ABSTRACT

Shawn A. Moore, INCREASING AFRICAN AMERICAN ADVANCED STEM PROFESSIONALS: A CASE STUDY OF TWO PREDOMINANTLY WHITE FLAGSHIP UNIVERSITIES IN THE SOUTH (Under the direction of Dr. David Siegel). Department of Educational Leadership, November of 2017.

This qualitative multiple-case study explores how two select predominantly white institutions (PWIs) have learned to be successful in advancing undergraduate African-American students to advanced degrees in the life sciences. This study utilized an integrated theoretical framework developed from Birnbaum's (1988) cybernetic loop of institutional interaction and Marsick and Watkins's (2003) seven constructs of organizational learning. Semi-structured interviews were conducted with nine participants and informed by data from institutional profiles. These interviews produced six themes and four sub-themes that informed the following research question: How have interventions that influence African-American students to doctoral degrees in Life Sciences shaped select Predominantly White Institutions as learning organizations? Findings from this study revealed that the two PWIs behaved somewhat like a learning organization as characterized by Marsick and Watkins, but with some meaningful additions. Major thematic findings are as follows: (1) Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields; (2) Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way; (3) Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions; (4) Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses, and advocacy

increases morale; (5) Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability; and (6) Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs. The implications for theory and practice inferred from the findings include a new model for how certain higher education institutions operate as learning organizations and the processes and systems by which these select PWIs might evolve their campuses to be among the most successful in advancing African-American students to completing doctoral degrees in life science areas.

INCREASING AFRICAN AMERICAN ADVANCED STEM PROFESSIONALS: A CASE STUDY OF TWO PREDOMINANTLY WHITE FLAGSHIP UNIVERSITIES IN THE SOUTH

A Dissertation

Presented to

The Faculty of the Department of Educational Leadership

East Carolina University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education in Educational Leadership

by

Shawn A. Moore

November, 2017

©Copyright 2017
Shawn A. Moore

INCREASING AFRICAN AMERICAN ADVANCED STEM PROFESSIONALS: A CASE STUDY OF TWO PREDOMINANTLY WHITE FLAGSHIP UNIVERSITIES IN THE SOUTH

by

Shawn A. Moore

APPROVED BY:

DIRECTOR OF DISSERTATION:____

David Siegel, PhD

COMMITTEE MEMBER:____

Crystal Chambers, PhD

COMMITTEE MEMBER:____

Mary Farwell, PhD

COMMITTEE MEMBER:____

Alana Zambone, PhD

INTERIM CHAIR OF THE DEPARTMENT OF EDUCATIONAL LEADERSHIP:

____

Marjorie Ringler, EdD

DEAN OF THE GRADUATE SCHOOL:

____

Paul Gemperline, PhD

DEDICATION

Not many people are blessed to have their very own angel, right here on Earth. But I have been blessed to have mine, not only in name, but in Sprit. This dissertation is dedicated my wife, Angel Leigh Moore, for your love, patience and support. You are truly strength and grace.

ACKNOWLEDGEMENTS

First, I give thanks, praise, honor and glory to God. I thank Him for His never ending love, His grace, His mercy and His power through the Holy Spirit. Without the expression of God's love through His son Jesus the Christ, no accomplishment would be possible.

I want to thank and acknowledge the woman who has been everything to me. My wife, Angel. You have shown such support, patience, understanding, encouragement, and stamina throughout this process. You must have been Maya Angelou's muse when she wrote Phenomenal Woman. The words in that poem capture your very essence, highlighting your beauty, your intelligence, your confidence and strength. I also want to thank my daughter Kennedy for being so understanding when daddy is writing in his office instead to going to the park.

I want to thank my family for all of their love and support. To my Dad, Larry Moore, thanks for always believing in me and making me feel like I can accomplish any goal. To my brother Larry Allen and sister Sophia, my aunts, uncles, in-laws, nieces and nephews, Ann, Gail, Wanda, Glenda, Pinky, Johnny, Gary, Mr. Robert Moore and Mrs. Celestine Moore, Katrina & Bernard and family and Terri & Frank and Family, I love you all and thank you for your love, wisdom and support.

Thank you to my dissertation committee, Drs. David Siegel, Crystal Chambers, Alana Zambone and Mary Farwell, for all your patience, advice and guidance. Thank you to my extended College of Education family, and a special thank you to Dean Grant Hayes for your support. Also, thank you to Drs. Dan Dickerson, Len Annetta and Melani Duffrin for your support and encouragement. A special thank you to my Center for STEM Education Family, Cheryl, Ann, Lugenie, Michael, Anisha, Dylan, Cayla, Jana, and all other student workers, your support for me during this process was unmeasurable.

I would like to thank all my cohort members, for your support and encouragement. For those of you still in the process, keep moving forward! A special thank you to my dissertation writing group, Drs. Levy Brown, Katrina Ramsey-Arnold and the future Dr. Catrina Davis, thank you for your time, support, and prayers.

For anyone who may be reading this, I would like for you to recognize and appreciate that we all stand on the shoulders of those who have come before us and those who stand for us.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Overview/Background

For the United States to remain a leader in the global economy, higher education professionals are urged to recruit students from diverse backgrounds to study Science, Technology, Engineering, and Mathematics (STEM) subjects (Malcom, Chubin, & Jesse, 2004). In 2005, the U.S. Senate Committee on Energy and Natural Resources and the U.S. House of Representatives Committee on Science requested that the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine study the critical challenges that await the United States in order to sustain global leadership and remain competitive in science and engineering (Benderly, 2007). In response to pressures exerted by Congress, U.S. corporations, the national security community, and the global economy, the National Academies addressed the issue of U.S. competitiveness and identified strategies to keep the United States at the forefront of global innovation in a report entitled *Rising Above the Gathering Storm*. The report extensively documented the need to address global competitiveness. According to the Chair of the Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, Dr. Freeman Hrabowski, it did not, however, sufficiently articulate the severity of the need to increase diversity and inclusion in the areas of science and engineering to respond to our national interests (National Academy of Sciences, 2011).

As an impetus to create a more robust and diverse science and engineering workforce, U.S. Senators Edward Kennedy, Barbara Mikulski, Patty Murray, and Hillary Clinton asked the National Academies to investigate the condition of underrepresented minorities in the Science and Engineering enterprise (National Academy of Sciences, 2011). To solidify their commitment to addressing the need to increase diversity in the science and engineering areas, the U.S.

Congress included the National Academies' report in the 2007 America COMPETES Act. The National Academies' directive was to study the role and value of diversity in the STEM workforce, examine the frequency of change and the obstacles to creating a diverse workforce, and highlight and analyze successful and maintainable best practices (National Academy of Sciences, 2011). In 2010, President Barack Obama reauthorized the American COMPETES Act, as part of the National Science Foundation's Education and Human Resources Directorate. The directives for the education community were to support research essential to the nation's understanding of STEM teaching and learning, and how to increase underrepresented minority (URM) participation in STEM fields (AAU, 2013; America COMPETES Act, 2010).

To address the lack of URM students pursuing and completing degrees in STEM fields, federal agencies and special interest groups, just to name a few, established initiatives to substantially flood the STEM pipeline with a talented pool of students. Some examples include the establishment of federal grant programs like the Robert Noyce Teacher Scholarship Program to increase minority STEM teachers, the Ford Motor Company's minority STEM outreach collaboration with schools, and non-profit initiatives such as Great Minds in STEM, an organization aimed at increasing the number of Hispanics working in the the STEM enterprise. Initiatives like these are discussed in Chapter two of this study. According to the National Academies 2011 report on STEM Minority Participation, from 2002-2006, 54% of the top 25 institutions that were the most successful at matriculating URM students into doctoral degree programs in the natural sciences were predominantly minority-serving institutions (MSIs), Historically Black Colleges and Universities (HBCUs), and Hispanic Serving Institutions (HSIs) (National Academies, 2011). Approximately 46% of these top 25 institutions are predominantly white institutions (PWIs) (National Academy of Sciences, 2011). During the same reporting term, a closer examination of African American students pursuing doctorates in Natural Sciences and Engineering reveals that the majority of those students attended an HBCU for their undergraduate education. This study will focus on how two of the top PWIs, ranked 20th and 25th overall, responded to the need to increase the number of minority (particularly African-American) students pursuing an advanced STEM degree since the above charge of the America COMPETES Act of 2010.

Before the America COMPETES Act, there had been a long established history of national interest and initiatives that supported American innovation. For example, on October 4th, 1957 the Russian government launched the first successful satellite, Sputnik, into space, which injected a sense of urgency into the American education system. Since that time American leaders have been attentive to science and engineering, which are critical to the United States' economic competitiveness. In 1986 the Council on Competitiveness was established with a twenty-four member board of industry, academic, and labor leaders. This council is charged with the responsibility to keep the importance of American competitiveness in a global economy at the front line of our national awareness (Council on Competitiveness, 2008). In 2007 the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act, otherwise known as the 2007 America COMPETES Act, was signed into law. The goal of this law was to establish an all-inclusive plan to create strong science education and research enterprises, improve the nation's technology infrastructure, and prepare a talented and well-trained pipeline of workers for 21st Century training (Office of the Press Secretary, 2007). Despite the support from the federal government via research dollars in STEM and STEM Education and for-profit and non-profit support of STEM Education, the National Academy of Sciences report, Expanding Underrepresented Minority Participation: American's Science and

Technology Talent at the Crossroads, suggests that the problem of low minority representation in the STEM pipeline persists to this day. The Higher Education Research Institute has indicated that since the 1980s, URM students aspire to complete degrees in a STEM field at the same rate as their white and Asian counterparts; however, the completion gap between the two groups continues to widen, as URM students have lower completion rates (Herrera & Hurtado, 2011; National Academy of Sciences, 2011).

