, Kara left Prairie View A & M University to pursue an internship opportunity with Toyota in 2007. Despite her decision to abruptly leave, Kara returned to Prairie View A & M University to complete her electrical engineering degree.

I've come this far. I might as well go ahead and do it now. To be honest with you, at first I had to leave, I left school in '07, and I said, "I need to get away because I don't know if I want to do this anymore." I decided to go work. I did an intern or co-op for Toyota in Indiana.

Reluctantly, Matthew considered changing his major to business during his sophomore year at Prairie View A & M University. However, despite challenges that emerged, Matthew persisted in mechanical engineering.

During my sophomore year, probably the second semester when everything gets taken, and you just have to...that's when you decide that you wanna maybe switch over to business or something else, or if you want to push forward. And seeing some of the

research programs, like the project, I said, “I really want to do this. I will push forward to achieve some of my goals.”

With zeal, Jeff described an internship experience that increased his self-confidence:

My freshman year for my internship I was dealing with...okay this is going to sound really crazy...so I basically I looked up space debris. And that's from when the space shuttle gets launched-off and its satellites will break apart and asteroids or, because other countries will have satellites. So it rotates around Earth. Some of these objects make huge dents in the shuttle.

According to Jeff, this experience not only contributed to his self-confidence but enabled him to gain valuable insight into the field of engineering. Similar to Jeff, Katherine developed strong self-confidence as an intern in the Center for Space Exploration Technology Research (cSETR).

My fluid flow courses...like “I know this stuff. They already explained it to me back at the research center, especially with thermal fluids.” I was actually working on another project looking at the heat transfer capabilities of liquid methane. And a lot of that heat transfer information and the techniques using different equations and different principles actually applied to my thermal fluids class. And so I got in there and I was like “I know this, I got this.”

Elizabeth described feeling intimidated by fiber optics. Nonetheless, she stated that she gradually became more comfortable with the concept and “learned a lot about electrical stuff.” Jessica detailed a research project that involved repeatedly testing different set-ups to determine accurate values.

You are going to run into things that this isn't working the way it is supposed to and you have to modify things. So actually right now we have been working on this test all semester and we have been getting results that do not really make sense to the theoretical. So we have been changing our set-up a million times because it has to be the set-up’s fault. And if it is not the set-up’s fault, these are the values and it is not very efficient. Actually today is the day of the truth so this is like the set-up looks like it is working and we should be getting the right values. Those are just obstacles, but I think it just comes with - it is part of the experience you have to figure out how do we figure this out, this information that we are trying to get you know...to get the best and most accurate results we can.

Undeniably, these obstacles can cause frustration. Nonetheless, students received challenging research projects to build self-confidence. Inevitably, these experiences also provided realistic simulations of challenges that emerge in STEM career fields.

Personal Challenges

In addition to academic challenges, many students also confront personal challenges as undergraduates. Financial issues frequently deter many underserved and underrepresented undergraduates from persisting in their academic careers. Matthew communicated his difficulty with finances, which subsequently caused him to temporarily leave Prairie View A & M University:

I had a rough a period. I had to take-off due to financial issues, and both of my parents did everything they could to get me back into school because they knew that this is what I wanted to do...so they did everything they could to get me back. And here I am, and I'm in my senior year and I've finished.

In addition, Brad struggled to maintain a job concurrently while attending Texas Southern University:

Sometimes you get so caught-up in school that you don't want to go. You need to finish your school work. But it's like got to keep going, got to keep everything together. At the time you don't want to hear that. "I hate math, I got to be at work."

Shannon also correlated her lack of time to the internship with C-BER. However, Shannon suggested that the experience she received benefited her academically.

For the internship they wanted us to just focus on that, so my personal life was kind of, you know, gone, but I didn't mind...cause I learned a lot so. I guess that would be a minor thing, but it was worth it.

Grace, a female African American senior biology major discussed her arduous schedule. "I have a very hectic schedule. And so like I am basically sort of...I'm feeling like a robot." Family problems also plagued many students. Katherine verbalized her admiration for her father, who

despite continuous family problems, graduated with his engineering degree. Like her father, Katherine also defied on-going personal challenges:

My dad had to deal with a lot of similar difficulties that I did personally. So family situations and he had to do, he had to get his degree all while dealing with his personal issues as well with his family. So I kind of admired my father in that respect because he had to deal with a lot and still managed to pull out with a degree.

She continued, “With my family it’s kind of hard to balance both work, school, and my family sometimes. So I mean it’s not really a problem with the program, it’s just an individual issue.”

Like Katherine, many students had to endure personal challenges. These personal challenges, whether financial or familial, occasionally dissuaded and distracted students.

Tinkering Self-Efficacy

Tinkering self-efficacy refers to the ability of individuals to successfully overcome hands-on challenges. Manual proficiency contributes to students’ self-confidence, and therefore increases the likelihood that many will remain in STEM degree fields. Erica affirmed that her self-confidence became reinforced while performing simple research tasks in coordination with her mentor. “I would say basically most of my project was hands-on. My mentor was there to help me and to make sure I was doing things correctly.” Erica also recalled her mentor gradually beginning the research to ensure she remained comfortable and understood various concepts.

Matthew reminisced about the opportunity to build a hammer during his internship at the Center for Radiation Engineering and Science for Space Exploration (CRESSE).

We actually got...were able to use this thing to build a hammer. It seems real elementary. I thought it's just a hammer...it took us like a week or so. We really didn't know what we were making initially. But we really got to learn how to use the tools and create threads and everything. It was...it was just different. It was refreshing just because we get so caught up in formulas...and computer programming. It increased my self-confidence...seeing something on the computer and seeing something in your hand...but to actually build it, it's really fulfilling.

Heather evaluated testing facilities for her internship at Prairie View A & M University. In addition, she participated in “stressing” exercises that determined the durability of specific objects. Heather perceived this exercise as beneficial as she felt she acquired a more advanced understanding of hands-on applications. In addition, Mary attributed her self-confidence to research she conducted in a laboratory at NASA Ames Research Center. “Before I didn’t have any lab experience. I was just doing my lab classes. Then I had a professor in the Chemistry Department. He allowed me to shadow his grad students for a few days and participate in hands-on lab experiences, so that grew my confidence a lot.” Katherine also acknowledged that hands-on experiences like machining increased her self-confidence:

Actually, as part of my research project we had to machine a lot of the parts that we’re using to put together our thrust measurements. It was kind of cool getting to use like all the different machines too. It’s a lot of fun. And you never realize just how much thought you have to put in to the process of machining before you do it.

Overcoming challenging hands-on activities can bolster student self-confidence. Students that develop strong self-confidence become more likely to persist in STEM degree fields than their counterparts that have difficulty surmounting challenges. Therefore, facilitating challenges for students that involve hands-on experiences can benefit individuals pursuing STEM degrees.

Technical Self-Efficacy

Technical self-efficacy involves the capacity of students to overcome challenges related to technology. Similar to tinkering self-efficacy, technical self-efficacy describes the propensity of students to successfully manipulate technology, which strengthens self-confidence. Erica explained using technology to expand her knowledge of microscopes. “I know my first internship was with a detector and it was with, what was it called, it was a FLV reader and I got comfortable with it...I got real comfortable with microscopes.” Erica surmised that working with microscopes contributed to her self-confidence and provided her with extensive experience.

Additionally, Matthew discussed a scenario that enhanced his self-confidence and technical proficiency as an intern at NASA:

On my internship, when I was on-site at NASA, one of the tools that we used were the...we was making element analysis. Basically, it tells you the strength in a system or in a structure. So what I was doing in there, it felt as though I was going to be new to it, I'd never seen it before. But here in the program we're integrated with machine design classes. So it really gave me an advantage because going there I already had an idea of it.

Jeff utilized NetLast software during his internship at Prairie View A & M University. Initially he found learning the software program somewhat challenging. Nonetheless, Jeff succeeded in learning the software, improving his technical prowess. Further, Shannon expressed her enthusiasm for learning a software program that isolated genomes. While the complexity of the software overwhelmed her, Shannon's mentor provided guidance. Steven explained his work with cancer cells that heightened his self-confidence:

It is also an interesting confidence point when you go to some of these conferences and you are talking to some of the physics students and engineering students and they are asking you what you did. And you're like, "I played around with cancer all day. Well how do you do that? I grow them. I grow them in a microgravity environment." And then you start explaining technical aspects of the hard machine and it really takes you from just being a regular biology student to like "Wow!"

For students like Jessica, learning different applications became more beneficial than developing self-confidence. "Not just the self-confidence. It gives you the tools to do your job better or you know...it can be applied with not just a job, but school. Once I am out in the real world I will use it then too." Further, Charlie implied that interfacing with technology enabled him to speak more intelligently. "When you know about technology you can talk with someone else about it, so I think I feel confidence by that. By doing that, I get more experience and then I can talk with others and, and get confidence myself."

Self-Concept

A student's self-perception frequently predicts their inclination to persist in STEM degree fields. Negative self-concept can deter students and increase attrition. Kevin articulated his concern regarding a research assignment he received as an intern at NASA. "Yeah, when I first saw the program I felt like -- I'm like man, I got to do that shit...but I feel like I can't do this. It's probably too hard, it's NASA. They gave me some really big project I can't handle." Kara also conveyed her frustration relating to a research assignment. "I was like, you know, I can't do this, so I'm not doing it." Other students exuded a positive self-concept. Sean communicated a sense of pride when wearing his Center for Bio-Nanotechnology and Environmental Research (C-BER) t-shirt on-campus at Texas Southern University:

Just walking around campus, apparently C-BER is a well-respected program here. And you know sometimes we have to wear our t-shirts for various events. Like it says C-BER, you know and my classmates are like, "oh you're in CBER, oh wow." You know it kind of makes you feel like you know you're held to a higher standard and so, "I'm a little tired, I don't feel like doing some work I need to accomplish." That gives me the extra push that I need to continue.

In addition, Nick detailed an experience working collaboratively with graduate students that increased his self-confidence. "The post-docs at [University of Houston], they were like 'so you're only an undergraduate' ...and I was like, 'yeah.' He's like, 'really, we thought you were a graduate.'" As a student participant in the Center for Space Exploration Technology Research (C-SETR) project, Charlie acquired a more positive self-concept as well:

I haven't been too much in contact with electrical engineering professors, because, you know, they are not in the, in the C-SETR program, but every time that I tell a professor that I'm in the C-SETR department...they say, "Whoa." That's cool, you know, because they know about it. So it has helped me a lot also through that.

When asked about her desire to locate a job at NASA, Elizabeth responded, "I'm smart, I can get a job there." Further, Elizabeth emanated a strong allegiance to her institution (the

University of Texas at El Paso). She recalled a recent exchange with an engineer from a neighboring university. “She said, ‘Oh I graduated. I’m mechanical engineer. I graduated from [New Mexico State University],’ and then she admitted it, she’s like ‘You guys have a better program. And I’m going to admit that. And I’m like, really? I know it.’” In contrast, Oscar’s self-concept relating to the University of Texas at El Paso’s reputation became apparent:

People feel that maybe because they’re from here and they live here that they feel it’s not as prestigious as another school or it’s not as you know, it’s just [the University of Texas at El Paso]. I’m very proud to be a student, but I think it’s just more from the community, I don’t know why people...they don’t have it in high regard.

A student’s perceived self-concept can influence success in STEM degree fields. Many students interviewed conveyed a strong self-concept due in part to their participation in the URCs project. Therefore, students exhibited more self-confidence in their interactions with their peers and STEM professionals.

Academic Workload

To remain an intern in the URCs project, students must allocate hours towards completing research projects. While conducting research benefits most students, each also has academic responsibilities and must maintain a respectable GPA. Undeniably, some students have difficulty managing their time. Jessica explained her predicament. “Sometimes you will find you are fine in school and then things get really, really busy but, you still have to perform on this side. That is time management. I have always been pretty good but I think now I am an expert. It is a good thing.” Complementary to Jessica’s statement, Nick also described his efforts to address the demands of school and work. “It’s a balance with school, because you never know, even like with our classes. You’re like this day, I’m gonna have class that day, at that same time. So it was like the big obstacle was going to school, trying to make it work.” Other students struggled to ensure they had adequate time to complete tasks assigned by the

Center for Bio-Nanotechnology and Environmental Research (C-BER). Steven resisted pressure from principle investigators to perform additional responsibilities:

After my classes in the evening I can spend four or five hours. It depends on what project you are running. Some projects may be 30 minutes to two hours. Some projects can take as long as you showing up on a weekend to help finish that project. But that is not an issue. It is much better that way as opposed to trying to do those projects while you still have classes that you are supposed to attend. And some investigators don't quite get that. And you have to be - it's a matter of being stern. Because when I was volunteering I was...I think I said "yes" a lot. This semester I've learned to say a lot of "no's." And it's not because I don't want to do the work. It's because I know what priorities, how to spend my priorities. And some NASA C-BER scholars may not do that because I have seen a few students quit.

For Elizabeth, the accumulation of school work and research activities became most overwhelming at the end of each semester:

Well sometimes it gets overwhelming like towards the end of the semester, you know, you have finals, you have a lot of just work. You have work, you have so many things and it's just...sometimes it gets really overwhelming...you know, with school, and-and everything.

While the URCs project provided students with support in their academic endeavors, many felt burdened by the rigid and sometimes excessive work schedule. Many students asserted that the mandated schedule often conflicted with the hours necessary to complete coursework. Inevitably, students reported that the restrictive scheduling occasionally put their academic coursework in jeopardy.

Internship Challenges

Students of the URCs project participated in internships. Whether at Prairie View A & M University, Texas Southern University, the University of Texas at El Paso, or at a NASA center, students frequently admitted that challenges emerged. Kara became concerned about the funding that Prairie View A & M University should have provided. However, she assumed that her institution delayed funding, not the Center for Radiation Engineering and Science for Space

Exploration (CRESSE). “We’re still waiting on our finances. Nobody at the university now has helped these guys.”

Uncertainty about the validity of his research troubled Jeff. Wanting to compile useful research, he debated about the feasibility of facilitating a project that might not fulfill the expectations mandated by his internship:

I would say I guess with the research project it was very broad. It’s kind of difficult to come up with a complete product that satisfied their requirements. So those obstacles...still trying to figure out what to do, what to actually incorporate in the research that was valid and that can actually be something that people would be interested in listening to. Trying to I guess brainstorm to make it a complete product.

Steven sought to diminish the reliance of the Center for Bio-Nanotechnology and Environmental Research (C-BER) principle investigators. He often performed tasks unrelated to his internship:

Like today, I had an exam. Somehow they needed my technical abilities to take pictures and make a PowerPoint to help with someone’s graduation ceremony. But you know, here is what I would change about C-BER. Sometimes C-BER investigators are - not all of them, but some of them, they overlap their NASA C-BER responsibilities with their [Texas Southern University] responsibilities. And if they depend on you a lot, it becomes so intertwined where it always seems like you are always doing something extra. And it is not always C-BER related. If it was C-BER related, I wouldn’t mind...it wouldn’t be an issue. If it was [Texas Southern University] related and I had time, it wouldn’t be an issue.

Students expressed concern about identifying appropriate research topics for their research. Additionally, students had difficulty managing the expectations of faculty members within the URCs project that became overly-demanding, or requested assistance with tasks unrelated to the URCs project. Further, students also felt disconcerted by the untimely allocation of funding by institutions. Comprehensively, these issues created internship challenges for student participants.

Conclusion

Underserved and underrepresented undergraduates continuously experienced academic challenges during their participation in the URCs project. Students reported feeling overwhelmed because of the intensity of the URCs project. In addition, students struggled to excel in academic coursework while adhering to mandatory work hours, as established by each URCs project. Nonetheless, many students explained their ability to overcome challenges that emerged (self-efficacy). Personal challenges also detracted from student success. However, students consistently persisted in their pursuit of a STEM degree.

Student participants of the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso frequently experienced hands-on challenges in their research. Consistently, students indicated that mentors and peers assisted by suggesting alternatives to their research. Similarly, students also described technical challenges that occurred during the facilitation of research and in their internships. Students implied their initial discomfort with technology and software applications. Nevertheless, most students gradually acquired a greater sense of self-confidence because they prevailed in overcoming a challenge.

When prompted to analyze their abilities, many student's self-concept appeared strong. Students largely attributed their self-confidence to participation in the URCs project. However, multiple students insinuated that their academic workload became strenuous each semester due to the expectations of the URCs project at their institutions. Students inferred that time management became critical to their continued success. Moreover, students also experienced challenges in internships. Students recalled feeling frustrated by research assignments, as they frequently lacked applicability to their designated STEM degree field.

Faculty Support

Instrumental in providing support and engaging students, faculty members have comprehensively contributed to the success of each URCs project. Many students in the URCs project associated their success to the continuous support they received from faculty. Kara inferred that a professor from the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University factored into her personal growth. “I feel like he really helped me build my character as a person, and not just as an engineer.” In addition, Erica articulated her appreciation for a faculty member within CRESSE that assisted her with academic challenges. “[My faculty advisor] always has a helping hand and to help with interns and stuff and classes.” Further, Michelle valued the accessibility of faculty members from CRESSE that consistently offered support:

[The faculty’s] office door is always open. Anyone here’s office door is always open. That’s the one thing that I love about the engineering department here, as a whole. Everyone’s door is really open. I mean, most - I took a class at the University of Texas in Arlington before. And, you know, you had to schedule an actual appointment to talk to your professor regardless of what it is about...it had to be scheduled. So I love the fact that everything here is open door policy.