Today, the more immediate national concern regarding the STEM enterprise revolves around student performance against global benchmarks and competition for access to education. Over the past two decades, U.S. education performance in the areas of STEM fields has been progressively diminishing in comparison to its global competitors. In an international assessment among fifteen-year-old students, known as the Programme for International Student Assessment (PISA), U.S. students ranked 27th in math competency and 20th in science competency (OECD, 2012). A past study reported that U.S. students twenty-four years old were ranked 20th among students who earned degrees in natural science or engineering (Kuenzi, 2008). Interestingly, during the period between 1960 and 2000, the number of STEM postsecondary degrees awarded to U.S. students more than doubled. In the two years that followed, only 16% of postsecondary degrees awarded were from a STEM field (Kuenzi, 2008). In a January 2010 press release from the White House, President Obama outlined a plan to extend the Educate to Innovate campaign to promote excellence in STEM education (White House, 2010). In this initiative, Educate to Innovate established partnerships with public and private institutions and invested more than $250 million to train new and current teachers (White House, 2010).

Historically, the United States STEM workforce has been predominately male and ethnically white or Asian. More recently, a surge of international personnel has added another dimension to this demographic (National Academy of Sciences, 2011). According to the U.S. Bureau of Labor Statistics, the STEM workforce has more than five million employees and is projected to expand beyond any other sector in the years to come. However, America will be starting this era of progression with a demographic disadvantage (National Academy of Sciences, 2011).

Statement of the Problem

The U.S. Bureau of Labor Statistics states that the science and engineering workforce is the largest and fastest growing employment market, with more than 5 million participants and growing (National Academy of Science, 2011). As stated in the College Completion Agenda, authored by the College Board, the goal is to increase the proportion of 25 to 34 year olds who hold an associate degree or higher to 55% by the year 2025. This is critical in order for America to be the world leader in college degree completion (College Board, 2012). Accomplishing this will allow Americans to be more competitive in procuring those 5 million jobs. Also, the Lumina Foundation, via its Making Opportunity Affordable initiative, has established a goal to increase the proportion of the U.S. adult students who earn a post-secondary degree by 60% by the year 2025 (Lumina Foundation, 2009).

In 2010, over 5.5 million first degrees were awarded worldwide; 24% of those degrees were awarded to students from China, 17% were awarded to students in the European Union (EU), and 10% were awarded to students in the United States (Science & Engineering Indicators, 2014). Between 2001 and 2010, the number of first-time degrees in the United States increased by 30.8 %. In 2010, only 5% of the bachelor’s degrees awarded in the United States were in engineering, whereas 18 % was awarded throughout Asia (Science & Engineering Indicators, 2014). A discrepancy of this magnitude (a 13% difference) may affect global workforce competitiveness between America and other countries vying for the same sector of employment.

Demographically, the U.S. racial and ethnic configuration of students earning bachelor's degrees in science and engineering has increased since 2000, suggesting an increase in the general population as well as an increase in enrollment of URMs (Science & Engineering Indicators, 2014). However, this small movement of the needle has not made a significant impact on minority representation in STEM degree completion or STEM employment. This phenomenon is illuminated in a report indicating that African-American and Hispanic students aspire to major in a STEM discipline at the same rate as Asian American and White American students, but do not earn their first degree in a STEM discipline at the same rate (Herrera & Hurtado, 2011; National Academy of Sciences, 2011). This aspiration discrepancy has resulted in 62 % of African-Americans and Hispanics combined, versus 94.8 % of Asian-Americans and 86.7% of White Americans, who want to become scientists and engineers (National Academy of Science, 2011). In a 2011 National Academies report, only 3.3% of Native Americans and Alaska Natives, 2.7% of African-Americans, and 2.2% of Hispanic and Latino Americans 24 years of age had confirmed their first degree in a STEM field during the 2009 reporting year (National Academy of Science, 2011). Given the importance of maintaining global competitiveness and national security and perpetuating innovation, URM students represent a talent pool that has yet to be adequately developed (Burke & Mattis, 2007). In a more recent report by the National Science board of NSF (2016), it was calculated that for the reporting year 2013, 8.4% of African-Americans, 0.6% of Native Americans and Alaska Natives, and 9.9% of Hispanic and Latino Americans earned a bachelor's degree in science or engineering areas (National Science Board, 2016). This is a significant statistical increase in URM students with

STEM bachelor's degrees; however, it still is not competitive with the benchmark set by Finland, France, Taiwan, South Korea, and the United Kingdom as the top countries that produce science and engineering graduates (National Academy of Sciences, 2011). One caveat regarding the recent National Science Board report mentioned above is that this report only reports bachelor's degrees among U.S. citizens and permanent residents by race and ethnicity and does not make a distinction on the basis of age, degree category (such as associate degree), or traditional or non-traditional student type.

Very few PWIs have been successful at addressing the lack of URM in STEM. However, the 2011 National Academies report identified three southern state flagship universities as successful in advancing URMs to doctoral training in Life Sciences. The first step of this study is to identify the characteristics of these successful PWIs in order to explore the process by which these PWIs learned how to be successful. Currently, there are no syntheses of the successful factors these PWIs used to increase minority representation in STEM fields of study. This study will inform future research that can be used to validate and replicate effective organization learning practices to increase successful URM undergraduate students who advance to doctoral programs in the natural sciences.

Purpose of the Study

The purpose of this study is to investigate how select PWIs have learned to substantially increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Sciences. More specifically, this research will examine the relationship among academic leaders, faculty, and students that has led to interventions, the establishment of coalitions, and institutional support to address underrepresentation in Life Science areas. For this study, a framework that fuses Birnbaum's concept of the Cybernetic Loop and Marsick and

Watkins's dimensions of the learning organization will be utilized to inform the study. The objectives were two-fold: First, this study identified the combinations of factors select PWIs have utilized, those cited in the 2011 National Academies report, that are reported to be successful in advancing URM undergraduate students in STEM fields to doctoral training in Life Sciences. Second, this study examined how institutional change influences the PWIs as learning organizations.

The primary research question (RQ) guiding the study is: How have interventions that advance African-American students to doctoral degrees in Life Sciences shaped select Predominantly White Institutions as learning organizations?

Sub-questions are as follows:

SRQ1: In what ways and to what extent do Life Sciences departments exhibit the characteristics of a learning organization that influences their STEM environment to allow African-American students to advance to Life Sciences doctoral programs?

SRQ2: At what level (Global, Organization, Team, or Individual) has organizational learning and change occurred to propel African-American undergraduate students to doctoral programs in Life Sciences?

Theoretical Framework

This study is viewed through the contextual lens of open systems and focuses on the dynamic environments higher education institutions are influenced by, must respond to, and are dependent upon. The provisional theoretical framework (see Figure 1) for this study is an integration of Birnbaum's (1988) Cybernetic Loop of institutional interaction and Marsick and Watkins's (2003) seven constructs of organizational learning. This framework aims to describe how higher education institutions, as learning organizations, navigate in an ever-mutable