Comparably, Sean reported receiving substantial support in his academic endeavors from the faculty members at Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University:

I cannot say that there’s been a time when I have not received support. Everyone here is quite supportive. I mean they’re -- they’re open and it’s kind of like almost -- they’re like mind readers. They will tell you things before you can even ask, you know. So you just really feel like they’re -- the people...the faculty here care. They genuinely care about what happens to you and your success, and your careers in the STEM fields.

Faculty members also provided guidance for students as they progressed in their research, offering ideas to improve concepts. Katherine discussed her interactions with faculty members

within the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso:

Faculty members have always been very receptive to looking over my papers, looking over my designs. [One faculty member], he takes a very hard stance against certain things and he'll tell you exactly what's wrong immediately. So you kind of want to perfect your idea before you take it to the boss. So you don't look quite so much like an idiot.

Faculty members within the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University consistently demonstrated concern for their students.

Mary recalled her C-BER internship interview where she received re-assurance from a faculty member:

At my interview I thought I did so bad but later I found out they thought I did well. But, I was upset about it. And one of the professors told me, "You work too hard, you need to find that balance...and don't stress over it too much, cause when you start to stress out, that's when you start to mess up on the little stuff."

Oscar also recalled a conversation with a faculty member who emphasized the importance of the experience that students gained from cSETR, rather than the outcome of research.

Conversely, students found some faculty members external to the URCs project apathetic. Brad suggested that faculty members at Texas Southern University did not adhere to their posted office hours:

Anytime that you want to get to a teacher or a professor you might not be able to get to them at the time that you want to, you make an appointment or you keep coming back and checking... you'll eventually get to them. Like I said, it's not like you want to keep coming back three or four times, but eventually you will get in touch with somebody.

Similarly, Heather found some faculty members less than helpful:

Some professors are just a little less willing to help during office hours, or even just in class. They're just like...I'll get to that later, and you're like, "well is later now?" I think there are some professors who are more interested in making sure that the student succeeds versus "I did what I had to that day...I taught and was in for office hours. And I may have answered all the questions or I may not have, but an hour is up."

Faculty support has become imperative for underserved and underrepresented undergraduates pursuing STEM degrees. Repeatedly students affirmed that they received continuous support from faculty members within the URCs project. The support and guidance received from faculty members can increase the persistence of underserved and underrepresented undergraduates, and has the potential to strengthen knowledge and interest in STEM degree fields.

Relationship with Faculty

Students commonly develop and sustain meaningful relationships with faculty members. These relationships often encourage underserved and underrepresented undergraduates to persist in STEM degree fields, and act as a mechanism for support. Kara described her affinity for faculty members within the Center for Radiation Engineering and Science for Space Exploration (CRESSE). “They helped me along the way, but what is wonderful is they pick you like they want you, and act like you’re one of their children. You know...they don’t want to see you fail.” Katherine also portrayed faculty members at the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso as welcoming. “Even when there was personal issues going on I was always able to go in and be completely honest...you know, just tell him ‘look this is what’s going on and this is why I’m struggling at this point, what do you suggest?’” Further, when asked to evaluate his relationship with faculty members at cSETR, Max asserted that all reacted positively to student requests for assistance. “All the professors are really nice and I’m not scared to go up to talk and ask one of them what he thinks about something just because they’re all very friendly.” He also indicated that many students retained long-term relationships with faculty members at cSETR following graduation in an effort to reciprocate:

One of the grad students that graduated from here a couple of years ago...he is doing his Ph.D. in Maryland and he is actually going to come during his Christmas break to help us

out with some of our stuff because [our faculty advisor] keeps a relationship with all of his previous grad students and we work in conjunction with them.

Students often developed a rapport with faculty members within the URCs project. Students largely reflected on their relationships with faculty members positively. These relationships usually sustained beyond graduation. As such, previous participants of the URCs project returned to their alma mater to assist former faculty members and current students.

Admiration of Faculty

Students often develop a strong admiration for faculty members that assist with academic and personal challenges. These relationships motivated many students to follow in the career paths of their faculty members. Kara described her admiration for a Center for Radiation Engineering and Science for Space Exploration (CRESSE) faculty member. “Believe it or not, and I tell anyone...I’d like to fill [my advisor’s] shoes.” Kara referred to the repeated help she received from a specific CRESSE faculty member. “That’s why I’ve cherished [my advisor] so much...because he didn’t have to, but he was the one that did.” Sean displayed admiration for the level of education that faculty members achieved, and their expertise:

[My professor] out of the mathematics department. A remarkable young lady. She’s in the Math Department, but she’s actually a statistician. But the knowledge -- the amount of knowledge that she has is unbelievable, I mean just the first meeting I had with her opened my eyes to a lot of different things in programming.

Grace also articulated her admiration for a faculty member, “I actually wish I had her brains.” Further, Oscar divulged his approbation for his faculty advisor. “I mean that guy’s like super smart, how do people get so smart?” Moreover Oscar insisted, “he’s always been there...he’s been a really good kind of advisor to help us.”

Faculty Encouragement to Pursue Academic Interests

Faculty members promote learning opportunities for students and encourage the development of academic interests. Brad discussed the support he received from faculty members:

Every day they encourage me to continue the research. And they are the ones who help with what you been doing in the lab. They ask, “Do you need anything?” Or “How’s it been going in the lab?” They want to know why we’re doing it because they want to keep us in-check.

Many faculty members within the URCs project also tried to advance student learning by providing individual assistance on research projects. Shannon received support from a faculty member conducting independent research. “A lot of my professors...they actually have their own lab, so when they teach in class they tell you what they’re doing in the lab, and encourage us to join if that’s what we’re interested in.”

Indecisiveness sometimes hindered the ability of students to conduct research. Steven acknowledged feeling uncertain of his research interests. “Seeing as I was new to this I really didn’t have a research interest coming into this, but I have developed certain interests since I have been in the program. And yes, my faculty mentor has encouraged them.” Oscar indicated that faculty members encouraged the proliferation of ideas for research. Nonetheless, Oscar encountered difficulty narrowing his research interests:

They’re very supportive of your interests...that’s what makes it kind of tough. It’s like where do you find something or focus on something when you can do whatever you want? It’s kind of hard to like find something, but it is nice to have that support to know that when you do find something that you want to research they’re gonna be very supportive.

Underserved and underrepresented undergraduates need the consistent support and encouragement of their faculty members. These individuals not only have the ability to offer

support, but can inspire students struggling with difficult concepts. As such, faculty became integral in advancing student interests in STEM degree and career fields.

Faculty Assistance with Academic Challenges

Aware of the academic challenges that underserved and underrepresented undergraduates routinely confront, faculty members play an essential role in student success. Required work for the URCs project confounded pressure that students experienced. However, most students reported receiving adequate support from faculty members within the URCs project. In evaluating his experience, Joseph recalled working with a faculty member. “There’s been several times whenever I’ve been working on a project or I’ve had to do something that’s a little bit out of my range. There’s a project and we...me and [my advisor] worked real close...real closely on that project...I’ve received plenty of help on it.” Sean and his mentor established times for weekly meetings to discuss his research. “Now we meet weekly...ensures that we are working on our projects that we started this summer so that we don’t lose any ground, lose any footing and are using the skill sets that we’ve acquired, so absolutely. It’s an ongoing basis, a weekly basis.”

Shannon and her faculty mentor worked consistently to ensure accuracy on her research. Moreover, her faculty mentor made her research applicable to real world scenarios in the field of biology. “Whenever I just go to the lab he teaches me how to do it right...even the simplest task. I’m ready for the real field, so I can apply it and like actually know how to do it, so they teach me how it’s done.”

Expanse of Faculty

An extensive network consisting of faculty, deans, staff, and other administrators support students in their academic pursuits within the URCs project. Upon evaluating his experience,

Matthew corroborated that an array of individuals supported his participation, “even all the way from the dean of mechanical engineering all the way down to [my faculty] and some of the other professors.” Additionally, Nick described a collaboration that occurred between the Center for Bio-Nanotechnology and Environmental Research (C-BER) and other academic departments at Texas Southern University. “Everybody...other people from other departments and other schools participate. They brought people in to help us out and make sure that everyone was good. They have everybody from every department...which is a good thing.”

Structured to ensure responsiveness in regards to student needs, participants have significant access to faculty and staff. Nick substantiated the constant accessibility of C-BER faculty and staff.

We had all different professionals that we can go to. ...we still have other faculty, and according them you could shoot it over to our coordinator. She can point us in that direction, where we can go. So, there was never a downside, like “oh, I couldn’t get help on this part.” You just grab somebody else to fill-in. I like to say it’s more of a family. We help each other out as much as possible.

Melissa also discussed the availability of faculty and staff within C-BER. Like faculty members, staff must also assist students with their research questions and other problems that emerge. “Well, I get support from everyone. Whenever I have a problem or question, I can go to her, or the other coordinators that I know here; they’re very helpful, so...they’re supportive. They just help us on research.”

Students become more inclined to persist in STEM degree fields if they receive adequate support from faculty members. Aside from faculty members, staff and administrators that lent support for students pursuing STEM degrees also provided encouragement. Beneficially, the structure of the URCs project allows students access to an array of individuals capable of assisting with personal and academic challenges.

Accessibility of Faculty

Underserved and underrepresented undergraduates remain largely dependent on faculty members for continuous support. Thus, faculty members must remain accessible in order to assist these students with academic and personal challenges. Steven recalled distributing an e-mail to one of his faculty members:

I remember one particular email at 11 p.m. at night...I got a reply back at 2 a.m. which was surprising. I thought he would get to it the next day. But it was pretty fast. My faculty mentor is very, very articulate and he is very responsive. He is very responsible and very responsive to his students.

Grace found a faculty member especially helpful in her research endeavors. “[My faculty mentor] is great. She’s really great. She’s very knowledgeable. She has her own laboratory, and if I have a question in regards to my own laboratory, she ends up answering my questions if someone else is not accessible.” Charlie’s response coincided with the feedback provided by Steven and Grace. He reflected on a relationship he maintained with a faculty member. Frequently, he sought the professional perspective and expertise of a faculty member for his research project. Consistently, this faculty member met with him to evaluate his progress and refine his concept. Charlie explicated the accessibility of this faculty member. “I know he’s busy and he has a lot of things going on, but I still go out to his office and ask him about certain things. And, yes, he has helped me a lot with that.”

Faculty members at the University of Texas at El Paso facilitated weekly meetings to field questions relating to student research projects. Moreover, faculty members used weekly meetings as a forum to encourage students and provide academic and personal guidance. Jessica provided details about the weekly meetings for the Center for Space Exploration Technology Research (cSETR), which involved the participation of undergraduates and graduates alike. Jessica inferred that occasionally the meetings induced stress:

We have our weekly meetings. So there is always that when we are having trouble with something...it is like we keep trying this but this doesn't work so the faculty is always there to give us advice or ideas on how to approach it on a regular basis. We each have our different groups and each group has a weekly meeting. So our meetings are tomorrow. Sometimes the meetings are scary because you don't have any updates for a whole week.

The vulnerability of underserved and underrepresented undergraduates makes the accessibility of faculty even more critical to persistence in STEM degree fields. Reportedly, faculty members offered insight and recommendations for research and academic challenges. However, some students described feeling anxious about constant oversight from faculty members. Nonetheless, this pressure from faculty members seemed to compel students to perform at a more advanced level.

Presence of Mentors

Mentors can motivate underserved and underrepresented undergraduates to persist in STEM degree fields. Further, mentors can provide a strong support system for susceptible students. Joseph's mother urged him to pursue his college degree. "Well, my mother was - is always wanting me to do anything and everything. So my parents really pushed me too...it wasn't really an option not to do college." Matthew became inspired to pursue his degree by his mother, who returned college to complete her degree. "My father, he graduated from Grambling, but my mother did not graduate until three years ago; she went back to school and got her degree at 50, so that was kind of...that pushed me as well." Additionally, he observed his mother's struggle to advance in her career without a college degree.

She started out as basically an administrative assistant and worked her way all the way up to manager. That took her 20 years, I guess...20 years to do. With a degree it would take half the time and that really...so that was kinda the way that I could see like how important education is and the earning power that I have from it.

A Prairie View A & M University alum also mentored Matthew during his internship at NASA Johnson Space Center. Matthew sustained his relationship with his mentor following the completion of his internship, which has the potential to lead to employment opportunities at NASA, post-graduation.

When I was at NASA as well, it was when I was on-site, he wasn't my direct mentor...but he kinda became my mentor, he was a Prairie View alumni. He really took me under his wing and even now he still texts me and we still talk and a few months ago...was it last month I guess, when at homecoming we met and kinda sat around, talked a little bit. Also over the summer, I was put on the hiring list.

Mary attributed her desire to attend college to her parents. As such, Mary admitted feeling pressure to achieve stellar grades to satisfy her parents.

My father and my mother mainly supported me- they went to college and you know, were going to be supportive even if I didn't go to college. They're just really supportive people. Well, my father, he works for Dell so we don't - I don't really qualify for programs or anything. And to me it's like, yeah, I'm having to pay for my education, so I want to get those A's, you know, but that's my only fret. I like to hear that he's proud of me.

Analogous to Mary, Jacob felt compelled to meet the expectations of his parents. "My Dad is a master's holder and my Mom is a Ph.D. holder and they've always inspired me throughout my life. They've always told me, you know, they want us to do better than them." Moreover, Jacob deduced that his parents would support any profession he chose to pursue.

They always told me, like "you want to do medicine?" I told them "yes." And from that moment on, you know, they've encouraged me and told me they loved me. Just the little stuff. All that little stuff throughout my whole life. Whatever decision I make, you know, they always told me, "pray about it, think about it you know, make sure it's what you want." Whatever I decide to do, they have 100 percent support.

Mentors often encouraged students to excel in their academic careers. Kara's mentor inspired her to become more ambitious. "It's like [my mentor] saw something in me and he kept pushing me. He would say, 'You know what your problem is? You're not pushing yourself hard enough.' He said, 'The minute you try to push yourself hard enough, you're going to be able to

see your full potential.” However, students like Kevin could not identify mentors. “Well, really, I just had people that tell me ‘pursue what you want to do, do what you want to do,’ but not specifically.”

The Prairie View A & M University Center for Radiation Engineering and Science for Space Exploration (CRESSE) website promotes the mentoring of underserved and underrepresented students. Nonetheless, neither the website for Texas Southern University nor the website for the University of Texas at El Paso provides information relating to mentoring. Prairie View A & M University’s website details efforts to offer mentoring for students involved in CRESSE:

The CRESSE Mission is to perform research that is aligned with the strategic plans of NASA and encourage, facilitate and mentor students – especially minority and underrepresented student groups – in research and education in the sciences, mathematics, engineering and technology in order to strengthen NASA and the nation. (CRESSE, 2009, para. 4)

Underserved and underrepresented undergraduates require aggressive mentoring to succeed in their academic endeavors. For the students interviewed, mentors largely consisted of parents and faculty members. Parental involvement frequently triggered an early interest in STEM for many students. Moreover, students recognized that their parent’s profession in STEM career fields generated interest from an early age. Faculty members also became instrumental in mentoring students, providing support and encouragement as students progressed in their academic careers.

Positive Mentoring

Positive mentoring can improve a student’s self-concept. The Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University recruits graduates of the program to mentor students. The Prairie View A & M University CRESSE website highlights the “Shadow Program” which, “supports joining students with

CRESSE engineers and scientists in research environments to strengthen the education and outreach component” (CRESSE, 2009, para. 2). Kara described the mentoring she received from Prairie View A & M University graduates as positive. “That's what I like about Prairie View. They don't bring outside engineers that graduated from Purdue, you know, or schools like that. They bring engineers that graduated from Prairie View. So we have a connection already.” In addition, Kara elaborated on the positive mentoring provided by faculty members within CRESSE. According to Kara, faculty members offered suggestions for enduring strenuous coursework.

Many parents also offered guidance and perspective for students pursuing STEM degrees. Jeff’s father continuously encouraged his interest in chemical engineering. As a chemical engineer himself, Jeff’s father had the ability to provide unique insight on the field:

I would say that my Dad would be the mentor, that he pushed me toward that. Once I told him my interest in it and all he told me different things that I might have to go through...how it is rewarding, but it does take a lot of work as well. And if you don’t know what you’re doing everyday it’s hard. So my father was a mentor as well.

Nick’s parents also urged him to pursue a degree following his deployment in the military:

I would say my family members or my father was a big push in making sure of that, cause when he figured out I was getting out of the military, he’s like “what are you gonna do? You’re not gonna just stay home and work all the time...like you need your degree.” And my mom was a big push as well.

Mentors at NASA also became influential in the success of student participants. Matthew recollected on his experience as an intern at a NASA center. As an intern, he initially became concerned that NASA personnel would reject his ideas. “Coming in I was kinda feeling you know, push me off to the side like ‘that’s a good idea...whatever.’” However, Matthew soon discovered that NASA personnel generally accepted most of his ideas, and consistently encouraged him to refine others. “They took my ideas and if they worked we’ll use it, if not we

explain it.” Inevitably, this interaction strengthened Matthew’s self-concept while providing an understanding of complex concepts used in the field of mechanical engineering. Max’s father also became instrumental in the development of his interest in mechanical engineering. Also an engineer, Max’s father constantly provoked his interest by conducting hands-on experiments with his son.