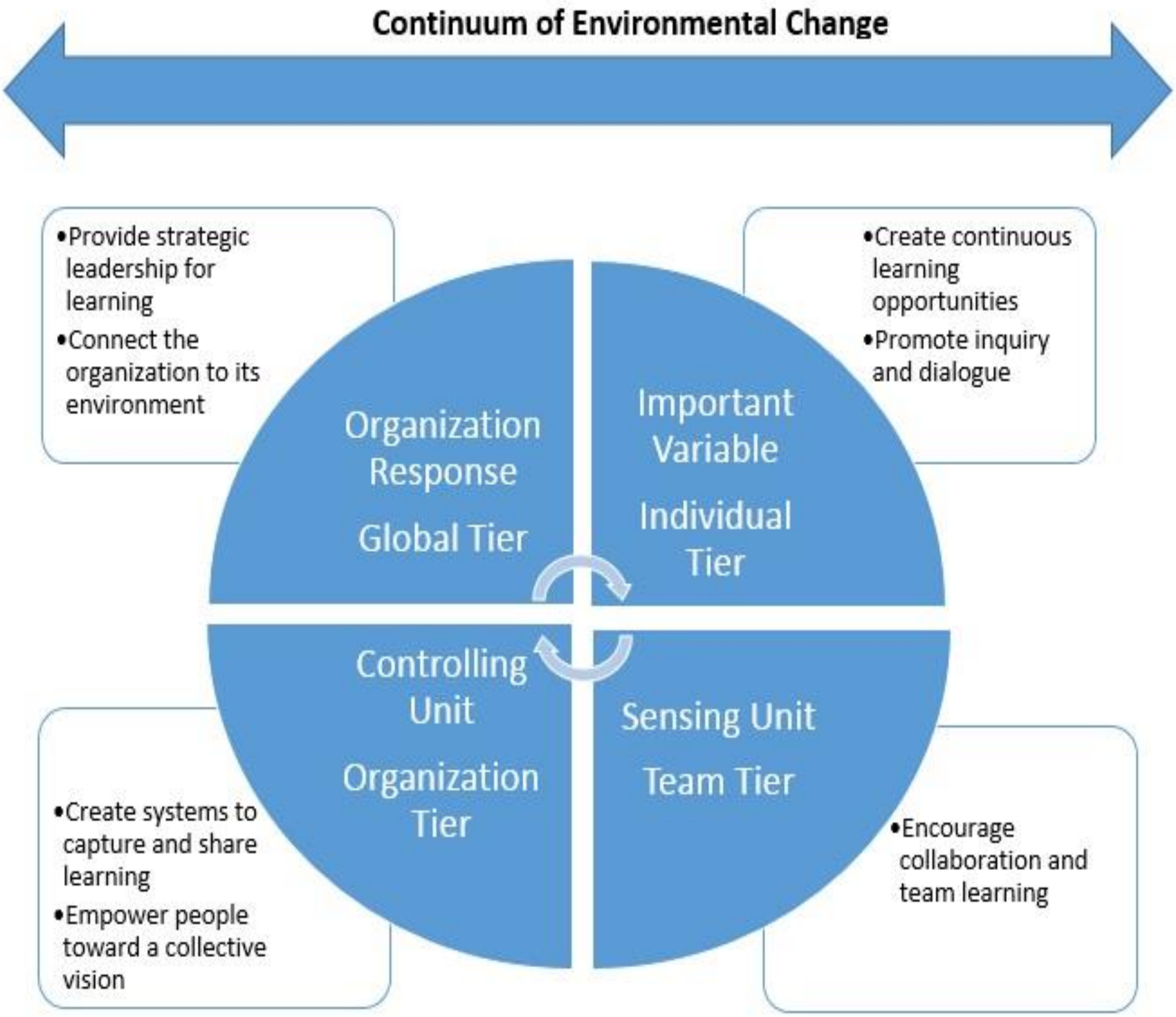

Figure 1. Theoretical Framework.

environment within the cybernetic process. Birnbaum (1988) sees higher education institutions as cybernetic, a system whose operations are governed by vertical feedback mechanisms that are fortified by the institution's structure and horizontal feedback mechanisms embedded in its social scheme. Birnbaum describes the cybernetic process as a casual loop, where the process of institutional change begins with some change in the external or internal environment that changes the value of some variable. This variable is being examined by formal or informal coalitions, or what Birnbaum refers to as the "sensing unit." Once the sensing unit detects the variable outside of normal limits, the coalitions attempt to influence the administration, which Birnbaum refers to as the "control unit," in order to change the organization's response to moving the variable back to acceptable levels. This study theorizes that universities, operating like Birnbaum's cybernetic organizations, will learn to continuously transform themselves with a proactive systemic approach that activates growth for individuals, teams, various groups, the organization itself, and the broader community, in order to become a network (Marsick & Watkins, 2003). Marsick and Watkins (2003) established seven constructs that define a learning organization: (1) Create continuous learning opportunities, (2) Promote inquiry and dialogue, (3) Encourage collaboration and team learning, (4) Create systems to capture and share learning, (5) Empower people toward a collective vision, (6) Connect the organizations to their environment, and (7) Provide strategic leadership for learning. Combining these two institutional paradigms allows for a clearer explanation of the phenomenon of PWIs advancing URM students to doctoral degrees in life science areas. Therefore, this framework aligns the sequence of the cybernetic process with the level of engagement of learning within an organization and their corresponding learning constructs.

The Cybernetic Organization

The hallmark of Birnbaum's theory is a description of higher education institutions as loosely coupled open systems (Birnbaum, 1988). The Open Systems Model (OSM) became popular after World War II, a period in which scholarly excitement began to flourish (Scott & Davis, 2007). Boulding (1956) views open systems as being proficient in self-maintenance that is dependent on a flow of resources from the environment, much like a living cell. In other words, these systems rely on the exchange of resources that are available parts of its ecosystem in order to survive. Open systems have also been described as entities that influence their environments and are concurrently influenced by their environments (Hall, 1972). However, Scott and Davis (2007) have argued that viewing open systems as self-maintaining is inaccurate, because an organization needs its environment for survival. Birnbaum (1988), however, asserts that no particular organization existing in an open system solely utilizes one paradigm of operation; rather, multiple paradigms are actively engaged at various levels and according to different arrangements. Birnbaum (1988) proposed four models of organizational function: the Collegial model, where individuals share authority and significance in a population of counterparts; the Bureaucratic model, where institutions have particular structures and parameters for decision-making; the Political model, where institutions contend for resources and control; and the Anarchical model, where institutions are described as problematic, have ambiguous technology, and yet have fluid participation in an environment where independent actors strive to find importance in their community and make decisions. The aforementioned models collectively make up the Cybernetic model, which allows for institutions to auto-regulate in order to engage in institutional change or bring the institution back to an acceptable level (Birnbaum, 1988).

The Learning Organization

Learning organizations are entrenched in a perpetual learning progression within their structure and have a heightened aptitude for change or transformation (Watkins & Marsick, 1993). Given this description of a learning organization, Watkins and Marsick framed their perspective of a learning organization around seven dimensions or behaviors, and they are described in Table 1. There are four levels where the seven aforementioned learning organization constructs operate: the individual, the team, the organization, and global or societal levels. Learning at the individual level occurs when a disconnection, inconsistency, nuance, or dispute leads to reply (Marsick & Watkins, 2003). Teams learn collaboratively in order to observe a change in the environment from various perspectives (Marsick & Watkins, 2003). Learning at the organizational level is characterized as a collective activity, using technology and developing systems and processes to aid in decision-making (Marsick & Watkins, 2003). Learning at the global or societal level affects the entire enterprise and the community, and leaders promote the progression of their organization (Marsick & Watkins, 2003).

Significance of the Study

To address the issue of deficiency of URM students completing STEM degrees, and to increase diversity in general, it has been suggested that the higher education enterprise respond with a comprehensive approach to change (National Academy of Sciences, 2011). According to the National Academies, higher education institutions should do the following: Develop a campus climate that holds diversity and inclusion as a top priority, determine the current institutional diversity climate, and develop and evaluate a plan to systematically implement academic and social change (National Academy of Sciences, 2011). In regard to advancing diversity in STEM, and to aid higher education institutions in accomplishing the previously

Table 1

Descriptions of Constructs for Dimensions of the Learning Organization

Construct	Description
Create continuous learning opportunities	Learning is designed into work so that people can learn on the job; opportunities are provided for ongoing education and growth.
Promote inquiry and dialogue	People gain productive reasoning skills to express their views and the capacity to listen and inquire into the views of others; the culture is changed to support questioning, feedback, and experimentation.
Encourage collaboration and team learning	Work is designed to use groups to access different modes of thinking; groups are expected to learn together and work together; collaboration is valued by the culture and rewarded.
Create systems to capture and share learning	Both high-and-low technology systems to share learning are created and integrated with work; access is provided; systems are maintained.
Empower people toward a collective vision	People are involved in setting, owning, and implementing a joint vision; responsibility is distributed close to decision making so that people are motivated to learn toward what they are held accountable to do.
Connect the organization to its environment	People are helped to see the effect of their work on the entire enterprise; people scan the environment and use information to adjust work practices; the organization is linked to its communities.
Provide strategic leadership for learning	Leaders model, champion, and support learning; leadership uses learning strategically for business results.

Note. (Adopted from Marsick & Watkins, 2003).

mentioned approaches, many federal sponsored programs have been designed, deployed, and assessed, such as the Louis Stokes Alliances for Minority Participation (LSAMP) and the Alliances for Graduate Education and the Professoriate (AGEP), whose mission is to increase the number of URM students who complete undergraduate and graduate degrees in a STEM field. In addition, many predominantly white institutions (PWI) and minority serving institutions (MSI) have acquired federal funding to provide fiscal support for URM STEM students. Programmatic initiatives, undergraduate research, and the establishment of mentor relationships have been incorporated or developed (National Academy of Sciences, 2011). Given that the issue of representation in STEM fields has been highlighted since the early 1980s, the gauge on the URM student STEM pipeline has not markedly moved in a positive direction. Research that has addressed how institutions respond to STEM degree completion by URM students, or lack thereof, has been in the realm of student preparedness, recruitment of top faculty, and the degree of investment acquired by an institution (Agasisti & Johnes, 2007). However, these studies do not sufficiently address how URM students, particularly African-American students, have been successful at completing STEM degrees at PWIs and moving on to advanced study in STEM.

Overview of the Methodology

This study utilizes a multiple-case study approach to determine how select PWIs have learned to be successful at advancing undergraduate African-American students to doctoral degrees in Life Sciences. First, this study will illuminate factors, those outlined in Chapter 2, that are impactful in supporting African-American undergraduate students in pursuing doctoral degrees in the life sciences at two select southern Flagship research universities. To establish an inventory of activities that these PWIs engage in, data were collected by reviewing the universities' websites, archives, and other available documents. These data were collected from state and federal databases. Numeric scores were assigned to describe what initiatives or interventions the sample universities have established or implemented. Primary data were obtained by conducting semi-structured interviews with Life Science departments' leaders and faculty. Pre-codes were determined using Marsick and Watkins's (2003) seven constructs of the Learning Organization, within the context of Birnbaum's (1988) Cybernetic Loop of institutional interaction. Emergent codes were also documented during the course of the research.

Definition of Terms

For the purpose of this study, the following terms are defined:

Underrepresented Minority (URM) - People who include African-Americans, Mexican-Americans, Native Americans (American Indians, Alaska Natives, and Native Hawaiians), Pacific Islanders, and mainland Puerto Ricans (Johns Hopkins School of Medicine, Retrieved from http://www.hopkinsmedicine.org/Medicine/diversity/urm_definition.html).

African-American students- People having origins in any of the Black race groups of Africa (U.S. Census, 2000).

Predominately White Institution (PWI) – Describes a higher education institution where at least 50% or more of its enrolled students are White.

STEM – An acronym that stands for science, technology, engineering, and mathematics. For the context of this study, STEM represents the academic discipline of the natural sciences and mathematics (U.S. Department of Education, National Center for Education Statistics, 2016).

Life Sciences – Fields and subfields of scientific study that include Biology, Environmental Biology, Medicine, and Agriculture (National Science Foundation, Retrieved from http://www.nsf.gov/statistics/fedfunds/pubs/dst42/technote/fields.htm).

Assumptions, Limitations, and Delimitations

As this study depends on data from universities' websites and archives, as well as from National Science Foundation databases, there is an assumption that the information collected from these sources is accurate. Moreover, study participants have their own experiences and biases that have shaped their opinions on underrepresentation in STEM fields of study, and it is assumed that they have provided accurate and honest responses to interview questions.

This study also has limitations and delimitations. The study is limited by data and other disclosed public information accessible via websites or other public documents. This study is delimited by its interest in Life Science fields of study, thereby excluding other disciplines within the STEM areas. Further, the study only investigates two of the top 13 PWIs that have been successful in matriculating African-American undergraduate students to PhD programs in the Life Sciences. These two PWIs are southern flagship institutions with associated schools of medicine.

Summary

This study explores how the establishment of interventions described in the literature influences select PWIs as learning organizations. The organization of this study consists of a review of the pertinent literature involving American competitiveness, the condition of the diversity in the STEM enterprise, and the foundations of organizational learning, all highlighted in Chapter 2. A multiple case study approach is utilized in this study, which is described in Chapter 3. The results of the study will be presented in Chapter 4, and the implications of the study will be featured in Chapter 5.

For higher education to address the shortage of STEM talent in the pipeline of the STEM enterprise, universities must find the most effective ways to increase completion of advanced

STEM degrees. It is imperative to understand how successful institutions have learned to provide an environment where aspiring URM STEM students can matriculate to advanced STEM study. It is important that universities show how they can better serve URM STEM students, as the numbers who succeed in STEM majors are very dismal. Developing this underrepresented population to become part of the STEM workforce and advancing STEM scholarship will be critical in maintaining America's lead in the science and engineering global economy.

CHAPTER 2: REVIEW OF LITERATURE

In conceptualizing and contextualizing the environment and processes of producing successful URM students that advance in academic STEM fields of study, this chapter will describe the pertinent literature and theoretical foundations related to URM students' experience and success, as well as organization theory. Furthermore, this chapter will highlight, synthesize, and analyze quantitative and qualitative research on various aspects dealing with underrepresented minority (URM) students in the Science, Technology, Engineering, and Mathematics (STEM) environment. For the purpose of this study, URM students are defined as those who identify themselves as African-American or Black, Hispanic or Latino, Native American, Asian-American, or female.

Revisiting the STEM Pipeline

Over a 30-year period, the education community has made strides towards addressing the significant lack of students, particularly URM students, who aspire to complete a degree in a STEM field. These strides, however, have been underwhelming (Allen-Ramdial & Campbell, 2014). The popular 15-year-old metaphor that has been used to describe and explain this phenomenon, the STEM "leaky" pipeline, has been used to identify inadequacies in participation and achievement in STEM areas (Allen-Ramdial & Campbell, 2014; Cannady, Greenwald, & Harris, 2014), and has been used as a framework to develop and implement education policies (Allen-Ramdial & Campbell, 2014; Cannady et al., 2014). This illustration describes a story of the loss of potential STEM students, who, at the beginning of their secondary education career, had a possibility to enter the STEM workforce. This representation suggests checkpoints of successional measures with the goal of ensuring successful employment in the STEM workforce (Cannady et al., 2014). Two presumptive underpinnings are the foundation of the pipeline metaphor, and they are as follows: (1) Each measure is essential, and (2) the summation of all measures is adequate to enter the STEM workforce (Cannady et al., 2014). In spring 2001, there were 4,012,770 high school freshmen with a possibility of entering the STEM pipeline; however, that number drastically reduced to a projected 166,530 students who graduated with a post-secondary degree in a STEM field (NCES & Science and Engineering Indicators, 2008). During that era, only 7.3% of the projected 166,530 STEM graduates were from an underrepresented group (Planty et al,, 2008). However, some have challenged the pipeline metaphor's impact and translation to the STEM workforce, particularly as is relates to URM students. One team of researchers concluded that the pipeline metaphor reduces to bare bones the degree of intricacy involved in becoming a STEM professional and offers no explanation for the dynamic nature of STEM career progression (Cannady et al., 2014). Another criticism of the pipeline metaphor is that it lacks the ability to fluidly react to the dynamic skill-set needs of the STEM workforce and inadequately describes the diverse career environment that STEM professionals inhabit (Cannady et al., 2014). In an effort to thoroughly comprehend the progression of the STEM pipeline metaphor, another group of researchers redesigned the pipeline metaphor to a vertical construction that is influenced by the laws of physics. Students in the vertical pipeline are influenced by downward forces, such as insufficient mentorship that resists the upward flow of STEM student advancement and leading to attrition (Allen-Ramdial & Campbell, 2014). This redesign illustrates that the greatest barrier to STEM student persistence happens at the undergraduate-to-graduate interface, highlighting a necessary continuous upward force of initiatives in order to preserve STEM diversity and persistence (Allen-Ramdial & Campbell, 2014).

STEM Workforce and Economic Development

The U.S. Bureau of Labor Statistics states that science and engineering are the largest and fastest growing economic sectors in the world. Even though the data on URM who are pursuing a career in a STEM field show gains, there still remains much advancement to be made in diversifying the STEM enterprise (National Academy of Sciences, 2011). In 2005, the non-academic, baccalaureate-educated science and engineering workforce was composed of 5.1% African-Americans and 5.2% Hispanics. This was during a time when African-Americans and Hispanic-Americans made up 11% and 14% of the population, respectively (NCES, 2006). This paints a challenging picture for American competitiveness, as maintaining our competitive superiority will become increasingly exigent as the global economy demands tremendous enhancements in STEM education (Honda, 2008). Historically, America has been the leader in introducing the greatest numbers of engineers into the global economy; however, since 2004, China has transcended the US in the realm of information technology exports, and it has been estimated to equal the U.S. economy by 2041 (NSF, 2005). One way to increase the numbers of individuals who are pursuing a degree that will allow them to become part of the STEM workforce is to tap into the URM talent pool. In order to meet demands to sustain the future of the STEM workforce in America, to encourage global economic competitiveness, and to advance America's unique creativity, it is critical to prepare, support, and develop URM students who aspire to obtain a STEM education and become part of the STEM enterprise (NSF, 2005).

Data have been collected to illustrate the relationship among global economic representation and students earning degrees in STEM fields. In 2010, over 5.5 million first degrees were awarded across the world; 24% of those degrees were awarded to students from China, 17% were awarded to students in the European Union (EU), and 10% were awarded to students in the United States (Science & Engineering Indicators, 2014). Interestingly, during the time period between 2001 and 2010, the number of first-time degrees in the United States increased by 30.8%. During the time period between the years 2000 and 2010, the majority of first-time degrees in science and engineering were awarded to students from China, Taiwan, Turkey, Germany, and Poland (National Academy of Sciences, 2011). In 2010, only 5% of the bachelor's degrees awarded in the United States were in engineering, whereas 18% was awarded throughout Asia (Science & Engineering Indicators, 2014). Demographically, the racial and ethnic configuration of students earning science and engineering bachelor's degrees has increased since 2000, suggesting an increase in the general population and the increase in enrollment of URMs (Science & Engineering Indicators, 2014). Adding to the evidence of improvement, in 2010 the United States substantially increased the numbers of doctoral-trained graduates in Science and Engineering; producing more than China, Russia, Germany, and the United Kingdom. Moreover, in 2011 URMs constituted 12% of students enrolled in graduate science and engineering programs, while Asians and Pacific Islanders make up 6%, as compared to 47% of white students (Science & Engineering Indicators, 2014).

To increase participation and success of URMs in STEM fields of study, higher education institutions should develop sustainable and comprehensive efforts to impact recruitment, retention, outreach activities, and research activities (National Academy of Sciences, 2011). American higher education's ability to develop and nurture such an environment has been the envy of the world's educational systems, especially in the myriad of fields in science and medicine. However, as previously stated, U.S. school performance in STEM fields has been steadily declining. The Center for Institutional Data Exchange & Analysis also states that the rates of science baccalaureate completion for URM students are dismal: 24% of African

American, Latina/Latino American, and Native American students take six years to complete a science bachelor's degree, compared to 40% of White Americans (Center for Institutional Data Exchange and Analysis, 2000).