Pretty much any type of hands-on project, he’d be there helping me, asking, “what if we do this?” Or just making it a little more difficult that way. My first grade project was a pressure differential...a pressure drop in the line, in the air line. So really simple...but just concepts that you don’t think about as a little kid.

Not all students related their success in college to positive mentoring. Students like Elizabeth rarely received positive reinforcement from her parents, as they did not attend college. They were not supportive about it, ‘cause they’re like, “Really, is there jobs for that?” They were concerned about that instead of, you know, what is it really? And then, when I started getting opportunities, internships, and different jobs, now...I told them, “like everything in this room involves engineering,” and they’re like, “Really? You know?” And they really didn’t know.

Most student participants of the URCs project could recall having a mentor that inspired them to pursue their interest in STEM. High-levels of parental involvement at an early age in STEM often resulted in students pursuing degrees. In addition, NASA personnel that interacted with student participants of the URCs project during internships also provided positive reinforcement.

Pressure to Pursue an Advanced Degree

Many components of the URCs project have the potential to benefit underserved and underrepresented undergraduates. Nonetheless, multiple students reported feeling pressure from faculty members to pursue an advanced degree, rather than enter the STEM workforce pipeline. As a senior mechanical engineering major at Prairie View A & M University, Michelle recounted a meeting with a faculty member. “They pushed us as much as possible. It’s better to kind of go straight from your undergrad to your grad and there on versus going out and getting

stuck in the industry...because you kind of get stuck." However, Elizabeth became concerned about the security of her job. She cited the need to continue her research as a reason for pursuing her master's degree. "I'm going to get fired if I don't go for my master's."

As much of the Center for Space Exploration Technology Research (cSETR) program centers around the collaborative research efforts of undergraduate and graduate students, faculty members attempt to encourage students to pursue advanced degrees. Since students facilitate research in groups, if one student leaves, the research ultimately suffers. Elizabeth verbalized her concern for the research project she committed to:

It makes you think about it because they kind of like, um...they tell you have to stay for your master's. Like they ask you, you know, it's not like a must, but they kind of tell you...you need to stay for your master's if you want to work here because it's research. And, you know, they want to keep you here, which is good...you know. I mean, getting a master's is a good...a great accomplishment.

Further, Jessica, a senior mechanical engineering major described the problem at cSETR that had perpetuated over several semesters.

I know recently there has been problems with people that said they were staying and then like last minute they were like "oh no, I am leaving," so you lose a team member you were counting on. I cannot really think how that can be addressed. It is going to happen regardless. You cannot force people to stay for grad school. It is not like a huge issue, but its just happened a lot this semester.

Jessica also verified that faculty members within cSETR suggested that she stay at the University of Texas at El Paso for graduate school. According to Jessica, faculty members promoted graduate school through the cSETR program. As the success of research often depended on the availability of participants, faculty members urged students to pursue advanced degrees.

Conclusion

Faculty support became vital to student success within the URCs project. Often the relationships that students maintained with faculty contributed to their success in the classroom

and as interns. Moreover, students expressed their admiration for faculty members that provided guidance with academic and personal challenges. Additionally, many faculty members within the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso offered valuable assistance with academic challenges and encouraged students to pursue their academic interests. Faculty members, staff, and other administrators provided extensive support for students at their institutions. Further, many students described the regular accessibility of faculty members that afforded motivation for students struggling with coursework and research projects. Faculty also became instrumental in ensuring students received information relating to internship opportunities at corporations, and within the URCs project. Nonetheless, students spoke candidly about the sometimes immense pressure from faculty members to pursue an advanced degree. As the research facilitated at institutions like the University of Texas at El Paso depended on the retention of students, faculty members frequently promoted graduate school for undergraduates.

Mentors also supported students in their academic endeavors. Mentors consisted of faculty members, former teachers, parents, and peers. Students readily recalled positive experiences with their mentors, and detailed the importance of their presence. Mentors generally offered students guidance, suggested alternatives for research, stimulated interest in STEM, and encouraged students to pursue STEM degrees.

Influence of Mentors

Mentors have the capacity to encourage and motivate underserved and underrepresented undergraduates in their academic careers. Kara described her reverence for a faculty member within the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University. As a result of his prolific mentoring, Kara wanted to follow his

example. “I want to be the next [my mentor], to work to, you know...mend that gap with students coming from high school, or even in high school right now, who don't have the math and science background and feel like if they don't have the ability.” Kara explained how she would reciprocate to students with low-confidence in STEM:

Their GPA might not be what it is. So I want to get out and talk to these students, and say, “Okay, you know, these are difficult classes. You're struggling with it. You're going to need these when you go into engineering. So how about I would tutor you...twice a week, you know, in your Algebra, in your Trig...in your pre-calculus, in your physics, in your chemistry.”

Underserved and underrepresented undergraduates have high attrition in STEM degree fields, as a result of becoming dissuaded by rigorous coursework. Brad struggled to adequately perform in his biology class. However, his professor worked with him to address his deficiencies.

Sure he was a great teacher, and he was also a part of the URC program. He taught a general biology class, and it was a classroom of about 80 to 100 people. You think you know everything, you think you know how to do everything, but you don't. So he was like my mentor. When things got hard...it was like “I don't get it,” and he would help me. I'm still a science major because of him.

Mentors also motivate students to espouse certain academic and personal skills. Steven's mentor encouraged him to become meticulous in all aspects of his life. “He tends to be a perfectionist so he follows a certain pattern and you know I have adopted that behavior, even in my studies, and it has helped me to improve myself in so many ways.” Other mentors influenced students by providing specific information relating to STEM career fields. Elizabeth's mentor in high school advocated for her to pursue a career in STEM because of her impressive mathematical and technological abilities.

He really supported me. He would just tell me, “You know, you're really good at math. You should definitely focus on an engineering career. It's very mathematical, you know, you get to work on technical things.” And he would just like tell me what it was about. When he would talk about it, it seemed very interesting.

Charlie's siblings, also engineers, stimulated his interest in the field. "They taught me about their engineering experience and they taught me about their job and so I liked it and...and they pretty much ...talked to me about all the experiences they have had and, and that's when I started to like it also." Similar to Charlie, many students interviewed asserted that mentors often offered ample support and encouraged persistence in STEM degree fields. This mentoring inevitably even spurred some students to consider helping struggling high school students in STEM, thus likely strengthening the aptitude of underserved and underrepresented students preparing for college.

Peer Mentoring

Parents, teachers, faculty members, and siblings actively mentor students as they progress through their academic careers. In addition, peers also inspire students to persist and succeed. Kara described the "team effort" exacted to ensure success among her classmates. "That's what engineering is like. It's not everybody for themselves. We all help each other." As well, upper-classmen regularly attempted to assist younger undergraduates new to the program. As a senior mechanical engineering major at Prairie View A & M University, Matthew sought to aid students in need of mentoring. "Especially if we like see a younger student that has a vision and know what they want...and even some of those that do not. When we hear that they have potential for it and that you can get them on the right track...it really helps that person out." Upper-classmen at the University of Texas at El Paso provided Jessica with guidance in her academic endeavors:

All of these people were older than me so all of them I believe graduated in 2007. So when I switched they were all in their senior years. And so they all encouraged me. I guess they didn't realize until the end "I should have done this or that," and so they were always encouraging me to apply for internships and co-ops and stuff and to work for research and all that stuff before I graduated.

Correspondingly, Grace explained her relationship with a fellow student pursuing a biology degree. “I have a mentor. She’s also a student actually. So we kind of worked together. She’s a master’s student. She kind of assists me where I need help or whatnot. That’s about the only person I’ve sat and collaborated with.” Peer mentors have the ability to relate to students in STEM degree fields as they often have overcome comparable challenges. As such, peers can significantly influence student success.

Long-Term Goals

Many students establish long-term goals. These goals, often encouraged by mentors, influence students in their decision to enter the STEM workforce pipeline or pursue an advanced degree. As a result of her participation with the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University, Kara felt inspired to pursue an advanced degree. In addition, she had already made a definitive decision regarding her future career; she hoped to return to Prairie View A & M University to teach. Jeff, a senior mechanical engineering major also decidedly wanted to return to teaching after pursuing his career. “I’d like to be an instructor or something on the side where I can actually have tutoring for college students or even high school students. Something where I can use my mechanical engineering and technical background to encourage college students.” As an international student, Jacob felt compelled to assist his native country. “I don’t know really how my path will flow, but you know, after graduation I have to get a job obviously, but also to try to help my country.” Additionally, Elizabeth planned to locate employment with General Motors following the completion of her degree. Elizabeth claimed she would consider graduate school if GM would subsidize the cost of her education. “I was thinking of getting a master’s...I know GM supports that a lot and they pay for it even. Your company will pay for it. That’s even better, ‘cause you

know, sometimes we're a little concerned about how am I going to pay for it." Moreover, she eventually planned to return to contribute to her community. "I just want to feel that I did something for my community. It's not about me. It's not about the money or how successful I am...you know? I just want to be a good leader."

Mary seemed assured of her future in research. "I know I want to do medical research on diseases, like trying to find a cure for diabetes and AIDS. I know I want to work on something like that - in that field." Mary planned to earn a Ph.D. to succeed in her field. Jessica also appeared confident about her future. As a senior at the University of Texas at El Paso, Jessica decided to enroll in graduate school in order to eventually locate employment at NASA.

Like I said, I am going to do grad school and eventually my plan is to work for NASA. I guess as far as long-term goals I would like to have my own business, hopefully contracting to something engineering-related. I want to stay in the field. I guess explore to see what I can do with my degree. That is one of the reasons I chose mechanical.

Oscar also described his life-long desire to work at NASA. As a senior mechanical engineering major at the University of Texas at El Paso, Oscar hoped that his internship experience would make him a viable candidate for NASA:

I actually have always wanted to work at NASA, so I'm really excited that I got that internship. For me it's like a super dream come true. You know, since I was a little kid I just thought it would be cool to work at NASA or like to be an astronaut or you know whatever have you...so I always kind of have that in my head, and I never thought it would actually happen.

As participants in the URCs project, students ambitiously established long-term goals. These long-term goals generally involved entering the STEM workforce, or earning an advanced degree. Some students expressed uncertainty regarding which to do first. However, most students discussed their desire to eventually obtain an advanced degree, either immediately or as a member of the STEM workforce. To mitigate the need for financial aid and to reduce costs

associated with attending graduate school, many students seemed more inclined to initially locate employment.

Pursuit of an Advanced Degree

Although many students sought to determine their earning potential upon the completion of their degrees, others opted to pursue an advanced degree. Kevin sought to earn a medical degree, and later a Ph.D. Likewise, Erica joined the Undergraduate Medical Academy at Prairie View A & M University to prepare for the Medical College Admission Test (MCAT). Since his internship at NASA Ames Research Center, Brad also considered a degree in medicine:

Last summer I was an intern with NASA Ames in California. I had the opportunity to see Stanford Medical School. I always wanted to be some type of doctor and I didn't have a clue what school I wanted to go to. I hadn't started looking at the information or anything. I did plan to go to med school when I graduated from undergrad, but working for NASA gave me even more time to prepare for med school. Being an intern really showed me a lot and I got to see a lot of things you don't see on a regular day basis. Those are my plans for right now. What I am actually doing to get to this point...right now I am actually enrolled in an MCAT class with a couple of friends. We are all interested in going to med school. We have a study group and we study together.

Additionally, Mary wanted to attend medical school, but felt initially pursuing a career at NASA would benefit her more. Max, already assigned to a professional position (following his pending December graduation) at NASA Johnson Space Center, elected to wait for the agency to fund his graduate education.

Heather contemplated pursuing an advanced degree, but feared she would "waste time," as she remained undecided about the specialization of her degree. Ostensibly, Michelle also lacked certainty about her decisions. "I was really open to, of course, going straight into the workforce just for experience, but I'm fighting between going straight into my master's or going out. . .going into the industry and then possibly coming back for my master's." David acted

reluctant to pursue an advanced degree, but considered his age and lack of experience an obstacle in the workforce.

I think I want to do a master's before I go into work. Uh, the reason being is that I'm still kind of young...I don't think I'm ready to go work. Well, I'm not ready but I just want to, you know, be more prepared. I mean, actually I was interviewing for an internship position and the person actually told me, like, "you're going to be working all of your life so you might want to do other things and then start working."

However, Katherine spoke with determination about earning her master's and doctoral degrees. "I definitely want to go for my master's and Ph.D. from working this hard for my undergraduate. Somebody better be calling me doctor by the time I'm done." Oscar also fervently articulated his goal to attend graduate school at the University of Texas at El Paso or Northwestern University:

I'm gonna apply to graduate school at a few different schools, [University of Texas at El Paso] and Northwestern. I would really like to get into a program there for the material science engineering program. I've been in communication with someone, the graduate coordinator there, and that program...they fund their Ph.D. students. So I'm looking, if I'm gonna go to graduate school, I'm gonna go for a doctorate degree. I'm not gonna go with master's and then that's all.

Lastly, Jessica cited the cohesiveness of the Center for Bio-Nanotechnology and Environmental Research (C-BER) at the University of Texas at El Paso as an incentive to pursue an advanced degree. "Well first of all I wasn't really sure about doing grad school. But I guess after a while the mechanical engineering department...you know a lot of people. Everyone is like a little family." The cohesiveness of students in the URCs project often prompted many to pursue advanced STEM degrees rather than immediately entering the STEM workforce. As well, exposure to various degree fields through the URCs project largely benefited students uncertain of their interests.

Student Motivation

Student participants in the URCs project already appeared inclined to succeed in their academic careers. Nonetheless, numerous students asserted that their participation in the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso provided additional motivation. Joseph conjectured that his involvement in the Center for Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University encouraged him to become ambitious. “I don’t like school, but I love the field and you know, as much as I can’t wait to get out and start working, I’m obviously not in any hurry. But it really motivated me to, you know, do something.” Matthew speculated that CRESSE had taught him to prioritize and become more motivated in his academic career:

When you have commitments such as this you really do need to learn how to manage your time, and you figure out that video games are always going to be there, so let’s finish your work, finish your homework, and then whatever’s left is yours. You just really have to learn how to manage it...to figure out what is the right thing for you.

Also, Katherine claimed to become more efficient in her research practices as a result of her participation in the Center for Space Exploration Technology Research (cSETR) at the University of Texas at El Paso. Katherine explained, “It’s good in that it expands your expertise and expands your area of knowledge.” Additionally, Mary postulated that since her immersion in the Center for Bio-Nanotechnology and Environmental Research (C-BER) at Texas Southern University, she had become more intent on succeeding in her coursework. However, Mary recognized her limitations. “I’m pretty much motivated just to study...but not to study too much, so I don’t get burnt out.” While some students initially lacked motivation, participation in the URCs project required students to more effectively manage their time in order to sufficiently address research and academic coursework.

Conclusion

Mentors have the capacity to influence and sustain underserved and underrepresented undergraduates during critical years. Students reported that mentors usually influenced the initial development of their interest in STEM. However, many students affirmed that peer mentoring also largely provoked their interest in STEM. Frequently upper-classmen and graduate students mentored younger and less-experienced students as they first entered the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso.

Students also ardently discussed their long-term goals. However, many students appeared to lack certainty about their futures. Many students interviewed assumed that they would enter the STEM workforce pipeline upon the completion of their degrees. Nonetheless, students expressed concern about their decision to enter the STEM workforce pipeline prematurely. Students described their desire to pursue an advanced degree, though financial constraints became a deterrent. Opting to pursue employment and graduate school conjointly became a more realistic alternative. Nevertheless, all students spoke fervently about their ambitions, illustrating strong motivation.

CHAPTER V: IMPLICATIONS AND CONCLUSIONS

Underserved and underrepresented undergraduates represent a proportion of the population with minimal growth in science, technology, engineering, and mathematics (STEM) degree fields. This trend continues. In 2007, the National Center for Education Statistics (NCES) (2010) reported that underserved and underrepresented undergraduates earned a mere 17% of STEM degrees awarded in the U.S. As the demographic composition of the U.S. continues to shift, the need to address shortages in STEM degree fields will become more urgent. The population of “African American, Hispanic or Native American has increased from 16 percent to more than 30 percent today” since the 1970s (Pender, Marcotte, Domingo, & Maton, 2010, p. 3). Moreover, demographic indicators suggest that by 2020, underserved and underrepresented students will comprise nearly 40% of the population on college campuses (National Science Board [NSB], 2010). According to the Committee on Prospering in the Global Economy of the 21st Century and the Committee on Science, Engineering, and Public Policy (2007), the stability of the STEM pipeline has become contingent on the capacity of underserved and underrepresented students to succeed in STEM degree fields in institutions of higher education.

Few underserved and underrepresented undergraduates persist in STEM degree fields as a result of deficient academic preparation and financial hardship (Elliot, Strenta, Adair, Matier, & Scott, 1995; Pender, Marcotte, Domingo, & Maton, 2010; Schneider, 2000; Vetter, 1994; Villarejo & Barlow, 2007; Tyson, Lee, Borman, & Hanson, 2007). In addition, Villarejo & Barlow (2007) have implied that a lack of academic preparation frequently hinders the ability of

underserved and underrepresented undergraduates to excel in foundational science coursework. Tyson, Lee, Borman, & Hanson (2007) have contended that underserved and underrepresented undergraduates tend to enroll in low-level STEM classes during high school, which limits their ability to succeed in college. Consequently, these students struggle in undergraduate STEM coursework, which inevitably leads to high attrition in degree fields.

Financial problems “often prolong time to graduation for these students lowering their motivation to persist” (Pender, Marcotte, Domingo, & Maton, 2010, p. 3). Seymour & Hewitt (1997) asserted that even the most intellectually talented students rarely persist because of financial hardship. Underserved and underrepresented undergraduates often struggle to integrate (both academically and socially), develop angst about stereotypes, and lack appropriate mentors. Similarly, numerous researchers have also discovered a correlation between academic preparation, financial hardship, and persistence (Barlow & Villarejo, 2004; Building Engineering and Science Talent [BEST], 2004; Maton & Hrabowski, 2004; Pender, Marcotte, Domingo, & Maton, 2010; Summers & Hrabowski, 2006). “In the last two decades, a number of initiatives and educational enrichment programs have been instituted to retain minorities in the STEM education pipeline. These programs have provided various academic services and financial support” (Pender, Marcotte, Domingo, & Maton, 2010, p. 3). Providing early academic preparation and financial support has the potential to increase the persistence of underserved and underrepresented undergraduates (Tyson, Lee, Borman, & Hanson, 2007; Villarejo & Barlow, 2007). Further, Merkel (2001) proposed that underserved and underrepresented undergraduates should receive exposure to research during their academic careers.

The purpose of integrating students into research is to enhance students' learning experiences and increase persistence during college, boost interest in STEM careers, and encourage pursuit of graduate education in STEM disciplines. Such research-based

learning has become standard practice, especially in science education, and was prominently recommended by the Boyer Commission Report in 1998. (p. x)

Essentially, the Boyer Commission Report recommended the amalgamation of learning with research to make this a “standard of students’ college education” (Hunter, Larsen, & Seymour, 2006, p. 37). As such, funding agencies have urged institutions of higher education to facilitate more “interdisciplinary, and student-centered learning” (Hunter, Larsen, & Seymour, 2006, p. 37; National Research Council, 2000; NSF, 2003). Aligned with the “recommendations, tremendous resources are expended to provide undergraduates with opportunities to participate in faculty-mentored, hands-on research” (Hunter, Larsen, & Seymour, 2006, p. 37). In recent years, more extensive research has elucidated the importance of research experiences for underserved and underrepresented undergraduates, faculty members, and institutions of higher education (Bauer & Bennett, 2003; Hunter, Larsen, & Seymour, 2006; Lopatto, 2004; Russell, 2005; Seymour, Hunter, Laursen, & DeAntoni, 2004; Zydny, Bennett, Shahid, & Bauer, 2002a, 2002b). Previous research has focused primarily on “retention, persistence, and promotion of science career pathways for underrepresented groups” (Adhikari & Nolan, 2002; Barlow & Villarejo, 2004; Hathaway, Nagda, & Gregerman, 2002; Hunter, Larsen, & Seymour, 2006; Nagda et al., 1998).

To address consistent shortages in STEM degree fields amongst underserved and underrepresented undergraduates and graduates, NASA created the University Research Centers (URCs) project. Intended as an initiative to aggressively reduce attrition among these students and increase persistence in STEM degree fields, NASA provides funding for minority serving institutions to facilitate hands-on and highly-technical research experiences. Students receive financial compensation for their experience, and have the opportunity to become immersed in intensive, yet fulfilling research. These research experiences yielded substantial evidence

regarding the effectiveness and benefits of the URCs project among participating underserved and underrepresented undergraduates.

Answering the Research Questions

Research Question One:

How do underserved and underrepresented undergraduate students experience STEM in relationship to the URCs project?

Underserved and underrepresented undergraduates become more inclined to persist in STEM degree fields if they possess strong self-efficacy. Self-efficacy describes “the specific self-assessed belief in one’s own capability” (Hackett & Betz, 1989, p. 261). “With regard to their content, self-efficacy measures focus on *performance capabilities* rather than personal qualities, such as one’s physical or psychological characteristics” (Zimmerman, 2000, p. 83). As such, self-efficacy acts as a mechanism to measure capabilities, and “differs conceptually and psychometrically from related motivational constructs, such as outcome expectations, self-concept, or locus of control” (Zimmerman, 2000, p. 82). As participants of the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso, students explained challenges that they encountered in STEM-related research. Self-efficacy can relate to various events, and “it is particularly important in choosing and executing constructive actions in situations that can be barriers to successfully achieving the ultimately desired outcome” (Marra, Rodgers, Shen, & Bogue, 2009, p. 27). Often students recounted feeling challenged by research projects that involved elaborate designs. As such, many students described the presence of faculty members as integral to achieving success with the identified challenge. Nonetheless, other students asserted that they autonomously addressed challenges without the assistance of a faculty member.

To further understand the complex challenges that occasionally impeded the progress of underserved and underrepresented undergraduates in STEM research and degree fields, students responded to a series of questions specific to tinkering and technical self-efficacy. Generally, students readily described multiple scenarios that involved intricate, hands-on research problems, and subsequently detailed a solution for overcoming each (tinkering self-efficacy). Research problems typically resulted from a lack of knowledge related to the topic. Additionally, students struggled to grasp unfamiliar concepts that integrated hands-on experiences. Moreover, students that engaged in hands-on activities expressed a sense of anxiety about handling foreign materials. Students explained feeling apprehensive about manually constructing objects using the provided materials. Nonetheless, many of the students reflected on their hands-on experiences with enthusiasm and confidence, suggesting the significance of tinkering self-efficacy. If students experience repeated performance accomplishment, they become more likely to develop self-confidence, which contributes to their ability to overcome challenges in the future (Brand & Wilkins, 2007; Zimmerman, 2000). Other students in the URCs project developed a stronger dependence on the support of faculty members. Intimidated by research that required an advanced knowledge, students eagerly sought the counsel of faculty members within the URCs project. Students that possessed less self-confidence that worked in coordination with faculty members developed an increased sense of tinkering self-efficacy. “Low self-efficacy beliefs, unfortunately, impede academic achievement and, in the long run, create self-fulfilling prophecies of failure and learned helplessness that can devastate psychological well-being” (Margolis & McCabe, 2006, p. 219). As such, faculty members have become essential to student success. Most students report becoming more content with the college experience as a result of their interaction with faculty members (Fleming, Engerman, & Griffin, 2005).

Self-efficacy associated with student beliefs, can reflect “subtle changes in students’ performance context, to interact with self-regulated learning processes, and to mediate students’ academic achievement” (Zimmerman, 2000, p. 82). Thus, the identification of factors that contribute to increased self-efficacy can largely benefit students in their academic careers. In addition, strengthening self-efficacy can increase persistence in STEM degree fields as students become more confident in their capacity to overcome challenges (Hackett & Betz, 1989; Marra, Rodgers, Shen, & Bogue, 2009). Comparable to developing strong manual proficiency, underserved and underrepresented undergraduates also exerted effort to overcome technical challenges in research projects. If students receive the opportunity to learn and master technologies, they become more self-confident (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007). Most students related technical challenges to mastering software skills necessary for conducting research or performing a critical function. In addition, students cited the use of technological equipment (such as microscopes) as challenging. Nevertheless, multiple students interviewed implied that the repetition of using technology and other high-tech equipment eventually led to technical expertise. Students also asserted that previous technical preparation within the URCs project provided sufficient problem-solving skills for internships (at NASA or within other industries). However, dissimilar from tinkering self-efficacy, the majority of students interviewed suggested that they had the ability to overcome challenges without reliance on a faculty member, indicating a prior understanding of technological concepts. Students affirmed that they often encountered technological challenges. Nonetheless, students inferred that they possessed adequate experience with technology (especially software applications) that allowed them to more easily overcome challenges. However, the manipulation of materials proved more intimidating for students with less hands-on experiences.

Research Question Two:

How do students perceive the URCs project as a conduit to their success in STEM degree fields?

“Fostering success among racial and ethnic minority students in science, technology, engineering, and mathematics (STEM) has never been more important to our nation” (Ward & Wolf-Wendel, 2011, p. 1). The presence of underserved and underrepresented populations in STEM degree fields has the potential to fortify the workforce pipeline in the U.S. (Committee on Prospering in the Global Economy of the 21st Century and the Committee on Science, Engineering, and Public Policy, 2007). Nonetheless, with increasing deficits among minority populations, the STEM workforce continues to falter (Friedman, 2007). To reverse this trend, higher education must “foster success among racial and ethnic minority students in the STEM circuit because greater racial and ethnic diversity in STEM fields contributes to the enhanced ability of all members of the STEM workforce to function effectively” in a more diverse and competitive global economy (Ward & Wolf-Wendel, 2011, p. 5).

In an attempt to eliminate this disparate gap, federal agencies have begun to allocate substantial funding to initiate progressive educational programs that focus intently on the recruitment of undeserved and underrepresented undergraduates in the STEM workforce (Kuenzi, Matthew, & Mangan, 2007). In addition, educational research has begun to converge on this endemic problem. Educational researchers have begun to analyze “student data for predictors of STEM versus non-STEM interest. Researchers have also sought variables that predict which students will persist in their studies to ultimately obtain a degree in a STEM topic” (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007, p. 33). Further, according to Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn (2007), “the issue of ‘persistence’ in STEM requires knowledge of which students obtained a STEM degree relative to

those who initially pursued that degree” (pp. 33, 35). Other educational researchers have identified factors indicative to the success of students in college. Astin (1993a), for example, gauged student success in college on the Scholastic Assessment Test (SAT) and academic performance in high school.

In recent years, educational research has provided a more sophisticated understanding of persistence among underserved and underrepresented undergraduates in STEM degree fields (Ohland, 2008; Knight, Carlson, & Sullivan, 2007). Nonetheless, a lack of definitive answers for deterring these students from dropping out of STEM degree fields has urged many in academia to continuously seek a solution. Pantic (2007) suggested that “higher education must also be an active partner in efforts to ensure proper preparation for rigorous STEM curricula” (p. 26). To reverse this compounding problem, NASA developed multiple STEM education programs to ensure students received the most expansive opportunities in high-tech fields. In addition to advancing the STEM capabilities of students throughout the U.S., NASA sought to redress shortages in qualified and competent professionals, agency-wide. In recent years, global competition has heightened national concern regarding the potential of NASA to prolifically engage in research and other high-tech space-related endeavors. The 2007 report released by the Committee on Prospering in the Global Economy of the 21st Century (*Rising Above the Gathering Storm*) indicates the diminishment of superiority in STEM fields by the U.S. because of global competition. This considerable and imminent threat has inevitably resulted in the allocation of substantial government funding for colleges and universities nationwide.

For the purposes of this study, students considered the degree to which the URCs project influenced their capacity to persist in STEM degree fields. As a result of their participation in the URCs project, most students revealed that the initiative provided them with numerous skills

relevant to their specific STEM degree field. Moreover, students suggested that they acquired skills that elevated their knowledge regarding the use of machinery, materials, and technology. Multiple students also described their increased communication capability. Further, time management emerged as a valuable skill acquired through the URCs project. As students must devote significant time towards conducting research within laboratories on-campus, they must also balance their academic coursework and personal lives. As more students receive the opportunity to participate in STEM programs that offer academic and personal skill-building, students will become more inclined to remain in STEM degree fields, graduate, and pursue careers in STEM fields (Leslie, McClure, & Oaxaca, 1998). Therefore, these experiences have become critical to student success, as students often learn skills applicable to their chosen STEM degree field and future careers.

Most underserved and underrepresented undergraduates participating in the URCs project could appreciate the skills acquired that will provide leverage as they enter graduate school or the STEM workforce. However, few implied that the URCs project increased their inclination to persist in STEM degree fields. The majority of students interviewed believed that they already possessed intense motivation to persist and graduate. In addition, many students cited personal and financial reasons as a factor in their persistence, rather than their participation in the URCs project (Bean & Metzner, 1985). Some students sought to earn the approval of their parents by completing degrees. Others expressed concern over financial stability, post-graduation. The realization that obtaining a degree in STEM would equate to a lucrative salary became incentive for many students to persist (Leppel, 2001). Considering the rationale provided from students for persistence leads to the assumption that perhaps these students (at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso) already

possessed the mentality and determination to progress and succeed in college. Ultimately, the URCs project allowed students to springboard to new opportunities, but only moderately contributed to their capacity to complete STEM degrees.

Benefits of the URCs Project

Unique in focus, the URCs project recruited underserved and underrepresented undergraduates to participate in research relevant to NASA agency-wide objectives. In adherence with the stated goals of the NASA URCs project, underserved and underrepresented undergraduates researched STEM-related topics. These topics regularly proved challenging for some. As a component of the URCs project at Prairie View A & M University (Center for Radiation Engineering and Science for Space Exploration), Texas Southern University (Center for Bio-Nanotechnology and Environmental Research), and the University of Texas at El Paso (Center for Space Exploration Technology Research), students converged on research projects in coordination with their peers. The social and academic integration of students with their peers allows for a more rewarding and beneficial college experience (Tinto, 1997). Collaboration among peers also increases the probability of students to persist (Leppel, 2001).

Universities recurrently opted to structure collaborations around the seniority of students. Peers consisted of doctoral, master's, and other undergraduate students. Beneficially, doctoral and master's students offered advice to undergraduates regarding entry into the STEM workforce, entry into graduate school, and research unique to their internships. While some students regarded the collaborations as difficult, most students acquiesced that the collaborations provided significant opportunity to learn more about research and STEM degree and career fields. Daniels (1994) has contended that peer collaboration improves academic motivation and increases students' perceptions of success. Congruent with the assertion made by Daniels

(1994), students overwhelmingly appreciated the opportunity to work collaboratively with their peers, and contributed to general feelings regarding success. Only a few students specified the preference to work independently.

Underserved and underrepresented undergraduates also responded to questions relating to the personal benefits of the URCs project. Students acknowledged developing more confidence as a result of their participation in the URCs project, and asserted that they felt well-rounded. The development of self-confidence strengthens self-efficacy, which allows students to more readily overcome perceived challenges in STEM (Bandura, 1977). Furthermore, students recognized the long-term benefits of their participation in the URCs project. Interviewees maintained that their participation would bolster their résumé, and make them more competitive during the hiring process. Also, students emphasized their preparedness for graduate school. Conversely, strict alignment to NASA-related objectives displeased some. These students sought to broaden their expertise in STEM, regardless of the applicability to NASA.

Students also regarded financial compensation as an incentive to participate. However, while many students suggested that funding provided an opportunity to subsidize the cost of tuition and other personal expenses, most implied that funding did not ultimately determine their participation in the URCs project. As such, financial compensation only minimally encouraged students to participate. However, students had the tendency to cite finances as a reason to enter the STEM workforce pipeline, rather than pursue an advanced degree. Students reported feeling apprehensive about acquiring significant amounts of debt. Generally, underserved and underrepresented students decline loans to avoid incurring debt (Porter, 1990). Nonetheless, some students also expressed reluctance to immediately enter the STEM workforce pipeline, post-graduation. Many articulated the need to acquire additional education prior to determining

a career path. However, they also asserted that they needed to definitively select a career field before investing in a STEM graduate degree.

The URCs project did stimulate greater interest among students in both STEM and NASA, indicating the need for the continuation of such initiatives. Students largely attributed their interest in STEM to an event early in life. Nevertheless, the URCs project did generate additional interest in STEM among student participants. Interestingly, only one student described having an early interest in NASA. Seemingly, interest in NASA primarily developed among students as they entered the URCs project, implying that students rarely received exposure to NASA early in life.

Reportedly underserved and underrepresented undergraduates frequently encountered difficulty balancing research requirements and academic coursework. Nonetheless, students succeeded as a result of the support they consistently received from faculty members and peers, also within the URCs project. A lack of support on behalf of faculty members can increase attrition among underserved and underrepresented students (Astin, 1993a, 1993b, 1993c; Hayes, 2002; Hong & Shull, 2010; Moller-Wong & Eide, 1997). Students also repeatedly discussed advancing beyond the aptitude of their peers (external to the URCs project) as rewarding. Further, they described feeling fulfilled when they could easily translate NASA terminology and acronyms. As well, students implied that the URCs project provided more distinctive opportunities than other STEM-related programs on their campuses. However, many constantly struggled to effectively manage their time. Students expended significant time in university laboratories and towards challenging academic coursework, leaving few hours in the day. Nevertheless, multiple students considered the acquisition of time management skills as beneficial.

Internship Opportunities

Underserved and underrepresented undergraduates sought internship opportunities within the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso to gain hands-on experience, and to become more marketable in the STEM workforce. Additionally, student participants of the URCs project frequently applied for competitive internship positions at NASA centers. Students largely reflected on their experiences positively, adding that internships provided a snapshot of actual work in STEM career fields. Another student iterated the importance of research skills he acquired at NASA. Similarly, networking offered students an opportunity to interface with STEM professionals and student participants at other URCs projects housed within colleges and universities nationwide. Some interviewees recognized the importance of such an experience.

Uniquely, Texas Southern University mandated that students maintain and regularly update social networking sites such as: Facebook, Twitter, and MySpace. This technique proved effective in allowing students to network. In addition, providing exposure to technology and allowing students to engage and learn can strengthen technical self-efficacy (Baker, Krause, Yasar, Roberts, & Robinson-Kurpius, 2007). Students also recalled communicating virtually with their counterparts from other URCs projects and STEM professionals. Students had the tendency to maximize the use of these social networking sites by frequently posting questions relating to research. Further, the University of Texas at El Paso has started to utilize technology in an effort to strengthen relationships and connectivity between centers.