URM STEM Aspirants

College Readiness

Towards the end of the junior and senior years in American high schools, many students are preparing to take the next step in their lives by organizing a formula to enter post-secondary institutions. Studies have shown that a rigorous high school curriculum, competitive entrance exam scores, and earning high grades in high school course work contribute to undergraduate degree completion (AAAS, 2001; Chang, Cerna, & Saenz, 2008; National Academy of Sciences, 2011). One phase in that formula is preparation for college entrance exams. One of the most influential factors in URM STEM student persistence and retention is attributed to pre-college preparedness (Barton, 2003). Partnerships between school districts and postsecondary institutions are the most frequent partnership model in preparing high school students for college (NCPR, 2012). In a briefing by the National Center for Postsecondary Research (NCPR, 2012), it was found that institutions that exchange information and other resources may be enhanced to improve student outcomes, to exchange best practices, and to develop and environment of exchange between faculty (NCPR, 2012). However, student success on those exams illustrates a demographic achievement gap. A series of research investigations on subjects who were deemed scholastically primed for a STEM major sought to find the link between success in STEM majors and mathematics Scholastic Aptitude Test (SAT) scores. Over a period of four years, researchers followed 335 students majoring in a STEM field at colleges and universities, where all participants scored 650 or above on the mathematics portion of the SAT to ensure that all participants were capable of high performance in a STEM major (Seymour & Hewitt, 1997). Using qualitative methods, the researchers concluded that 25% of the participants changed from a STEM major to a non-STEM major, with students asserting that they felt underprepared for majoring in a STEM field (Seymour & Hewitt, 1997). This change from STEM major to non-STEM major was apparent with URMs, where the researchers reported that 50% of African-American and Native American students, and approximately 66% of Hispanic/Latino students, changed from a STEM major to a non-STEM major (Seymour & Hewitt, 1997). The majority of ethnic minorities and women students in the study did not successfully complete their intended STEM degree but changed their majors (Seymour & Hewitt, 1997). In other words, over half of all URMs who aspire to complete a degree in a STEM field do not and have the propensity to change their major. This research prompts attention to structural barriers within organizations that contribute to the lack of preparedness for standardized college entrance exams, specifically those barriers that traditionally affect URMs, such as financial capabilities for test preparation programs. In 2009, the average SAT score in critical thinking was 501; in mathematics, the average score was 515; and the average score on the writing portion of the SAT was 419. However, the greatest amount of variance between these categories of scores was seen among different ethnic groups (National Academy of Sciences, 2011). The widest margin was between Asian American and African American students, where the average SAT scores were 1623 and 1276, respectively (National Academy of Sciences, 2011). In addition, African American students had the lowest average combined mathematics and critical thinking scores (reported at 855), and Caucasians had an average combined mathematics and critical thinking score of 1064 (National Academy of Sciences, 2011).

Besides college entrance exams, it has been widely reported that students who are enrolled in more advanced high school mathematics and science courses tend to persist in STEM majors. It was reported that decreased enrollment in advanced placement (AP) courses in mathematics, biology, chemistry, physics, and calculus was substantially higher among African American students, and contributed to the lack of STEM degree completion (Elliott et al., 1996). In a more current publication, it was determined that in spite of the increasing numbers of URM students enrolling in AP courses, they continue to have inadequate education services and do not perform well on AP exams (College Board, 2010 & National Academy of Sciences, 2011). The 2009 graduating class of U.S. public schools consisted of 14.5% of African Americans; however, they only represent 8.2% of those who participated in AP exams. Hispanic Americans made up 15.9%, and only 15.5% of them participated in AP exams (College Board, 2010). In 2009, the only group whose percentage of students taking the AP exams were higher than the total percentage of students in the graduating class was Asian American, at approximately 10% and 5%, respectively (College Board, 2010).

Access

Our country's competitive advantage in science and engineering among the rest of the world has been established by way of talented baccalaureate recipients who majored in a STEM field. To increase ethnic and gender diversity in the science and engineering workforce, employers look to talented and successful URM who completed a STEM degree (National Academy of Sciences, 2011). During a 31-year period between 1976 and 2008, the National Center for Education Statistics (NCES) reported that Asian American students were the fastest growing population of undergraduate enrollment in STEM areas, growing from 169,000 students to 1,118,000 students (NCES, 2010). Hispanic American student enrollment grew from 353,000 to 2,103,000, American Indian student enrollment grew from 70,000 to 176,000, and African American student enrollment grew from 943,000 to 2,269,000 (NCES, 2010). The aforementioned statistics paint a deceptive picture; even though significant enrollment increases occurred in all ethnic groups, there has been no growth in the numbers minority students who are obtaining degrees in STEM. Also, those URM students who do aspire to major in a STEM field do not complete their degree at the same rate as their Caucasian and Asian counterparts over a four and five year completion period (National Academy of Sciences, 2011).

Affordability

One major factor that affects most students' pursuit of and access to higher education is the total cost of a college education. In a review of a national program aimed to increase the numbers of minority students entering STEM fields and moving onto the professoriate, it was reported that financial support had a positive impact on student persistence in their degree aspiration (Clewell et al., 2005). This factor is exacerbated when dealing with URM students who aspire to earn a STEM degree, as this will directly affect the pipeline of graduate students and professionals who will be expounding their knowledge base or entering the STEM workforce. This is evident when exploring the available financial incentives and targeted scholarships developed to increase representation in STEM fields, as higher education has been called to enter the legal system to justify its practices (National Academy of Sciences, 2011). The federal court cases Regents of the University of California versus Bakke, Hopwood versus Texas, Johnson versus Board of Regents, and Gratz versus Bollinger are court proceedings that dwelt with race and ethnicity in college admissions processes. These cases were landmark decisions that impacted the admissions of URM students, as well as financial aid and scholarships. Coleman (2002) expressed the dynamics of this issue with the following remarks:

> While critically important for those selective institutions that consider race as part of the admissions process, the affirmative action issue in financial aid has significance and potential impact that extends beyond the question of admission. First, minority students are more likely to come from low-income families. As a result, for most of these students, the availability of financial aid is a significant factor affecting their ability to go to college. Second, at a time of increasing national diversity, and with the recognition that we can leave no child behind; we face the prospect that by not providing the necessary financial aid supporting college and university attendance, college campuses will be mission 800,000 otherwise qualified minority students between now and 2015, with the commensurate losses of billions of dollars to the national economy. (p. 73)

Given the aforementioned importance of financial support to URM students pursuing a STEM degree, the issue of affordability of a post-secondary education has been a topic of discussion since World War II and the inception of the Servicemen's Readjustment Act of 1944, more commonly known as the Government Issue (G.I.) Bill. However, today the primary source of financial aid comes from scholarships, grants, and loans. Much criticism has been focused on the increased cost of tuition for most public undergraduate institutions and some private institutions (National Academy of Sciences, 2011). The counter argument from college administrators has been that the cost of tuition has increased while the amount of state funds has consistently decreased (National Academy of Sciences, 2011). One way to support URM students who aspire to complete a degree in a STEM field has been by embedding a financial aid incentive in STEM programs. Most need-based and merit-based aid is managed by federal, state, and institutional mechanisms; most financial support for STEM-based programs has come from the federal government, with institutional supplementation (National Academy of Sciences, 2011). College degree completion in STEM fields has been positively correlated to student financial support (NCES, 2000).

Diversity in STEM: Social Context

University Diversity

To better understand and address the need to study and create diverse academic environments, colleges and universities develop policies and procedures to reduce inequalities and to establish inclusive campuses (Iverson, 2007).

URM Student Engagement

An accumulation of behavioral and social elements can contribute to the acceleration or the inhibition of URM achievement (Hurtado et al., 2007). One study reported that not only does the overall competitiveness of being immersed in a scientific or research environments affect the degree to which students connect, but students must also come to terms with the cultural stereotypes and social stigmas that exist in a diverse society (Fries-Britt, 1998; Hurtado et al., 2009). Many URM students must find ways to rationalize the societal shame of poor academic execution particularly when they are the only minority students in a science course, which is a common dynamic in many STEM classrooms (Hurtado et al., 2009). To substantiate this STEM cultural phenomenon, one study highlighted that URM students who were enrolled at PWIs were more likely to describe feelings of segregation, or thoughts that the campus culture was not hospitable to their presence. These feelings were amplified throughout their tenure, which increased their probability to separate from the institution (Loo & Rolison, 1986). In a study conducted by Schuman, it was reported the URM experience a loss of enthusiasm to enhance their academic circumstance, a feeling many URMs encounter while operating in an environment where they are rarely well represented (Schuman, Steeh, Bobo, & Krysan, 1998). Even though the aforementioned evidence paints a disheartened situation of URM students in STEM environments, contemporary research has revealed that the situation is much more complex than unmotivated students, but more frequently catalyzed by occurrences of social stigma. To provide additional evidence, URM students participating in the classroom, laboratory, or other environments where they are one of few minorities can affect those students' academic self-confidence and performance (Hurtado et al., 2009).