While experiences in the URCs project proved fulfilling for students, many only received information pertaining to available internships from faculty members. Few students could remember noticing campus-wide advertisements, receiving informational pamphlets, or e-mails

detailing opportunities within the URCs project on their campus. This lack of marketing indicates a dire need to promote the URCs project at colleges and universities. Problematically, Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso lack effective and strategic marketing campaigns to attract underserved and underrepresented undergraduates. Therefore, many eligible students never received an opportunity to intern at either their university or a NASA center.

Other challenges also emerged for students in regards to time management and research. Students interviewed persistently described feeling over-extended. Required work hours for the URCs project often conflicted with academic coursework and personal schedules to create a chaotic and sometimes frantic pace. While the rigorous schedule encouraged the development of time management skills in some, others students described feeling anxious about establishing priorities. Also, students questioned the relevance of NASA internship assignments to their designated STEM degree fields. Frequently, students arrived prepared for an internship at NASA centers only to find their placement within the agency failed to parallel their interests. Regardless, most students reported a positive experience.

Academic Challenges

Academic challenges that confront underserved and underrepresented undergraduates have the potential to deter students from persisting in their academic careers. As students overcome challenges, their self-efficacy has the innate tendency to gradually increase. Self-efficacy teaches students "their capability to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1993, p. 118). In addition, self-efficacy describes the "judgments of their capabilities to organize and execute courses of action required to attain designated types of performance" (Bandura, 1986, p. 391).

Students described challenges involving hands-on experiences (tinkering self-efficacy) and technology (technical self-efficacy), during their tenure in the URCs project. Challenges related to research fortified both tinkering and technical self-efficacy and also increased student self-concept. Repeatedly, students discussed hands-on challenges that deferred their efforts to conduct research. While frustrating, overcoming these hands-on challenges generated more confidence and self-reliance. Presenting moderate challenges for students can strengthen self-efficacy (Margolis & McCabe, 2006). However, when queried about technical challenges, students had difficulty recalling incidents that proved intimidating. Rather, most implied that they already possessed advanced technical skills that eliminated challenges in research. Distinctly, many undergraduates became accustomed to technology early in life, allowing for the development of profuse technological abilities.

Students acknowledged feeling significantly more confident in their capabilities as a result of their participation in the URCs project. However, other students contended that faculty members periodically expected the assistance of students on work unrelated to the URCs project, creating an unnecessary challenge. Consequently a few students deduced that their involvement in the URCs project intermittently created conflict with their academic coursework, which became challenging.

Faculty Support

Faculty support provided within URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso allowed underserved and underrepresented undergraduates to develop relationships essential to their success. However, little research currently exists “on understanding the values and impact faculty could have on the learning outcomes of students” (Hong & Shull, 2010, p. 266). In addition, the lack of adequate

teaching coupled with few supportive faculty members, and intense STEM coursework leads to high attrition among students (Astin, 1993a, 1993b, 1993c; Hayes, 2002; Hong & Shull, 2010; Moller-Wong & Eide, 1997). As such, this study sought to determine how faculty members best assist students in their academic endeavors, and more specifically, STEM degree fields. The scarcity of STEM professionals in the U.S. has prompted “higher education to reexamine the role faculty play in attracting, retaining, and graduating more STEM students” (Hong & Shull, 2010, p. 276).

Beneficially, most students described the constant support of faculty members. The unwavering support of faculty members afforded students the opportunity to seek assistance with high-level research projects. Faculty members have become critical to the persistence of underserved and underrepresented students (Astin, 1993a), as their presence offers undergraduates a reliable support system for academic and personal challenges. Moreover, students reported that faculty members not only offered guidance, but steadfast encouragement to explore research and academic interests. Effectively, this support motivated many to excel both in STEM degree fields and in research projects. In addition, as a result of their interaction with faculty members, students frequently expressed gratitude and admiration for these individuals. Moreover, several students acknowledged their desire to eventually return to their institution to assume the role of a faculty member.

Further, the consistent accessibility of faculty members allowed students to regularly seek support and assistance. The expanse of faculty support within the URCs project at each institution also contributed to student success. Students at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso described numerous support networks embedded within their institutions. In many cases, URCs project staff and

administrators regularly interfaced with students to resolve personal and academic difficulties. Constant accessibility to these individuals (for students) appears imperative to ensuring persistence, as students recognized their regular need to seek guidance. Generally underserved and underrepresented students have the tendency to develop weak relationships with faculty members leading to attrition in STEM degree fields (Sunal, Wright, & Day, 2004). Thus, the cultivation of relationships between students and faculty can reduce attrition.

While students seemed to appreciate faculty for the assistance and guidance provided, several also articulated their discomfort with pressure received from faculty members to attend graduate school. As some institutions opt to structure their research teams with doctoral, master's, and undergraduates, students become dependent on each other for the development and continuation of research projects. As such, when students decide to pursue a career within the STEM workforce rather than an advanced degree, ultimately their research team struggles to compensate for a missing member.

Influence of Mentors

Similar to faculty support, underserved and underrepresented undergraduates frequently sought the support of mentors. For these students, mentors represented a source of guidance and inspiration, both personally and academically. STEM faculty members, respected by students "act as mentors, advisers, role models, and advocates" (Tapia, 2009, para. 14). For many students, faculty members within the URCs project fulfilled a mentoring role. Positively, students had the tendency to adopt behaviors unique to these faculty members. Many students discussed acquiring better study habits and improving personal attributes, as a result of "shadowing" their mentors.

Effective mentoring can also occur through former teachers, parents, siblings, and peers. Students often cited parental involvement during early childhood as key to the development of their interest in STEM. In addition, siblings roused interest in STEM for many students. Peer mentoring also assisted underserved and underrepresented undergraduates in diverse and challenging research projects. Mentors can assist students in adjusting to college, and have the ability to help students adapt psychologically and academically, improving persistence (Bean & Metzner, 1985). Working collaboratively, undergraduates had the opportunity to facilitate research with doctoral and master's students. Even more, undergraduates communicated their desire to work with doctoral and master's students to resolve problems in research and academic coursework. As a result of this interaction, undergraduates forged a bond with their peers. These peer mentors appeared largely influential for undergraduates pursuing STEM degrees, and provided students with information pertaining to internship opportunities and academic coursework.

Universities also often received mentors from the STEM workforce pipeline. In addition, students received assigned mentors during internships at NASA centers, or acquired them independently. Mentors often provided insight into STEM career fields, as well as friendship for students. Reportedly, students often sustained contact with their mentors following internships, and therefore had the ability to connect with industry professionals that possessed unique insight into the availability of careers. As a component of the Center of Radiation Engineering and Science for Space Exploration (CRESSE) at Prairie View A & M University, administrators initiated the "Shadow Program," which enabled student participants to connect with STEM professionals (CRESSE, 2009, para. 2). The development of mentoring programs at other

institutions can strengthen persistence among underserved and underrepresented undergraduates (James, 1991).

Data collection resulted in the development of five themes, including: benefits of the URCs project, internship opportunities, academic challenges, faculty support, and the influence of mentors. Each theme represented a critical facet of the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso. Benefits of the URCs project encompassed academic incentives garnered from participation. Collaborative work with peers frequently provided enriching experiences. Additionally, personal benefits emerged as an incentive, as students received financial compensation for their participation. Students also reported an increased interest in STEM and NASA, as a result. Internship opportunities generally provided students with the ability to acquire skills critical to the STEM workforce. Moreover, students typically had the opportunity to network with STEM professionals and students from other URCs projects during their internships, which increased and promoted information-sharing relevant to careers and research. Nonetheless, the time allocated for participation in the URCs project proved agonizing for some. Students inferred that the work hours became overly-demanding. Consequently, students had difficulty managing academic challenges. However, overcoming academic challenges inevitably led to fulfillment and an improved sense of self-efficacy for students. Faculty support became the crux of student success both within the URCs project, and within the classroom. Frequently, faculty support engaged and encouraged students that struggled. Likewise, mentors provided essential personal and academic support for students in the URCs project, and assisted students in the achievement of goals.

Recommendations

In a report released by the National Science Board (2007), foreign-born students compose nearly one-third of students pursuing STEM degrees in the U.S. Further, the U.S. continues to struggle to contend with international competition that produces significantly more STEM professionals each year. Annually, 63% of students in Japan, 53% of students in China, and 51 % of students in Singapore earn a bachelor's degree in either an engineering or science field (Nicholls, Wolfe, Besterfield-Sacre, & Shuman, 2010). A mere one-third of U.S. students earn degrees in engineering and science fields. To combat the decline of underserved and underrepresented undergraduates in the U.S., institutions of higher education should seek innovative alternatives to attract students to STEM degree fields. As well, "one key tactic is to support higher education in attracting, retaining, and graduating sufficient U.S.-born STEM students" (Hong & Shull, 2010, p. 266).

NASA's URCs project focuses specifically on the recruitment of underserved and underrepresented students to STEM degree fields, and eventually STEM career fields. Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and other minority universities that receive funding to initiate research programs often succeed in attracting numerous graduate students. However, few institutions can boast of impressive participation on behalf of undergraduates. Overwhelmingly, the number of graduate students greatly exceeds that of undergraduates at institutions that receive funding from NASA for the establishment a URCs project. This indicates the need for the aggressive recruitment of undergraduates, whose longevity in STEM degree fields becomes threatened because of demanding coursework and a lack of general support. As many underserved and underrepresented undergraduates hesitantly consider graduate school to avoid incurring

substantial debt, preparing the next generation of STEM professionals has become vital to economic stability and proliferation in the U.S. Nonetheless, encouraging these students to persist in STEM degree fields has become an arduous task.

Recommendations illustrate the need for modifications to current institutional practices (see Table 5.3). While some institutions already employ the practices recommended, the replication of best practices can lead to more effective programs nationwide. Further, the adoption of such recommendations can heighten student success and persistence in STEM degree fields at Hispanic Serving Institutions (HSIs), Historically Black Colleges and Universities (HBCUs), tribal colleges and universities, and other minority universities.

Recommendations for Practice

Since the inception of the URCs project, faculty members within institutions have continuously adapted components of the initiative to ensure underserved and underrepresented undergraduates receive a fulfilling and stimulating experience. Nonetheless the delineation of practices that have the potential to improve experiences for students can allow institutions to acknowledge and address deficiencies within programs. While a building network of URCs projects has generated more extensive information-sharing in recent years, recommendations filtered through the suggestions and opinions of participating students can also assist in strengthening implemented and newly-commenced programs. Further, the continuous refinement of practices can lead to increased productivity while creating an environment conducive to hands-on and experiential learning for students.

Table 5.3

Summary of Recommendations

Major Findings	Recommendations
Underserved and underrepresented undergraduates become more inclined to persist and excel in STEM degree fields when provided with a mentor.	<ul style="list-style-type: none">• Assign qualified and successful mentors to students upon entrance into the URCs project• Assign mentors to students based on their specialization in a STEM field• Integrate a mentor model into the URCs project for institutions to replicate
Self-efficacy increases as students engage in and overcome difficult challenges.	<ul style="list-style-type: none">• Students need to experience challenges in their research to develop self-efficacy, but should receive direction from faculty members• Offer students the opportunity to interface with a mentor that can provide support with research projects and academic coursework• Develop self-efficacy within students by encouraging the identification of appropriate resolutions to problems
Students become deterred because of challenging STEM concepts during their undergraduate years and are less likely persist.	<ul style="list-style-type: none">• Align research projects with academic coursework in student degree plans to increase understanding of complex concepts• Adapt research projects to align with undergraduate abilities to reduce frustration• Construct a more organized network of peers and mentors to support students in their academic endeavors
Aligning internship opportunities at NASA with student STEM degree fields provides more fulfilling experiences.	<ul style="list-style-type: none">• Match students with internship opportunities directly related to their STEM degree field• Provide students with insight/information relevant to their internships prior to the commencement of their position• Allow students to provide feedback on their internship to create a more engaging experience

Major Findings

Recommendations

Improved marketing on behalf of institutions more effectively promotes the NASA URCs project.

- Develop an extensive marketing campaign to attract underserved and underrepresented undergraduates on-campus
- Modify websites specific to the URCs project to provide comprehensive information relating to opportunities
- Utilize social networking sites (Facebook, MySpace, etc.) to market to underserved and underrepresented undergraduates

Face-to-face and virtual networking allows students to develop and sustain relationships with their peers and industry officials.

- Require students to maintain social networking sites to increase connectivity with peers participating at other institutions
- Encourage students to participate in networking events (with peers and industry officials) at their institutions, or at NASA centers
- Develop and organize networking events at institutions (with peers and industry officials) to promote and build relationships integral to success in STEM career fields

Underserved and underrepresented students lack appropriate mentors, increasing attrition in STEM degree fields (American Association of State Colleges and Universities [AASCU], 2005). Sunal, Wright, and Day (2004) and Tapia (2009) asserted that diverse faculty members can act as appropriate role models for students. The collected data implies that students need mentors to encourage persistence in challenging academic coursework for STEM degree fields. To deter students from withdrawing from institutions, the URCs project should assign qualified and successful mentors to students upon initial entrance to programs. These mentors usually possess both the expertise and knowledge relating to STEM degree fields that can reinforce self-confidence in students. Currently the Center for Radiation Engineering and Science for Space

Exploration (CRESSE) program at Prairie View A & M University maintains the “Shadow Program,” a progressive initiative that intends to connect students with STEM professionals (CRESSE, 2009, para. 2). Other institutions demarcated as a URCs project should also ensure students have proper mentors that can provide consistent guidance in an effort to increase persistence.

URCs projects at each university should not only seek to provide mentors for underserved and underrepresented undergraduates, but should attempt to align STEM degree fields. Mentors that have successfully progressed through the same STEM degree fields and entered either graduate school or the workforce, demonstrate possibility for students with low self-confidence or that have steadily struggled with coursework and research. Moreover, these mentors have acquired a specialized knowledge that allows for information-sharing specific to STEM degree-fields. Further, students have the innate tendency to form connectivity with mentors. As such, students can confide in mentors when confronted with personal and academic matters. Beneficially, most mentors can assist these students in overcoming challenges.

In recent years, institutions that receive funding to establish a URCs project at NASA have begun to work more collaboratively, allowing for the frequent interchange of ideas. While some institutions have already structured a successful mentoring program within their URCs project, others lag behind. To assure underserved and underrepresented undergraduates receive adequate mentoring, institutions should develop and replicate a universal model for implementation. As an exchange of ideas already occurs between URCs project institutions, the development of a concept for mentoring should occur relatively easy. Systematically devising a concept should enable institutions not only to determine the most appropriate means for

mentoring underserved and underrepresented undergraduates within their programs, but should also allow institutions to cement their commitment to collaboration.

Self-efficacy develops as students encounter and overcome challenges that arise, personally and academically. Overcoming these challenges also contributes to increased self-confidence. Nonetheless, underserved and underrepresented undergraduates should receive focused attention and direction from faculty members within the URCs project. Some participants reported feeling a sense of frustration and anxiety as they could not identify an apt research topic. While students appeared competent in their capacity to overcome challenges, they desired the approval of faculty as they initiated research projects with convoluted topics. Thus, faculty members should strive to reassure students that lack confidence in their research projects and academic coursework. Providing a foundation for students that characteristically fail to persist in STEM degree fields can categorically bolster confidence and reduce attrition. Further, meetings facilitated with students upon initial entry into the URCs project can allow faculty to isolate potential research topics, compliant with program objectives and suitable for an undergraduate.

Mentors can contribute to the self-efficacy of underserved and underrepresented undergraduates. As such, students should receive mentors, capable of assisting with rigorous challenges. Tinkering self-efficacy and technical self-efficacy relates to the manual and technological proficiency that students can acquire as they surpass challenges. Having experience with these skills, mentors can illustrate proper techniques, as well as alleviate stress related to learning new technologies. However, students indicated more difficulty with hands-on experiences and only minimal problems with technology. Thus, mentors should attentively assist students with hands-on challenges to increase STEM skills. Further, as directed by faculty

members, mentors should help students address and identify resolutions to intricate problems in research and academic coursework. Essentially this will re-affirm students' self-confidence and promote problem solving. Faculty members also become integral to this strategy. If students receive guidance in their research and academic coursework, they ultimately become more likely to succeed and persist in STEM degree fields.

Research projects that incorporated advanced and high-level concepts often deterred many underserved and underrepresented undergraduates. Consequently, students that feel alienated or imperceptible rarely persist in STEM degree fields. To reverse this trend, each URCs project at institutions should aim to align research projects with academic coursework. This alignment will become advantageous to students with less experience or expertise in fundamental STEM concepts. Further, the simultaneous participation of students in similar research projects and academic coursework will reinforce crucial STEM concepts. Moreover, this will diminish the paralyzing effects that can likely occur to students when confronted with challenging and unfamiliar concepts. Faculty members within each URCs project should identify and integrate concepts in the classroom that also appear as research requirements for participating students. Essentially this provides context for students conducting research within the URCs project, and can also advance student success in the classroom.