Campus Climate

A study by Seymour and Hewitt (1997) further implies that URM students have a greater likelihood of performing at lower levels as compared to their non-URM counterparts; this is primarily due to an uninviting campus climate accompanied by campus disengagement. The existence of an uninviting campus climate has been identified as a factor in poor performance and high attrition for students enrolled in what are known as gatekeeper courses in the STEM curriculum. Seymour and Hewitt also discovered that when students have "shameful" occurrences, like the lack of linking lecture material in a laboratory setting, or when they perform inadequately in gatekeeper courses, they often change their major, enroll in another institution, or separate themselves from higher education in its entirety (Seymour, 2001). To support this idea, it was concluded that failures in gatekeeper courses may lead to diminished achievement in impending courses, which has been correlated to changing from their intended STEM majors (Labov, 2004). Generally, introductory science and mathematics courses are designed to focus on rudimentary knowledge and fact achievement, while overlooking the necessity to develop critical thinking, problem solving, and scientific literacy, which are necessary to thrive in STEM programs (Handelsman et al., 2004). High attrition rates in gatekeeper courses have been linked to large student-to-professor ratios, a deficiency in engaging teaching methods, and intensified competition among students (Handelsman et al., 2004; Seymour & Hewitt, 1997). However, by reinforcing URM students' academic self-concept and involving them in undergraduate research experiences, students have shown a substantial increase in persistence and degree completion in STEM fields of study (Chang et al., 2014).

URM Student Academic Persistence

Studies have identified that active participation in the learning process positively affects the persistence of STEM students (Treisman, 1992). One study suggested that African American students performed at higher levels when participating in small study groups. Observation was the method to determine the study behaviors of African American students who were performing very poorly in mathematics course, and were compared to the academic behaviors of Asian American students, who were commonly performing well in the course. It was found that Asian American students have a tendency to study more in groups, where African American students are more inclined to study isolated from others (Treisman, 1992). A common instructional method that is frequently used in universities is the large-scale lecture in high volume lecture halls for gatekeeper science courses. This method is not very conducive to an active and engaging learning environment. The link between student learning and a positive and engaging learning environment has been extensively investigated. Knight and Wood (2005) conducted an experiment observing two terms of an advanced biology course. In term one, the mode of delivery was the traditional lecture method, and during term two, the mode of delivery incorporated cooperative learning practices, in addition to problem solving activities. The students' scores on pre-tests and post-tests were compared from the beginning until the end of each term, respectively (Knight & Wood, 2005). Students who participated in the cooperative learning environment experienced increased learning as compared to students who took part in the traditional lecture learning environment (Knight & Wood, 2005). In a large-scale quantitative study, it was found that in excess of 4,300 STEM students at a large four-year public post-secondary institution displayed a substantial positive correlation between co-op engagement and STEM degree completion (Jaeger et al., 2008). Ingrained in the body of literature is the notion that collaborative learning offers students the opportunity to exchange innumerable and diverse viewpoints pertaining to problem solving, as well as liberates students' awareness of different information sources and how to use this novel information to validate making a choice on a particular resolution (Smith, Sheppard, Johnson, & Johnson, 2005). However, as previously mentioned, URM students, particularly those pursing a STEM degree, feel isolated. Given this notion, it is often challenging for URM STEM students to take full advantage of the cooperative learning experience and small group study.

The URM Student Experience

The student development model established by Fleming (1984) has shown that experience with prejudice and discrimination on college campuses can drastically affect African American students' academic performance and reasoning skills. This phenomenon can also alter their cognitive development (Chang, 2009; Fleming, 1984). In a similar study, it was found that URM students' academic performance and persistence, factors such as student self-concept, coming to terms with racism, and coping abilities to deal with racism are all more influential than scholastic aptitude (Tracy & Sedlack, 1985). This correlation among racism, discrimination, and behavioral coping is reinforced by another study where the researchers found that racism and discrimination on college campuses is a factor that contributes to the heightened intensity of psychological and sociocultural apprehension suffered by URM students', which may retard or impede their acclimation to the college environment (Smedley, Myers, & Harrell, 1993). These events have the possibility to procreate sentiments of low self-worth and disregard. This claim is substantiated by a study that reported that students who have experienced harmful racial incidents are more likely to have inferior achievement in maneuvering within an academic lexicon during their freshman year of college, as compared to their White counterparts (Hurtado et al., 2007). Other studies have exposed factors aside from biases that can negatively affect URM students' performance in college. A study by Nora and Cabrera (1996) analyzed factors such as academic performance, familial support systems, cognitive improvement, and increased socialization, all having a greater effect than racial prejudice.

The Role of Faculty Members in URM STEM Development

Many in the academic enterprise believe that faculty members are the university's lifeblood, not to mention its advisors and mentors. However, in scientific fields such as engineering and biotechnology, URM faculty members are scarce, and in some STEM fields, non-existent. Faculty members in the STEM disciplines have a tradition of being perceived as cold, disengaged elitists who care only about their research (Seymour & Hewitt, 1997). One study found that the most commonly reported faculty grievance by students who persisted in their STEM program by or those who changed their major was inferior instruction, at 73.7% and 90.2%, respectively (Seymour & Hewitt, 1997). The popular Nelson (2007) study described how URM and female faculty members at research institutions are significantly underrepresented in science and engineering. This study also identified both benefits and vulnerabilities for various academic disciplines. The purpose was to create policies, acquire resources, and adopt a culture that would develop an environment and advance a set of best practices in order to address the issue of underrepresentation in the academy (Nelson, 2007). Data were collected via surveys of the top 100 departments, composed of fifteen science and engineering disciplines, using the amount of research funding as a metric (Nelson, 2007; NSF, 2004). It was revealed that URM U.S. professors are significantly fewer than the number of minority individuals found in the general population (Nelson, 2007). In other words, the percentage of URM faculty members in STEM fields was not proportionate to the percentage of URM citizens found in the general population, which is known as a disparity. It is problematic for an organization not to be representative of a community. This can be framed by Resource Dependence Theory wherein organizations need to look to the general population, or the social environment, in order to develop and encourage URM students to progress to the professoriate if gains in minority representation are to be made (Pfeffer & Salancik, 1978). Between the years 1986-1996 and 1996-2005, there was an increase of 2.5% in URM PhD recipients (Nelson, 2007). Specifically, in 2005 there was 3.0% representation among Black PhD recipients in biological sciences, but only 1.8% representation among Black assistant professors in biological sciences for fiscal year 2007 (Nelson, 2007). The representation of Hispanic PhD recipients in biological sciences obtaining an assistant professorship in fiscal year 2007 was slightly higher at 4.3% for Hispanics than for Blacks, at 4.3% (Nelson, 2007). The study also indicates that this trickle of URM through the professoriate pipeline may be due to a discrepancy in the amount of baccalaureate recipients completing the road to PhD programs (Nelson, 2007). In a general observation, Hispanic professors were more represented than Black professors in ten of the fifteen disciplines studied (Nelson, 2007). A substantial disparity among Hispanic and Black assistant professors may be attributed to the rising Hispanic population; in fact, the U.S. Census Bureau in 2009 reported that there were 48.4 million Hispanics in the US, making this ethnic group the largest minority group in the US. The result of such underrepresentation, particularly in the STEM fields, has presumably contributed to the decrease in productivity in science and engineering.

NSF (2010) reported that students from the top three countries that produce U.S. science and engineering doctoral degrees – those from China, India, and South Korea – have consistently been part of the US. STEM enterprise. Resource dependence theory would conclude that in order for the U.S. science and engineering industry to thrive, organizations must look to the available pool of future professors and recent professors to plug the leaky pipeline. According to resource dependence theory, the aforementioned data suggest that organizations inundate other organizations with students and professors from China, India, and South Korea, and even though they are considered to be minorities in America, based on ethnicity, they are not indigenous URM. Increasing the amount of non-indigenous talent will not address the issue of the underrepresentation for STEM students and professors in America.

Learning Organizations

Learning organizations are organizations rooted with a constant learning progression within their structure that improves the organization's ability to change or recondition (Watkins & Marsick, 1993). Some of the earliest works describe the learning organization as one where individuals are consistently enhancing their ability to develop desired outcomes, and new ways of thinking are collaboratively liberated and people are always learning (Senge, 1990). In Senge's (1990) *The Fifth Discipline,* the learning organization is composed of five key elements that are necessary in order for organizations to learn: systems thinking, personal mastery, mental models, shared vision, and team learning. Systems thinking deals with the comprehensive intricacy of many variables and their vibrant sophistication that occurs when cause and effect are not close to each other and activities do not yield the predictable results. Systems exist on a scale of systems thinking applications that incorporate various levels of rigor, approaches, and perceptions of environment. The tools of systems thinking are used to illuminate hidden structures and patterns of conduct that blur the day-to-day operations of a leader. Personal mastery is a collection of processes used to assist stakeholders in accomplishing their goals while encouraging them to be cognizant about the veracity of the environment in which they operate. Developing personal mastery is an individual intrinsic process honed by self-refection and is part of the lifespan of learning. This is important, as an individual's worldview tends to evolve throughout his or her life, which is formed by the decisions one makes. Mental models are customarily implicit, function at a level subordinate to conscious awareness, and are frequently unconfirmed. Mental models are used to inform a situation where two individuals can experience a common occurrence, yet draw very dissimilar conclusions. This tool may aid individuals and groups in clarifying the constantly changing lenses utilized during activities and redefine the experience by developing a new mental model that leads to more productive outcomes. The discipline of the shared vison is centered on a collection of applications that will unite all team members' hopes for success. The team will understand that they have a protective environment to express themselves about the task, the meaning of the mission, and unrestrained vison or fear of prosecution. The team learning discipline is designed to allow teams to reason and function collectively. The techniques of team learning are grounded in alignment that suggests that dispersed variables operate as one unit to align to each variable's mission (Senge, 2000).