Institutions should also attempt to identify student deficiencies, as students receive acceptance into the URCs project. To identify these deficiencies, institutions should consider creating survey instruments that would allow students to describe previous academic and personal challenges. Crafted to ascertain information relating to students' self-perceived strengths and weaknesses, survey instruments should comprehensively question STEM aptitude and personal characteristics that influence success. Administered as students begin their

participation in the URCs project, survey instruments can help faculty members recognize and address a student's academic and personal challenges and evaluate a student's ability to successfully perform research.

Similarly, mentors should become actively involved in the development of research projects in order to provide direction. Likewise, faculty members within URCs project should urge increased peer collaboration to help struggling underserved and underrepresented undergraduates facilitate research. While the URCs project at the University of Texas at El Paso (Center for Space Exploration Technology Research) ensures peer collaboration by assembling research groups that consist of doctoral, master's, and undergraduate students, other institutions employ less structured systems. As such, student participation does not yield the same benefits. To promote increased peer collaboration amongst students, institutions need to collectively generate a model that illustrates the most effective mode for cooperative learning. This model, a shared enterprise between institutions, can encourage peer collaboration between students by demonstrating the most appropriate approach.

Several students recalled feeling surprised when they discovered their internship assignments at NASA centers differed from their STEM degree fields. This variation created apprehension on behalf of participating students. Students reflecting on their experience as a NASA intern suggested receiving only scant information relative to their new position. Students also reported becoming disappointed by their internship assignments, as they hoped to learn more about their respective STEM career field. Therefore, students should receive information relating to their internship positions at NASA centers prior to their arrival. This allows students the opportunity to opt for positions more directly aligned with their STEM degree field. Moreover, following the completion of internships, faculty members at each URCs project

should contemplate facilitating focus groups to generate feedback from students. This measure will allow students to discuss modifications necessary for internships. Faculty members should distribute this feedback to pivotal NASA URCs program managers that have the capability to alter internship programs at NASA centers. In addition, during the 2010 fiscal year, NASA created a Technical Review Committee (TRC) charged with assuring URCs designated institutions adhere to mandated agency goals. NASA Technical Monitors (comprised of representatives from various NASA centers) should also receive all feedback to make necessary adjustments to internships. As Technical Monitors maintain performance metrics, student feedback can assist NASA URCs program managers in identifying less effective programmatic functions.

Frequently students voiced concern relating to the hourly requirements of the URCs project. In many instances, students felt that their internships within the URCs project jeopardized their academic standing. Also, weekly and even daily meetings for the URCs project compromised students' ability to focus on academic coursework. To better accommodate the chaotic schedules of students, faculty members within URCs project at institutions should consider distributing pertinent information via e-mail or through social networking sites regularly accessed by students. As students receive campus e-mail addresses and have access to social networking sites (Facebook, MySpace, etc.) utilized for the URCs project, this appears an optimal solution to eliminating time restrictions. In addition, to regulate the hourly requirements of students, faculty members should allocate multiple hours throughout the work day for students to focus on academic coursework. Even more, if each URCs project institutes mandatory "study halls," students would also have the opportunity to work with their peers to solve problems

specific to academic coursework. Faculty members should allow students to prioritize academic coursework, which will contribute to persistence in STEM degree fields.

When queried about pamphlets and other marketing materials distributed by either NASA or the URCs project at Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso, most students became unresponsive. Few could provide details about marketing materials they received that detailed the opportunities available through URCs project. Rather, most students reported receiving information pertaining to the URCs project by “word-of-mouth” (predominantly from faculty members). This general lack of knowledge indicates the need to develop a more extensive marketing campaign to attract underserved and underrepresented undergraduates. While the costs for such materials can become extreme, faculty members should seek viable, cost-effective alternatives to promote the URCs project. The utilization of technology can assist in eliminating many of these excessive costs. Campus e-mail addresses and social networking sites reduce time consumption for production, as well as costs. Each semester, faculty members should circulate e-mails and post messages via social networking sites, to alert students to potential opportunities. Further, the organization of social events on-campus that highlight internships and research projects can effectively attract students to the URCs project. As the number of graduate students that participate in the URCs project exceeds that of undergraduates, more aggressive outreach efforts should heighten awareness.

The URCs project should also create a comprehensive network of social networking sites in coordination with NASA to prevent fragmentation and encourage continuous information-sharing. Faculty members should also urge students participating in internships at NASA centers to attend networking events. These networking events allow students to interact with STEM professionals, increasing the likelihood of securing gainful employment, post-graduation.

However, faculty members should also actively host networking events for students and STEM professionals. These events might feature student research projects and promote the exchange of information relevant to innovations in STEM fields.

Recommendations for NASA

NASA ambitiously seeks to create STEM education programs recognized as legitimate by the higher education community. Vested in inspiring the next generation of STEM professionals, NASA seeks the cooperation of colleges and universities nationwide to advance underserved and underrepresented students. STEM education programs at NASA intend to increase the number of underserved and underrepresented students that opt to enter the high-tech workforce. Detrimentally, if colleges and universities cannot provide “the number and quality of degree holders to meet these needs, employers have an array of options to access them internationally or move operations offshore” (Chubin, May, & Babco, 2005, p. 73).

Acknowledging these economic shifts, NASA developed programs, such as the URCs project to address a growing shortage of underserved and underrepresented students. While the URCs project has experienced growth and productivity within institutions, NASA can offer more resources to ensure the longevity of this initiative. As a product of a larger paradigm, the URCs project may lack the funding necessary to make even moderate modifications to the current initiative. Taking this into consideration, some of the recommendations made below focus on the reduction of costs.

Similar to the recommendations made for participating institutions, NASA’s marketing strategy needs to involve a more thoughtful and extensive approach to attract underserved and underrepresented undergraduates to the URCs project. In effect, NASA should work collaboratively with institutions to create and advertise social networking sites (via Facebook,

MySpace, and Twitter) that specifically appeal to undergraduates. Free access to these sites eliminates costs for NASA, institutions, and the general public alike. Moreover, as these sites have become popularized venues for students to communicate, information relating to opportunities offered within the URCs project would likely become more widespread. Also, while not an optimal solution, low-cost marketing materials including brochures and pamphlets can stimulate student interest in the URCs project. Regardless of the marketing strategy chosen, NASA should forge a closer working relationship with institutions to determine an appropriate mechanism for recruiting students.

A movement to unify on behalf of URCs institutions has resulted in an alliance. The National Alliance of NASA University Research Centers (NANURC) distributes information that highlights individual centers in the form of a comprehensive newsletter. This newsletter allows each URCs project to recognize students for their accomplishments, and details the research activities of colleges and universities. While this effort seems to lack some momentum (largely because of distance between institutions and logistics), faculty members have attempted to begin assembling annual meetings for the purposes of organization and information sharing.

To ensure the public receives access to these newsletters and NANURC updates, NASA must post periodic updates on the agency portal. In essence this would also promote information sharing between institutions and create connectivity between NASA, faculty members, and students. Further, NASA should extend support for the alliance through the facilitation of meetings, conferences, and other events (with both faculty members and students) to share ideas and research discoveries. While participating institutions have become more proactive by initiating meetings, NASA seems to lack involvement in this process. By working cooperatively

and meeting regularly, NASA and colleges and universities can develop strategies to improve the URCs project.

Focus groups can also serve as an effective means by which to collect information relating to the URCs project. Essentially these sessions can yield data that allows NASA and institutions to adjust current practices. In addition, student interviews provide pertinent insight into overall satisfaction with programs, and indicators of student success. Limited data currently exists to suggest what components of the URCs project impact students the most. Therefore, the regular collection of data from student participants can assist NASA in replicating factors determined as significant. NASA should also consider regular interviews with faculty members that facilitate the URCs project. Faculty members possess the most significant information relating to the inner-workings of URCs project. As such, these individuals can offer valuable feedback pertaining to necessary program modifications, funding, and student success. Comprehensively, the consistent compilation of data will allow NASA to make funding allocations to strengthen specific aspects of the URCs project that advance students in STEM degree fields.

Recommendations for Future Research

The inclination of underserved and underrepresented undergraduates to persist in STEM degree fields has become stymied by a lack of stimulating experiences that enrich learning. As a direct result, fewer underserved and underrepresented undergraduates persist in STEM degree fields. This problem has become more pronounced as fewer U.S. students enter the STEM pipeline. An increasing gap exists between “the supply of students graduating from U.S. college science and engineering programs and demand for STEM workers. This is exacerbated by international competition” (Pantic, 2007, p. 25).

Persistence among underserved and underrepresented undergraduates has garnered more attention in recent years. Nonetheless, educational researchers remain perplexed by the staggering number of students that opt to pursue other majors, or drop-out. This anomaly deserves additional attention. Persistence rates must strengthen to make the U.S. viable among international competitors. As well, NASA must receive the next generation of qualified STEM professionals to continue to maintain dominance in high-tech fields. To assume this position in the global community, we must “arm our students with the tools for academic, personal and professional success” (Pantic 2007, p. 26). Therefore, understanding persistence among underserved and underrepresented undergraduates in STEM degree fields has become crucial to expanding a weak STEM workforce and ensuring national vitality.

Persistence generally weakens between a student’s first and second year as an undergraduate (especially in engineering) (Fleming, Engerman, & Griffin, 1998). As a result, students need positive first-year experiences to persist in STEM degree fields. Previous research also has indicated a strong correlation between persistence and family dynamics, finances, STEM proficiency, faculty accessibility, instruction, and advising. While defining these factors contributes to increased understanding, a sharp decline in STEM degree fields remains consistent. Thus, extensive research specific to the persistence of underserved and underrepresented undergraduates in STEM degree fields has become imperative for the reduction of this phenomenon.

Self-efficacy, which explains an individual’s capacity to successfully overcome challenges has become applicable in STEM degree fields. Essentially self-efficacy “serves as a generative mechanism” (Mau, 2003, p. 235), which ultimately influences the thought process and actions (Bandura, 1986). In comparison to their White counterparts, underserved and

underrepresented undergraduates possess lower self-efficacy (Leslie, McClure, & Oaxaca, 1998). Consequently, underserved and underrepresented undergraduates become less likely to persist in STEM degree fields. Interestingly, Mau (2003) contends that “academic proficiency is a significant predictor for persistence in SE (science and engineering) aspirations, it is less predictive than math self-efficacy (i.e., the way students think about the quantitative subjects)” (p. 240). However, insufficient literature currently exists that explicitly describes the relationship between STEM and self-efficacy.

Extensive literature searches also produced little evidence of research relating to tinkering self-efficacy and technical self-efficacy. Critical to success in STEM degree fields, underserved and underrepresented undergraduates need to acquire both hands-on and technical skills. The acquisition and refinement of these skills allows students to more aptly overcome obstacles in high-tech fields. These skills also contribute to the ability of students to progress either to graduate school or in the STEM workforce. However, students must first master these skills to adequately address challenges. The mastery of skills leads to increased self-confidence and perhaps increased persistence in STEM degree fields. Nonetheless, most current research relating to self-efficacy fails to identify tinkering self-efficacy and technical self-efficacy as fundamental to the development of underserved and underrepresented undergraduates in STEM degree fields. Qualitative research that focuses specifically on tinkering self-efficacy and technical self-efficacy can assist faculty members in isolating factors that influence a student’s ability to overcome hands-on and technical challenges that emerge in STEM experiences. Facilitating longitudinal studies can comprehensively examine these challenges through interviews, observations, and focus groups conducted with students. As faculty members frequently offer the support required for students to overcome challenges in STEM, researchers

should also exert effort towards determining the capacity in which faculty become most effective in encouraging persistence in degree fields. Further, the examination of other similar NASA initiatives, such as the Motivating Undergraduates in Science and Technology (MUST) project, has the potential to yield additional student data that identifies challenges related to hands-on and technical experiences.

In recent years, the academic community has made attempts to strengthen STEM educational research. As such, qualitative methods assist in answering “research questions that can not be answered through quantitative methods is taking on increasing significance. Well-designed qualitative studies often build on epistemological consistencies across theoretical perspectives, research questions, and research methods” (Koro-Ljungberg & Douglas, 2008, p. 163). Nonetheless, as the URCs project has become an expansive project consisting of hundreds of students nationwide, NASA should consider facilitating a quantitative study to further examine the effectiveness of this initiative. The collection of quantitative data has the potential to yield substantial data relating to the comprehensive experience of undergraduate participants. As this qualitative study sought to identify the most pertinent aspects of three institutions (Prairie View A & M University, Texas Southern University, and the University of Texas at El Paso), the development of a quantitative study could allow for a more widespread understanding of student perceptions of the URCs project. Further, such a study could allow researchers to identify specific factors that contribute to persistence among underserved and underrepresented undergraduates. The distribution of surveys to students participating at every institution would allow for the collection of extensive data that allows NASA program managers to make modifications to the URCs project to ensure effectiveness.

Conclusion

In 2005, the United States Department of Education issued a report indicating that the U.S. currently only produces roughly 15% of all STEM graduates; a significant and potentially detrimental decrease since 1960 when more than 50% of all STEM graduates originated in the U.S. (United States Department of Education, 2006). In addition, students that pursue STEM degrees have one the highest rates of attrition of any academic program (American Society for Engineering Education [ASEE], 2003). Half of all students “who enroll in these fields do not complete their engineering education” (Hong & Shull, 2010, p. 267). According to the National Science Foundation (2004), these confounding statistics have encouraged colleges and universities to search for innovative alternatives to ensure persistence among students that pursue STEM degrees.

In collaboration with colleges and universities nationwide, NASA initiated a progressive effort to motivate students to persist in STEM degree fields. While minimal growth in STEM degree fields has become a national crisis, the University Research Centers (URCs) project provides students with a fulfilling and realistic experience in an enriching environment. Nonetheless, despite the immersive experiences offered in the URCs project, the consistent lack of persistence among underserved and underrepresented undergraduates in STEM degree fields signifies a greater need to modify and remediate current practices. The refinement and replication of similar initiatives focusing on STEM can assist in fortifying the workforce of the future, and potentially lead the U.S. into an era of unsurpassed economic growth.

REFERENCES

- Adhikari, N., & Nolan, D. (2002). "But what good came of it at last?": How to assess the value of undergraduate research. *Notices of the AMS*, 49(10), 1252–1257.
- American Association for the Advancement of Science. (2009). *R & D budget and policy program*. Washington, DC: Author.
- American Association for the Advancement of Science. (1998). *A framework for federal science policy*. Washington, DC: Author.
- American Association of State Colleges and Universities. (2005). Strengthening the science and mathematics pipeline for a better America. *Policy Matters*, 2(11), 1-4.
- Astin, A.W. (1993a). *What matters in college? Four critical years revisited*. San Francisco, CA: Jossey-Boss.
- Astin, A.W. (1993b). Engineering outcomes. *ASEE Prism*. September, 27-30.
- Astin, A.W. (1993c). *The climate for undergraduate engineering education: Results from a recent national study*. Address presented at the Annual Engineering Dean's Institute, New Orleans.
- Astin, A. W., & Astin, H. S. (1992). *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences*. Los Angeles, CA: Higher Education Research Institute, UCLA.
- Babco, E. (2004). *Skills for the innovation economy: What the 21st century workforce needs and how to provide it*. Washington, DC: Commission on Professionals in Science and Technology.
- Baker, D., Krause, S., Yasar, S., Roberts, C., Robinson-Kurpius, S. (2007). An intervention to address gender issues in a course on design, engineering, and technology for science educators. *Journal of Engineering Education*, 96(3), 213-226.
- Baldwin, J., Ebert-May, D., & Burns, D. (1999). The development of a college biology self-efficacy instrument for non-majors. *Science Education*, 83(4), 397-408.
- Bandura, A. (2003). *Self-efficacy: The exercise of control*. New York, NY: W.W. Freeman Press.
- Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, 28, 117-148.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

- Bandura, A. (1977). Self-efficacy theory in human agency. *American Psychologist*, 37, 191-215.
- Barlow, A., & Villarejo, M. (2004). Making a difference for minorities: Evaluation of an educational enrichment program. *Journal of Research in Science Teaching*, 41(9), 861 – 881.
- Bauer, K., & Bennett, J. (2003). Alumni perceptions used to assess undergraduate research experience. *The Journal of Higher Education*, 74(2), 210-230.
- Bean, J.P., & Metzner, B.S. (1985). A conceptual model of nontraditional undergraduate student attrition. *Review of Educational Research*, 55(4), 485–540.
- Bilstein, R.E. (1989). *Orders of magnitude: A history of the NACA and NASA, 1915-1990*. Washington, DC: U.S. Government Printing Office.
- Bok, D. (2003). *Universities in the marketplace: The commercialization of higher education*. Princeton, NJ: Princeton University Press.
- Bolden, C. (2010a). *Prepared statement by NASA Administrator: Statement of Charles F. Bolden Before the House Subcommittee on Commerce, Justice, Science, and Related Agencies Appropriations*. Retrieved from <http://www.spaceref.com/news/viewsr.html?pid=33755>
- Bolden, C. (2009b). *Statement of Charles Bolden Before the Senate Committee on Commerce, Science and Transportation*. Retrieved from <http://www.spaceref.com/news/viewsr.html?pid=31734>
- Bollag, B. (2004). Enrollment of foreign students drops in U.S. *Chronicle of Higher Education*, 51(13), A1.
- Bonous-Hammarth, M. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. *The Journal of Negro Education*, 69, 92-111.
- Borrego, M., Douglas, E.P., & Amelink, C.T. (2009). Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education*, 98(1), 53-66.
- Bowen, W. G., & Bok, D. (1998). *The shape of the river: Long-term consequences of considering race in college and university admissions*. Princeton, NJ: Princeton University Press.
- Brand, B.R., & Wilkins, J.L.M. (2007). Using self-efficacy as a construct for evaluating science and mathematics methods course. *Journal of Science Teacher Education*, 18(2), 297-317.