Other learning organization theorists, like Garvin, see learning organizations as a skill of developing, obtaining, and deploying information, where the organization will respond to this newly acquired information and alter its conduct (Garvin, 1993). Given the several learning organization theorists who have defined the learning organization in similar ways, there seems to be harmony regarding what an effective learning organization should look like: one where performance improvement and data sharing are the hallmarks.

How Organizations Learn: Success and Failure

In creating a learning organization it is imperative to engage in learning actions that encourage growth and change, with mindful determination (Lien et al., 2006; Rouhana et al., 2013). Some research describes organizational learning as a result of experiences (Argote & Fuchs, 2011). One pioneering study described the organizational learning experience as being direct or vicarious, illustrating how organizations develop models and tools to understand their experience (Argote, 2013; Levitt & March, 1988). The study claims that status quo and ideals tend to evolve as a result of candid experience, using trial-and-error experimentation and organizational search (Levitt & March, 1988). The researchers claim that learning from experience is a collection of a small number of observations that occur in a mutable environment. One conclusion the researchers draw is that in the context of success and failure, the expectations from the learning process are not always well-defined (Levitt & March, 1988). Behavioralists view learning as systematic and spontaneous, where successful outcomes result in corresponding actions more likely to occur, and failures result in corresponding actions less likely to reoccur (Starbuck & Hedberg, 2001). The researchers assert that successful actions support previous behaviors, whereas failures obstruct earlier behaviors. However, neither of these behaviors reflects the broad comprehension of an issue; therefore, investigation and advancement remain cryptic (Starbuck & Hedberg, 2001). Somewhat counter-intuitive, popular theories view failure as an important element for organizational survival and success (Starbuck & Hedberg, 2001). It was found that failure had the effect of liberating resources that could be redistributed for other uses (Miner et al., 1996). Also, during that time a group of researchers introduced the concept of the “Red Queen” effect, an idea that sees organizations in a state of competition in which they will search for ways to enhance performance (Barnett & Hansen, 1996). On the other hand, Sitkin (1992) suggested that a reasonable degree of failure will illuminate latent complications, therefore igniting a quest for responses. Sitkin (1992) developed standards for what he termed "intelligent failure," and they are as follows: (a) Produce data that can identify issues, (b) Regulate the expense of failure, (c) disseminate feedback in a time appropriate manner, and (d) concentrate efforts on common areas of interest to enhance the analysis of outcomes. In support of this sentiment, a group of researchers studying the degree of catastrophe in coal mines determined that data obtained by the experience of failure, defined as a catastrophe, exhibited a decrease in knowledge for learning from minor catastrophes than more severe catastrophes (Madsen & Desai, 2010). Therefore, when failures as outcomes are grave, then organizations are extremely active in learning from failure (Argote, 2013).

Higher Education as Learning Organizations

Although Garvin (1993) contends that higher education institutions do not conform to a traditional corporate model, Dill (1999) formulates the assertion that higher education institutions have the ability to operate as a business, and therefore can be evaluated in the realm of learning organization theory. Several researchers have attempted to square this duplicity of function. It was proposed that staff traits, such as faculty members' intrinsic motivation, are more effective when less conventional structures for teamwork professional development are being used (Kezar, 2006). Kezar compares four universities that have qualities of an effective collaborative agency seen in the business archetype. Given the aforementioned unconventional higher education setting and the conventional business setting, it was postulated that the motivation of faculty was the result of the interaction with individuals, rather than objectives, return on investment, or administration. As a result, this study proposed a model for university collaboration, composed of ten recommendations that revolved around data acquisition, collaboration, communication, and dissemination (Kezar, 2006). This idea of collaboration has been a long standing characteristic of learning organizations. In a study about collaboration for academic change, department chairs are seen as integral components for promoting positive change, using Kotter's 1996 model to promote collaboration and exchange of information (Lucas, 2000). This study postulated that unless leaders adhere to Kotter's model, the ability of a team to facilitate change will be unsuccessful. It is well documented (Birnbaum, 1988) that higher education institutions exist in very dynamic environments, and this concept was explored in a study that investigated how education institutions behave and self-report performance measures (Kumar & Idris, 2006). The study concluded that leadership to support learning, establishment of team learning environments, and embedded methods have a positive correlation to the understanding of performance (Kumar & Idris, 2006).

Factors and Initiatives at Work for URM Students in STEM Fields

Education

Meyerhoff Scholars Program. As previously discussed, it has been shown that participation in research experiences has led to increased URM student retention rates, academic performance, and matriculation to graduate programs (Barlow & Villarejo, 2004). Many scholars continue to embrace the need for students, particularly URM students, to participate in undergraduate research opportunities as a pathway to attract and retain students in STEM degree programs, which will eventually lead to graduate education and careers in STEM (Kinkead, 2003). When examining programs for URM students in STEM fields, it was found that professional development opportunities, such as presentations, were a positive factor in encouraging students to remain in and excel in their STEM major (Gandara & Maxwell-Jolly, 1999; Hurtado, 2008). In a retrospective analysis, researchers surveyed alumni from research-based postsecondary institutions who participated in reputable undergraduate research programs and compared their matriculation to STEM graduate programs with alumni who did not participate in an undergraduate research program (Bauer & Bennett, 2003). The researchers found that 80% of alumni who participated in an undergraduate research program engage in a graduate program, whereas only 59% of alumni who did not participate in an undergraduate research program entered a graduate program (Bauer & Bennett, 2003). A related study compared alumni who participated in institutionally sponsored undergraduate research programs featuring personalized faculty/student interactions, alumni who participated in an unconventional research activity without personalized faculty/student interactions, and alumni who had no research experience. It was reported that 81.5% of alumni who participated in institutionally sponsored research, 82% of unconventional research alumni, and 65.4% of alumni with no research experience matriculated to graduate programs (Hathaway et al., 2002). The Meyerhoff Scholars Program (MSP) has been one of the most successful URM undergraduate research programs and has become a national model program for other institutions across the country to mimic.

The MSP is a strengths-based approach program established in 1988 on the campus of UMBC under the leadership of Freeman Hrabowski, with strong financial backing from philanthropists Robert and Jane Meyerhoff (Hrabowski & Maton, 2000). In the program's inception, the focus was on high achieving pre-college URM students, specifically African American students, but in 1996 the program was open to non-African American students (Hrabowski & Maton, 2000). The fourteen pillars that support MSP are financial aid, active recruitment efforts, summer bridge programs, formal study groups, adhering to program values, embracing the program community, personal advising and counseling, tutoring, participation in summer research internships, structured faculty involvement, administrative involvement, mentors, community service, and family involvement (Maton & Hrabowski, 2004). MSP students receive a comprehensive financial package contingent upon maintaining a B grade point average. MSP invites the top 100-150 prospective MSP students and their families for a weekend visit to UMBC. Each MSP cohort will attend the mandatory Summer Bridge Program prior to the fall semester, where they will participate in a variety of STEM-related events. The MSP values focus on obtaining STEM-based research PhD, support of academic achievement, peer support, and community outreach. The MSP community embraces a family-like support system, where MSP students reside in the same residence hall and must live on campus for their first year at UMBC. MSP students are provided personalized advising and counseling from staff that focus on academic planning, academic performance, and personal and social issues. Each MSP student will participate in various research internships at various national and international research sites. Integral STEM faculty and department chairs recruit and develop students by providing MSP students opportunities to conduct research in their laboratories. The MSP is supported at every level of UMBC's administration. One of the key values to the MSP students' success is family involvement, where the students' families are included in social events and are updated on the MSP students' progress (Maton & Hrabowski, 2004). The success of the MSP is first observed by the students who have completed a STEM PhD. Five MSP students received PhDs between 2000 and 2002, and 10 more students received their PhD in 2003 (Maton & Hrabowski, 2004). The accomplishments of this program have allowed students to participate in federal and private sector research projects, giving students first-hand experience in the processes needed to deal with the world's STEM needs. UMBC has over fifty biotechnology and industrial technology companies started by students and faculty. Initiatives like these help to fill the pipeline with well prepared, motivated, experienced students who are primed to venture into the private sector or the professoriate. Also, programs like MSP that provide students the opportunity to work in corporate research seem to be the missing link that postsecondary institutions usually lack in fostering these types of partnerships in order to address general social issues such as underrepresentation (Siegel, 2010). As colleges and universities continue to discover ways to address diversity and inclusiveness, it is feasible that policies or mandates will be created to focus on programs, offices, and leaders to guide institutions toward solving such issues. In one study, it was found that a university's School of Engineering was mandated by the office of the provost to create an all-inclusive plan for addressing issues of diversity (Siegel, 2006). It seems that leadership will drive the effort to address and solve issues of URM student persistence; however, organizations must find, encourage, and support leaders who have a passion for this particular issue.