Building Engineering and Science Talent [BEST]. (2004). A bridge for all- higher education design principles in science, technology, engineering and mathematics. San Diego, CA: BEST.

Burke, R.J., & Mattis, M.C. (2007). *Women and minorities in science, technology, engineering, and mathematics*. Northampton, MA: Edward Elgar Publishing Limited.

Business Roundtable. (2005). *Tapping America's potential: The education for innovation Initiative*. Washington DC: Business Roundtable.

Castells, M. (1997). *End of millennium, volume three of the information age: Economy, society and culture*. Oxford, UK: Blackwell Publishers Ltd.

Cavanagh, S. (2008). Federal projects' impact on STEM remains unclear. *Education Week*, 27(30), 20-21.

Center for Bio-Nanotechnology and Environmental Research [C-BER]. (2011). *C-BER scholars program*. Retrieved from <http://www.tsu.edu/pages/3616.asp>

Center for Radiation Engineering and Science for Space Exploration [CRESSE]. (2009). *CRESSE Center leading way in research to protect NASA astronauts, flight Instruments in deep space*. Retrieved from <http://pvamu.edu/CRESSE>

Chubin, D.E., May, G.S., & Babco, E.L. (2005). Diversifying the engineering workforce. *Journal of Engineering Education*, 94(1), 73-86.

Colbeck, C.L., Cabrera, A.F., & Terenzini, P.T. (2001). Learning professional confidence: Linking teaching practices, students' self-perceptions, and gender. *Review of Higher Education*, 24, 173-191.

Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. (2007). Washington, DC: The National Academies Press.

Daniels, R. (1994). Motivational mediators of cooperative learning. *Psychological Reports*, 74, 1011-1022.

Dervarics, C. (2010). Plan to consolidate STEM funding raises equity concerns. *Diverse Issues in Higher Education*, 27(4), 6.

Dunteman, G. H., Wisenbaker, J., & Taylor, M. E. (1979). *Race and sex differences in college science program participation*. Washington, DC: National Science Foundation. (ED199034)

- Edgerton, R. (2001). *Education white paper*. Retrieved from
<http://www.pewundergradforum.org/wp1.html>.
- Elliott, R., Strenta, A.C., Adair, R., Matier, M., & Scott, J. (1995). *Non-Asian minority students in the science pipeline at highly selective institutions*. Washington, DC: National Science Foundation.
- Enhancing Science, Technology, Engineering, and Mathematics Education (STEM) Act of 2008, H.R. 6014, 111th Cong. (2008).*
- Expectmore.gov. (2008). Detailed Information on the NASA Education Program Assessment.
Retrieved from
<http://www.whitehouse.gov/omb/expectmore/detail/10002310.2008.html>
- Farmer, T. (2009). A STEM brainstorm at NASA. *Techniques*, 83(9), 42-43.
- Felder, R.M., Beichner, R.J., Bernold, L., Burniston, E., Dail, P., & Fuller, H. (1998). Update on IMPEC: An integrated first-year engineering curriculum at N.C. State University. In *Proceedings of the American Society for Engineering Education Conference and Exposition*. Seattle, WA.
- Fencl, H., & Scheel, K. (2004). *Pedagogical approaches, contextual variables, and the development of student self-efficacy in undergraduate physics courses*. In J. Marx, S. Franklin, and K. Cummings (Eds.), 2003 Physics Education Research Conference: AIP Conference Proceedings (720), (pp. 173-176). Melville, NY: AIP.
- Flattau, P.E., Bracken, J., Van Atta, R., Bandeh-Ahmadi, A., De La Cruz, R., & Sullivan, K. (2005). *The National Defense Education Act of 1958: Selected outcomes*. Washington, DC: Science and Technology Policy Institute.
- Fleming, J. (1984). *Blacks in college: A comparative study of students' success in Black and in White institutions*. San Francisco: Jossey-Bass.
- Fleming, J. (1981). *Special needs of Blacks and other minorities*. San Francisco, CA: Jossey-Bass.
- Fleming, L., Engerman, K., & Griffin, A. (2005). Persistence in engineering education: Experiences of first year students at a historically black university. In *Proceedings of the 2005 American Society for Engineering Education Annual Conference and Exposition*. Portland, OR.
- Foshay, R. (2006). STEM is generating a lot of smoke, but is there any fire? *Tech Trends*, 50(3), 5.

- Friedman, T. (2005). *The world is flat: The globalised world in the twenty-first century*. London, UK: Penguin Books.
- Fullilove, R. E., and Treisman, P.U. (1990). Mathematics achievement among African American undergraduates at the University of California, Berkeley: An evaluation of the mathematics workshop program. *Journal of Negro Education* 59, 463–478.
- Geiger, R.L. (2004a). *The growth of American research universities, 1900-1940*. New Brunswick, NJ: Transaction Publishers.
- Geiger, R.L. (2004b). *American research universities since World War II and research relevant knowledge*. New Brunswick, NJ: Transaction Publishers.
- George, Y.S., Neale, D.S., Van Horne, V., & Malcom, S.M. (2001). *In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities*. Washington, DC: American Association for the Advancement of Science.
- Gibson, K. (2009). Guest editor's introduction: Science and public policy. *Technical Communication Quarterly*, 18(1), 1-8.
- Gohn, L.A., & Albin, G.R. (2006). *Understanding college student subpopulations: A guide for student affairs professionals*. Washington, DC: National Association of Student Personnel Administrators (NASPA), Inc.
- Government Accountability Office. (2005). Higher Education: Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends. Retrieved from <http://www.gao.gov/new.items/d06114.pdf>
- Greenberg, D. (1999). *The politics of pure science*. Chicago, IL: The University of Chicago Press.
- Guba, E.G., & Lincoln, Y.S. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology Journal*, 29, 75-92.
- Guston, D.H., & Keniston, K. (1994). *The fragile contract: University science and the federal government*. New Baskerville, MA: The MIT Press.
- Guterman, L. (2001). U.S. urged to invest in science education. *The Chronicle of Higher Education*, A26.
- Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education*, 20, 261-273.

- Hackett, G., Betz, N.E., Casas, J.M., & Rocha-Singh, I.A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology, 39*(4), 527-538.
- Hathaway, R., Nagda, B., & Gregerman, S. (2002). The relationship of undergraduate research participation to graduate and professional educational pursuit: An empirical study. *Journal of College Student Development, 43*(5), 614 – 631.
- Hayes, R. Q. (2002). *2001-02 STEM retention report: The retention and graduation rates of 1994-2000 freshman cohorts entering science, technology, engineering and mathematics majors in 200 colleges and universities*. Norman, OK: Consortium for Student Retention Data Exchange.
- Henderson, C., & Dancy, M. (2007). Barriers to the use of research-based instructional strategies: The influence of both individual and situational characteristics. *Physical Review Special Topics: Physics Education Research, 3*(2), 1–14.
- Hill, S.T., & Green, M.M. (2007). *Science and engineering degrees, by ethnicity of recipients: 1995-2004*. Arlington, VA: National Science Foundation (NSF 07-308).
- Honda, M. (2009). *Enhancing science, technology, engineering, and mathematics (STEM) act of 2008*. Retrieved August 2, 2009 from, <http://honda.house.gov/legislation/2008/stem.shtml>
- Hong, B.S., & Shull, P.J. (2010). A retrospective study of the impact faculty dispositions have on undergraduate engineering students. *College Student Journal, 44*(2), 266-278.
- House, D.J. (2000). Academic background and self-beliefs as predictors of student grade performance in science, engineering and mathematics. *International Journal of Instructional Media, 27*(2), 207-220.
- House, D.J. (1992). The relationship between academic self-concept, achievement-related expectancies, and college attrition. *Journal of College Student Development, 33*, 5-10.
- Hunter, A., Laursen, L. S., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development, *Science Education, 91*, 36 - 74.
- Hurtado, S. (1994). The institutional climate for talented Latino students. *Research in Higher Education, 35*, 21-41.
- Issacson, L. E., & Brown, D. (2000). *Career information, career counseling, and career development* (7th ed.). Boston, MA: Allyn & Bacon.

- Jaffe, A.B., & Trajtenberg, M. (2002). *Patents, citations and innovations*. Cambridge, MA: Massachusetts Institute of Technology.
- James, D. P. (1991). Minority student retention: The Prince George's Community College Program. In D. Angel and A. Ban-era (Eds.), *Rekindling minority enrollment, (pp. 57-62)*. *New Directions for Community Colleges*, No. 74. San Francisco: Jossey-Bass.
- Jolly, J.L. (2009). The National Defense Education Act, current STEM initiative, and the gifted. *Gifted Child Today*, 32(2), 50-53.
- Knight, D.W., Carlson, L.E., & Sullivan, J. (2007). Improving engineering student retention through hands-on, team based, first-year design projects. In *Proceedings of the International Conference on Research in Engineering Education*. Honolulu, HI.
- Koro-Ljungberg, M., & Douglas, E.P. (2008). State of qualitative research in engineering education: Meta-analysis of JEE articles, 2005-2006. *Journal of Engineering Education*, 97(2), 163-175.
- Kuenzi, J.J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action*. Washington, DC: Government Printing Office.
- Kuenzi, J.J., Matthew, C.M., & Mangan, B.F. (2007). Science, technology, engineering, mathematics (STEM) education issues and legislative options. In R.V. Nata (Eds.) *Progress in education* (pp. 161-189). New York, NY: Nova Science Publishers.
- Lent, R.W., Sheu, H.B., Schmidt, J., Brenner, B.R., Wilkins, G., Brown, S.D., et al. (2005). Social cognitive predictors of academic interests and goals in engineering: Utility for women and students at historically black universities. *Journal of Counseling Psychology*, 52, 84-92.
- Leppel, K. (2001). The impact of major on college persistence among freshmen. *Higher Education*, 41(3), 327-342.
- Leslie, L.L., McClure, G.T., & Oaxaca, R.L. (1998). Women and minorities in science and engineering: A life sequence analysis. *The Journal of Higher Education*, 69(3), 239-276.
- Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.
- Loo, C. M., & Rolison, G. (1986). Alienation of ethnic minority students at a predominantly White university. *Journal of Higher Education*, 57, 58-77.
- Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First findings. *Cell Biology Education*, 3, 270 - 277.

- Maddux, J. E., Norton, L.W., & Stoltenberg, C.D. (1986). Self-efficacy expectancy, outcome expectancy, and outcome value: Relative effects on behavioral intentions. *Journal of Personality and Social Psychology*, 51, 783-789.
- Margolis, H., & McCabe, P.P. (2006). Improving self-efficacy and motivation: What to do, what to say. *Intervention in school and clinic*, 41(4), 218-227.
- Marra, R.M., Rodgers, K.A., Shen, D., Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*, 98(1), 27-38.
- Marsh, H.W., & Shavelson, R. (1985). Self-concept: It's multi-faceted, hierachal structure. *Educational Psychologist*, 20(3), 107-123.
- Marshall, C., & Rossman, G.B. (2006). *Designing qualitative research* (4th ed.). Thousand Oaks, CA: Sage.
- Maton, K. I., Hrabowski, F. A., III, Schmitt, C. L. (2000). African American college students excelling in the sciences: College and post-college outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching* 37(7), 629 - 654.
- Mau, W.C. (2003). Factors that influence persistence in science and engineering career aspirations. *Career Development Quarterly*, 51(3), 234-243.
- May, C. (2002). *The information society: A sceptical view*. Cambridge, UK: Polity Press.
- McCormick, B. (2004). Science education reform and higher education. In D.W. Sunal (Ed.), *Reform in undergraduate science teaching for the 21st Century (research in science education series)* (pp. 17-29). Charlotte, NC: Information Age Publishing.
- Mendez, G., Buskirk, T.D., Lohr, S., & Haag, S. (2008). Factors associated with persistence in science and engineering majors: An exploratory study using classification trees and random forests. *Journal of Engineering Education*, 97(1), 57-70.
- Mendoza, P., & Berger, J.B. (2008). Academic capitalism and academic culture: A case study. *Education Policy Analysis Archives*, 16(23), 1-27.
- Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.
- Moller-Wong, C., & Eide, A. (1997). An engineering student retention study. *Journal of Engineering Education*, 86(1), 7-15.

Monastersky, R. (2008). Despite recent obits, U.S. science and engineering remain robust. *The Chronicle of Higher Education*, A1.

Murray, C., & Bly Cox, C. (1989). *Apollo: The behind-the-scenes story of one of humankind's greatest achievements*. Burkittsville, MD: South Mountain Books.

Nagda, B. A., Gregerman, S. R., Jonides, J., von Hippel, W., & Lerner, J. S. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education*, 22(1), 55 – 72.

Narum, J. (2008). Transforming undergraduate programs in science, technology engineering, and mathematics: Looking back and looking ahead. *Liberal Education*, 94(2) 12-19.

Nata, R.V. (2007). *Progress in education*. New York, NY: Nova Science Publishers, Inc.

National Aeronautics and Space Administration. (2010). *Minority university research and education program: Diversity in higher education*. Retrieved from http://www.nasa.gov/offices/education/about/murep_overview.html

National Aeronautics and Space Administration. (2009a). *NASA awards grants for research centers at six universities*. Retrieved on April 1, 2010, from http://www.nasa.gov/home/hqnews/2009/sep/HQ_09-213_Minority_University_Grants.html

National Aeronautics and Space Administration. (2009b). *Minority university research and education program*. Retrieved from <http://www.nasa.gov/offices/education/programs/national/murep/about/index.html>

National Aeronautics and Space Administration. (2009c). *NASA group 5 university research centers (FY 2009)*. Retrieved on April 1, 2010, from http://www.nasa.gov/pdf/388378main_URC_09_Abstracts.pdf

National Aeronautics and Space Administration. (2009d). *Project description: University research centers*. Retrieved on April 1, 2010, from http://www.nasa.gov/offices/education/programs/descriptions/University_Research_Centers.html

National Aeronautics and Space Administration. (2008a). *NASA group 4 university research centers (FY 2008)*. Retrieved on April 1, 2010, from http://www.nasa.gov/pdf/272510main_NASA%20GROUP%204%20URC%20%20ABS%20TRACTS.pdf

National Aeronautics and Space Administration. (2008b). *NASA awards education research grants to minority universities*. Retrieved on April 1, 2010, from <http://www.nasa.gov/offices/education/programs/national/murep/about/index.html>

National Aeronautics and Space Administration. (2007a). *Sputnik and the dawn of the space Age*. Retrieved from <http://history.nasa.gov/sputnik/>

National Aeronautics and Space Administration. (2007b). *One giant step for STEM education*. Retrieved on April 1, 2010, from
http://education.nasa.gov/divisions/higher/overview/F_One_Giant_Step_STEM_Education.html

National Aeronautics and Space Administration. (2007c). *Assistant administrator for education*. Retrieved from http://www.nasa.gov/about/highlights/winterton_bio.html

National Aeronautics and Space Administration. (2006). *NASA education strategic coordination framework: A portfolio approach*. Retrieved on April 1, 2010, from
http://education.nasa.gov/pdf/151156main_NASA_Booklet_final_3.pdf

National Aeronautics and Space Administration. (1992). *NASA's strategic plan for education: A strategy for change, 1993-1998*. Washington, DC: U.S. Government Printing Office.

National Aeronautics and Space Administration. (1958). *National aeronautics and space act of 1958*. Washington, DC: U.S. Government Printing Office.

National Center for Education Statistics. (2005). *Digest of education statistics, 2004*. Washington, DC: U.S. Department of Education. Retrieved on April 1, 2010, from
<http://nces.ed.gov/programs/digest/d04/index.asp>

National Research Council (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

National Science Board. (2007). Moving forward to improve engineering education. *National Science Foundation*. Retrieved on February 28, 2011 from
http://www.nsf.gov/pubs/2007/nsb07122/nsbO7I22_1.pdf

National Science Foundation. (2004). *Science and Engineering Doctorate Awards: 2003 (NSF 05-300)*. Arlington, VA: National Science Foundation. Retrieved February 28, 2011 from <http://www.nsf.gov/sbe/srs/nsfD5300/tables/tabc3.xls>.

National Science Foundation. (2004). *Women, minorities, and persons with disabilities in science and engineering*. Arlington, VA: National Science Foundation (NSF 04-317).

National Science Foundation. (2003). *Exploring the concept of undergraduate research centers*. Arlington, VA: NSF Workshop.

Nicholls, G.M., Wolfe, H., Besterfield-Sacre, M., & Shuman, L.J. (2010). A math model shows students' potential is evident by eighth grade. *American Society for Engineering Education Prism*, 20(2), 55.

- Nicholls, G.M., Wolfe, H., Besterfield-Sacre, M., Shuman, L.J., & Larpkiattaworn, S. (2007). A method for identifying variables for predicting STEM enrollment. *Journal of Engineering Education*, 96(1), 33-44.
- Nora, A., & Cabrera, A.F. (1996). The role of perceptions of prejudice and discrimination on the adjustment of minority students to college. *Journal of Higher Education*, 67(2), 119-148.
- Obama, B. (2011, January 25). Address before a joint session of the Congress on the state of the union. *Congressional Record—House*. Retrieved on April 1, 2010, from http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2011_record&docid=cr25ja1-1-87.pdf
- Office of the Press Secretary. (2009). President Obama launches “Educate to Innovate” campaign for excellence in Science, Technology, Engineering & Math (Stem) Education. Retrieved on April 1, 2010, from <http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en>
- Ohland, M.W., Sheppard, S.D., Lichtenstein, G., Ozgur, E., Chachra, D., & Layton, R.A. (2008). Persistence, engagement, and migration in engineering programs. *Journal of Engineering Education*, 97(3), 259-278.
- Ohland, M.W., Zhang, G., Thorndyke, B., & Anderson, T.J. (2004). The creation of the multiple-institution database for investigating engineering longitudinal development (MIDFIELD). *American Society for Engineering Education*, 1-10.
- Olds, B.M., Moskal, B.M., & Miller, R.L. (2005). Assessment in engineering education: Evolution, approaches and collaborations. *Journal of Engineering Education*, 94, 13–25.
- Pantic, Z. (2007). Stem sell. *New England Journal of Higher Education*, 22(1), 25-26.
- Parajes, F., & Miller, M.D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychologist*, 86(2), 193-203.
- Pascarella, E.T., & Terenzini, P.T. (2005). *How college affects students*. San Francisco, CA: Jossey-Bass.
- Pascarella, E.T., & Terenzini, P.T. (1991). *How college affects students: Findings and insights from twenty years of research*. San Francisco, CA: Jossey-Bass.
- Patton, M.Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

- Pender, M., Marcotte, D.M., Sto. Domingo, M.R., Maton, K.I. (2010). The STEM pipeline: The role of summer research experience in minority students' graduate aspirations. *Education Policy Analysis Archives*, 18.
- Perna, L., Wagner-Lundy, V., Drezner, N.D., Gasman, M., Yoon, S., Bose, E., Gary, S. (2009). The contribution of HBCUs to the preparation of African American women for Stem careers: A case study. *Research in Higher Education*, 50(1), 1-23.
- Person, C.S. (2009, October). NASA's Minority University Research and Education Program (MUREP) [PowerPoint slides]. Paper presented at the improving minority institution collaborations at NASA workshop, Ames Research Center, Moffett Field, CA. Retrieved on April 1, 2010, from <http://event.arc.nasa.gov/Minority-Institutions/home/pdf/MinorityInstitutionsWorkshopARC.pdf>
- Porter, O.F. (1990). *Undergraduate completion and persistence at four-year colleges and universities*. Washington, DC: The National Institute of Independent Colleges and Universities.
- Prairie View A & M University. (2009). History of Prairie View A & M University. Retrieved on April 1, 2010, from <http://www.pvamu.edu/pages/605.asp>
- President's Commission on Implementation of United States Space Exploration Policy. (2004). *President's Commission on implementation of United States space exploration policy: A Journey to inspire, innovate, and discover*. Washington, DC: U.S. Government Printing Office.
- Quinn, H.R., Schweingruber, & H.A., Feder, M.A. (2008). *NASA's elementary and secondary education program: Review and critique*. Washington, DC: The National Academies Press.
- Ramist, L., Lewis, C., & McCamley-Jenkins, L. (1994). *Student group differences in predicting college grades: Sex, language, and ethnic groups* (College Board Report No. 93-1). New York, NY: College Entrance Examination Board.
- Rayman, P., & Brett, B. (1995). Women science majors: What makes a difference in persistence after graduation? *Journal of Higher Education*, 66, 388-414.
- Reich, R. (1991). *The work of nations*. New York, NY: Vintage Books.
- Riccards, P.R. (2009). Advocating STEM education as a gateway to economic opportunity. *Education News*. Retrieved on April 1, 2010, from <http://www.ednews.org/articles/advocating-stem-education-as-a-gateway-to-economic-opportunity.html>
- Rochin, R.I., & Mello, S.F. (2007). Latinos in science: Trends and opportunities. *Journal of Hispanic Higher Education*, 6(4), 305-355.

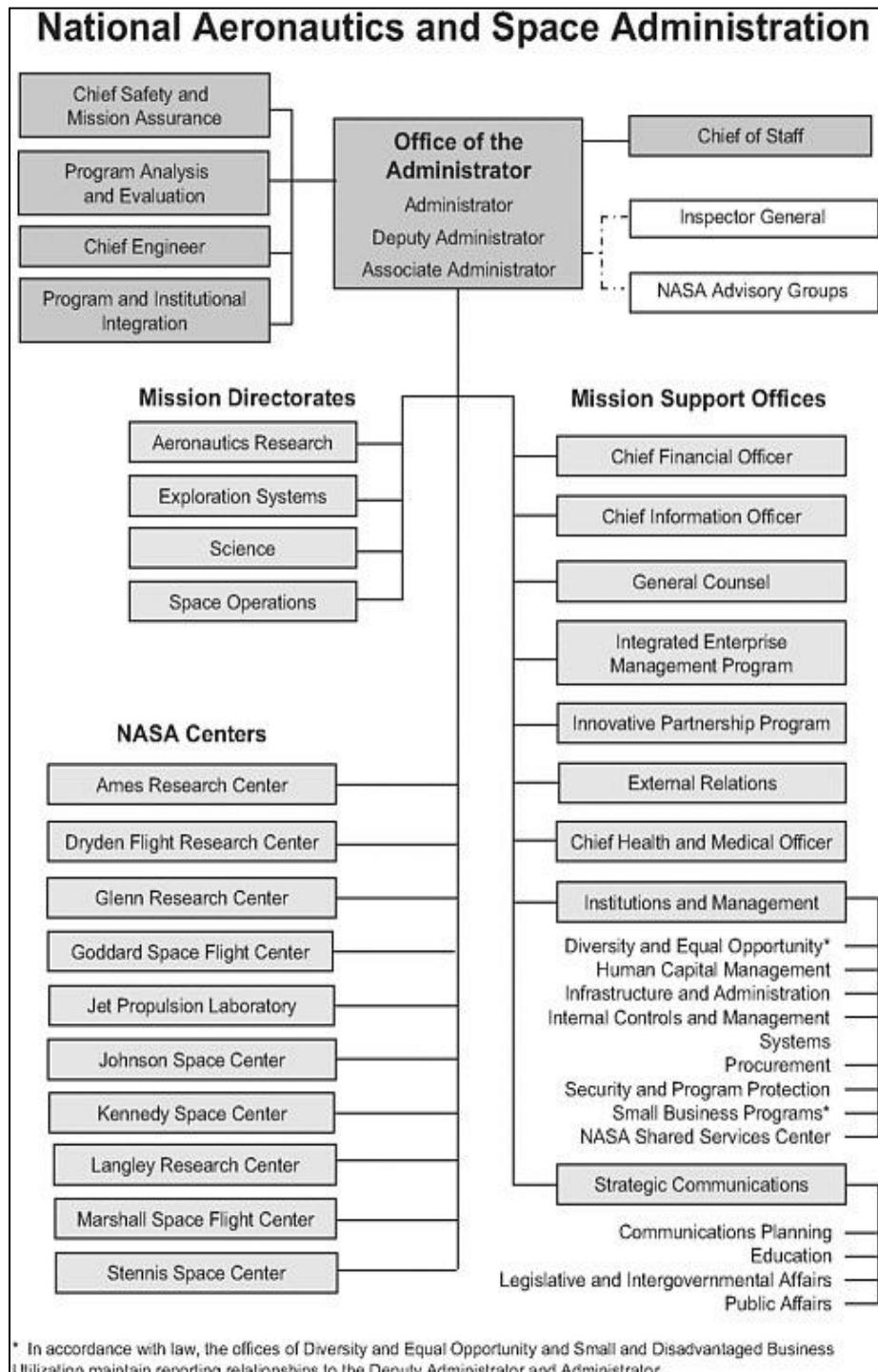
- Rubin, H.J., & Rubin, I.S. (2005). *Qualitative interviewing: The art of hearing data*. Thousand Oaks, CA: Sage.
- Russell, H. S., Hancock, P. M., & McCullough, J. (2007). The pipeline: Benefits of undergraduate research experiences. *Science, 316*.
- Samiullah, M. (1995). Effect of in-class student-student interaction on the learning of physics in a college physics course. *American Journal of Physics, 63*(10), 944-950.
- Schneider, B. (2000). Explaining the unrealized aspirations of racial and ethnic minorities. In G. Campbell, Jr., R. Denes & C. Morrison (Eds.), *Access denied- Race, ethnicity, and the scientific enterprise* (pp. 174-187). Oxford: Oxford University Press.
- Seymour, E., & Hewitt, N.M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.
- Seymour, E., Hunter, A-B., Laursen, S.L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education, in press*.
- Shulman, S. (1999, February 19). We need new ways to share our knowledge. *The Chronicle of Higher Education, A64*.
- Smedley, B. D., Myers, H. F., & Harrell, S. P. (1993). Minority-status stresses and the college adjustment of ethnic minority freshmen. *Journal of Higher Education, 64*, 434-452.
- Smith, B.L.R., & Karlesky, J.J. (1977). *The state of academic science: The universities in the nation's research effort*. New Rochelle, NY: Change Magazine Press.
- Smith, D. G. (1992). Diversity. In M. A. Whiteley, J. D. Porter, & R. H. Fenske (Eds.), *The premier for institutional research*. Tallahassee, FL: Association for Institutional Research Press.
- Smith, M.S., Morgan, D., & Schacht. (2003). *The National Aeronautics and Space Administration's FY2004 budget request: Description, analysis, and issues for congress*. Washington, DC: Government Printing Office.
- Smyth, F.L., & McArdle, J.J. (2004). Ethnic and gender differences in science graduation at selective colleges with implications for admission policy and college choice. *Research in Higher Education, 45*(4), 353-381.
- Suen, H. (1983). Alienation and attrition of Black college students on a predominately White campus. *Journal of College Student Personnel, 24*, 117-121.

- Sunal, D.W., Wright, E.L., & Day, J. (2004). *Reform in undergraduate science teaching for the 21st Century (research in science education series)*. Charlotte, NC: Information Age Publishing.
- Summers, M.F., & Hrabowski, F.A. III. (2006). Preparing minority scientists and engineers. *Science*, 311, 1870- 1871.
- Tapia, R.A.(2009). Minority students and research universities: How to overcome the 'mismatch.' *The Chronicle of Higher Education*, 55(29), A72.
- Texas Southern University. (2010). About TSU. Retrieved from on April 1, 2010, <http://www.tsu.edu/about/history>
- The Technology Teacher*. (2006). Taking action together, 66(3), 5-6.
- Thelin, J.R. (2004). *A history of American higher education*. Baltimore, MD: The Johns Hopkins University Press.
- Tinto, V. (1997). Classrooms as communities. *The Journal of Higher Education*, 68(6), 599–623.
- Tracey, T. J., & Sedlacek, W. E. (1987). Prediction of college graduation using noncognitive variables by race. *Measurement and Evaluation in Guidance*, 19, 177-184.
- Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *College Mathematics Journal*, 12, 362-372.
- Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, 12(3), 243 -270.
- United States Department of Education. (2006). A test of leadership. Charting the future of U.S. higher education. Retrieved on February 28, 2010, from <http://www.ed.gov/about/bdscomm/list/hiedfuture/reports/fmal-report.pdf>
- United States Department of Labor. (2007). The STEM Workforce Challenge: The Role of the Public Workforce System in a National Solution for a Competitive Science, Technology, Engineering, and Mathematics (STEM) Workforce. Retrieved from www.dol.gov
- University of Texas at El Paso. (2011). 2010-2011 Facts. Retrieved on April 1, 2010, from <http://universitycommunications.utep.edu/facts/index.html>
- Urban, W. (2010). *More than science and Sputnik: The National Defense Education Act of 1958*. Tuscaloosa, AL: The University of Alabama Press.

- Vetter, B. M. (1994). The next generation of scientists and engineers: Who's in the pipeline? In W. Pearson, Jr., & A. Fechter (Eds.), Who will do science? Educating the next generation (pp. 1-19). Walters, A.K. (2005). Business groups warn of gap in science and math. *The Chronicle of Higher Education*, 51(48), A21.
- Villarejo, M. & Barlow, A. E. L. (2007). Evolution and evaluation of a biology enrichment program for minorities. *Journal of Women and Minorities in Science and Engineering*, 13, 119-144.
- Ward, K., & Wolf-Wendel, L.E. (2011). Racial and ethnic minority students' success in STEM education. *ASHE Higher Education Report*, 36(6), 1-140.
- Williams, P.J. (2007). Valid knowledge: The economy and the academy. *Higher Education*, 54(4), 511-523.
- Yelamarthi, K., & Mawasha, P.R. (2008). A pre-engineering program for the under-represented, low-income and/or first-generation college students to pursue higher education. *Journal of STEM Education*, 9(3/4), 5-15.
- Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, 37, 215–246.
- Zhang, G., Anderson, T., Ohland, M., and Thorndyke, B. (2004). Identifying factors influencing engineering student graduation: A longitudinal and cross-institutional study. *Journal of Engineering Education*, 93(4), 313–20.
- Zimmerman, B.J. (2000). Self-efficacy: An essential move to learn. *Contemporary Educational Psychology*, 25, 82-91.
- Zydny, A., Bennett, J., Shahid, A., & Bauer, K. (2002a). Impact of undergraduate research experience in engineering. *Journal of Engineering Education*, 91(2), 151-157.
- Zydny, A., Bennett, J., Shahid, A., & Bauer, K. (2002b). Faculty perspectives regarding the undergraduate research experience in science and engineering. *Journal of Engineering Education*, 91(3), 291 – 297.

APPENDICES

Appendix A
NASA organizational chart (National Aeronautics and Space Administration, 2007a)



Appendix B
Gender, Ethnicity, Major, and Classification of Students Interviewed from URCs project

Name	Gender	Ethnicity	Major	Year
Joseph	M	Black	Electrical Engineering	Junior
Kevin	M	Black	Biology	Junior
Kara	F	Black	Electrical Engineering	Senior
Erica	F	Black	Chemical Engineering	Senior
Mike	M	Black	Computer Engineering	Senior
Matthew	M	Black	Mechanical Engineering	Senior
Heather	F	Black	Mechanical Engineering	Senior
Jeff	M	Black	Chemical Engineering	Senior
Michelle	F	Black	Mechanical Engineering	Senior
Sean	M	Black	Mathematics	Senior
Brad	M	Black	Biology	Junior
Shannon	F	Black	Biology	Junior
Nick	M	Hispanic	Aviation Science Management	Senior
Mary	F	Black	Biology	Junior
Jacob	M	Black	Electronic Engineering Technology	Senior
Melissa	F	Black	Biology	Senior
Steven	M	Black	Biology	Senior
Grace	F	Black	Biology	Senior
Katherine	F	Hispanic	Mechanical Engineering	Junior
Elizabeth	F	Hispanic	Mechanical Engineering	Senior
David	M	Hispanic	Mechanical Engineering	Senior
Jessica	F	Hispanic	Mechanical Engineering	Senior
Max	M	Hispanic	Mechanical Engineering	Senior
Oscar	M	Hispanic	Mechanical Engineering	Senior
Charlie	M	Hispanic	Electrical Engineering	Senior

Appendix C

Interview Protocol

Background

- 1) What is your classification?
 - a. What is your major?
 - b. When is your expected graduation?

STEM

- 2) Why did you first develop an interest in STEM?
 - a. Did you have a mentor, teacher, or parent that encouraged you to pursue a STEM degree?
 - b. How was this individual instrumental in motivating you to pursue a STEM degree?
- 3) Can you discuss your plans to enter the STEM workforce or pursue an advanced degree in STEM?
 - a. What do you hope to accomplish by graduating with a STEM degree?

URCs project

- 4) How did you find out about the URCs project?
 - a. Did the brochures or other information distributed by NASA pertaining to the URCs project contribute to your decision to participate? How?
 - b. Did the information you received about the URCs project from NASA fulfill your expectations? Why/why not?
 - c. Was there anything specific that you did not receive that has changed your perspective about the project?
- 5) Has your participation in the URCs project been rewarding or beneficial to you? How?
 - a. What are the two most important skills you've learned as a participant in the URCs project?
 - b. Has the URCs project inspired you to complete your STEM degree? How?
 - c. Have you collaborated with other students pursuing STEM degrees during your participation in the URCs project? How?
 - d. Can you discuss how you've networked with STEM professionals during your participation in the URCs project?
 - e. Can you discuss specific factors about the URCs project that you might change to make it more effective?
 - f. What has been the most surprising piece of information about NASA that you've learned?

Self-efficacy

- 6) Can you describe any obstacles or challenges you've had to overcome during your participation in the URCs project?
 - a. Has there been a particular task assigned to you that you found especially difficult? How did you address this challenge?
 - b. Have you been encouraged to pursue your research interests by faculty? How?
 - c. Can you tell me about a time when you received support from a faculty member, or when you wanted support from a faculty member and didn't receive it?

Tinkering Self-Efficacy

- 7) Can you discuss some of the hands-on interactive activities you've participated in as a student in the URCs project?
 - a. Have those activities increased your self-confidence? Why/why not?

Technical Self-Efficacy

- 8) Can you discuss some of the activities you've participated in as a student in the URCs project that used technology?
 - a. Have those activities increased your self-confidence? Why/why not?