Minority Engineering Program. The Minority Engineering Program (MEP), developed in 1973 by engineering professor Ray Landis at California State University-Northridge, has become a long-standing, extensively replicated program to encourage minority students to pursue engineering degrees (Tsui, 2007). This program is founded on the following common essentials: connection with the engineering department at the university, a robust pre-college and community college outreach agenda, strategic engagement with freshmen and sophomores, a focus on cooperative learning and community development, the establishment of a cohort model for MEP participants, professional development activities, academic support services, summer bridge programs, and counseling services (Collea, 1990; Landis, 1988; Tsui, 2007). MEP has been effective at producing increases in URM student learning and retention in engineering programs and has created increased retention by 10% per year (Tsui, 2007). This program has been established in more than 100 universities and independent programs across the county, from HEIs like Purdue University-West Lafayette, to North Carolina State University (May & Chubin, 2003; PUWL, Retrieved from http://www.purdue.edu/mep/,2018; NCSU, Retrieved from https://www.engr.ncsu.edu/wmep/mep/, 2018).

Higher education environment. Recent research on predictors of minority student participation in the STEM higher education environment has investigated the probability that students who aspire to pursue a STEM degree would become involved in or have access to STEM support services such as undergraduate research programs, supplemental instruction, major-related clubs and organizations, internship programs, and faculty mentorship opportunities (Figueroa, Hughes, & Hurtado, 2013). It was found that African-American students are 16.27% more likely to participate in undergraduate research programs and opportunities than Caucasian students (Figueroa et al., 2013). It was also found that incoming freshmen students with a 100 point increase in the average SAT scores were 4.55% more likely to be involved in undergraduate research activities, and their probability to participate in undergraduate research activities increased by 2.58% for every 100 point increase in SAT scores from the mean SAT score (Figueroa et al., 2013). Supplemental instruction, or SI, has the goal of addressing challenging topics that students choose to engage outside of the regularly scheduled class time (Arendale, 1997; Figueroa et al., 2013) and has been a significant activity in the success of students majoring in a STEM degree (Armstrong et al., 2011; Blat & Nunnally, 2004; Figueroa et al., 2013; Reid & Yonger, 1997). It was found that students who are involved in clubs or other organizations related to their major, or are involved in academic programs for racial or ethnic minorities, were more likely to participate in SI (Figueroa et al., 2013).

Government/Federal. In 2001, the U.S. government attempted to address education reform by signing into law the No Child Left Behind Act (NCLB), a federal law that enforced increased accountability for states, school districts, and schools, as well as providing more educational choices for parents and students from underserved populations. In addition, NCLB allowed for great flexibility for states to use federal dollars for education (National Academies, 2011). More recently, President Obama signed into law the American Recovery and Reinvestment Act in 2009, which included a $4.35 Billion fund for a program called Race to the Top, a grant program aimed at rewarding states for creating an innovative educational environment, and for plans to reform a state's education enterprise (National Academies, 2011).

NSF Robert Noyce Teacher Scholarship Program. The Robert Noyce Teacher Scholarship Program has been a long-standing National Science Foundation program, with a mission to educate STEM teachers at the highest levels possible (AAAS, 2012). As part of the 2010 America COMPETES Act, this program supports STEM majors and post-baccalaureate students who have committed to teaching in the K12 arena (AAAS, 2012). The goal is the recruitment of individuals with strong STEM backgrounds who may not have considered a career in education (AAAS, 2012). The program consist of four project tracks: Scholarships and Stipends, Teaching Fellowships, Master Teaching Fellowships, and Research on Preparation, Recruitment, and Retention of K12 STEM Teachers (nsf15530, 2015). The Scholarships and Stipends track provides institutions support for recruitment and preparation of K12 STEM teachers and makes available scholarships for undergraduate STEM majors, as well as stipends for STEM professionals (nsf15530, 2015). The Teaching Fellowship track provides awards to institutions to develop and implement fellowship and programmatic initiatives to develop STEM professionals, for both new STEM graduates and for current and emeritus STEM professionals.

These individuals must be enrolled in a graduate teacher education degree program, with licensure in a STEM area for elementary or secondary education (nsf15530, 2015). The Master Teaching Fellowship track provides institutions fellowships and program support for veteran and excellent K12 STEM teachers who have been awarded a master's degree in their area of expertise. These "Master Teaching Fellows" will serve as mentors and leaders for programs (nsf15530, 2015). The Research on Preparation, Recruitment, and Retention of K12 STEM Teachers track will award proposals that aim to respond to the 2010 National Research Council's report titled *Preparing Teachers: Building Evidence for Sound Policy* (nsf15530, 2015). This track will support proposals with foci on partnerships for STEM teacher preparation and the future landscape for STEM teachers (nsf15530, 2015).

NSF Louis Stokes Alliances for Minority Participation. The Louis Stokes Alliances for Minority Participation (LSAMP) is an NSF-sponsored program to assist colleges and universities in increasing the diversity of the STEM workforce by increasing the number of students who matriculate through excellent STEM programs of study (nsf12564, 2012). Established in 1991 by the U.S. Congress, the LSAMP specifically aims to increase the number of minorities who successfully complete a baccalaureate degree in a STEM field and matriculate on to graduate school (nsf12564, 2012). The LSAMP provides support for new, mid-level, and senior-level alliances; Bridge to the Baccalaureate (B2B) alliances; Bridge to the Doctorate; and Broadening Participation Research in STEM Education. New alliances are designed to develop innovative recruitment and retention programs for undergraduates with a particular focus on pre-college, freshman, and sophomore students pursuing a STEM degree. The Mid-level alliances focus on recruitment and retention of STEM upperclassmen and include community college partnerships in order to promote student transfer enrollment to 2-year and 4-year higher education institutions. These B2B alliances will support programs, primarily in collaboration with community colleges, dealing with team and cohort building principles, individual skill development, undergraduate research, and career support (nsf12564, 2012). Mid-level and senior-level alliances look to develop effective institutional pathways to STEM graduate programs and the STEM workforce, with senior-level alliances having an added feature regarding sustainability (nsf12564, 2012). The B2B alliances are designed to increase novel approaches and enhance skills of the American STEM workforce (nsf12564, 2012). Although there are many success stories of participants of the LSAMP program at various institutions, there is no current comprehensive evaluation of the LSAMP program. However, the overall mission is to generate five million community college associate degrees and certificates by the year 2020.

US DoEd TRIO programs. The TRIO program began as a progressive initiative to address economic and workforce issues. The program advances together with the Economic Opportunity Act of 1964 and the establishment of the Upward Bound program, whose aim was to focus on the War on Poverty (ED.gov, 2011). The purpose of Upward Bound is to provide higher education opportunities for students designated as pre-college students, with hopes that they will earn a college degree. This program serves high school students from low socioeconomic families and families from which neither parent was awarded a baccalaureate degree. Upward Bound’s ultimate objective is to increase the rate at which students complete high school, matriculate to college, and complete postsecondary training (ED.gov, 2011). The Math and Science Upward Bound program is designed to enhance the science and mathematics skills of students, as well as to encourage them to pursue degrees in science and mathematics fields of study and ultimately secure a career in those fields. To provide support of military veterans, and to motivate them to pursue a post-secondary education, the Veterans Upward Bound program was established. Services for this program include remediation for mathematics and science skills, support for foreign language, and academic support for English Language and Composition (ED.gov, 20110). This program was followed by Talent Search, an outreach program that is part of the Higher Education Act of 1965. The goal of Talent Search is to provide academic, career, and financial advising to students and encourage them to pursue a college education (ED.gov, 2011). In 1968, the third program, the Special Services for Disadvantaged Students, now known as Student Support Services, was ratified by the Higher Education Act Amendments.

Business and Industry

Boeing. The Boeing Company is an American multinational corporation and world leader in the advancement of the aerospace industry. Boeing designs, manufactures, and sells airplanes, rotorcraft, rockets and satellites (boeing.com, 2015). Boeing, in conjunction with the Boeing family, contributed $30 million dollars toward the development of a substantial STEM training program at the Museum of Flight in Washington. The purpose of the program is to focus on the advancement of young women, minorities, and economically under-served children who have an interest in STEM fields of study (Wilhelm, 2015). Boeing hopes to expand the current number of 1,000 children in STEM immersion programs to 5,000 children (Wilhelm, 2015).

Ford Motor Company. The Ford Motor Company is an American multinational automaker located in Dearborn, Michigan, a suburb of Detroit. In order for Ford be competitive in the global marketplace, it is critical to have a talented pool of technically trained professionals. Ford’s contribution to developing this talent pool is to support opportunities for students to engage in the STEM environment (Ford Motor Co., 2015). Ford has developed a program, referred to as the High School Science and Technology Program (HSSTP), which is a 30 year initiative that offers students in southeast Michigan the opportunity to discover what it would be like to work on the Ford campus. Ford highlights that the rate of women earning engineering degrees is uniform and the rate of minority women is diminishing, mostly among African-American women (Ford Motor Co., 2015). The students will engage with scientists, engineers, and technicians to see how science and engineering can have real-world applications (Ford Motor Co., 2015). Students who participate in the program are eligible to apply for a summer internship at Ford. Ford hopes to increase and maintain student interest in STEM fields.

Exxon Mobil. Exxon Mobil Corp is an American multinational oil and gas corporation headquartered in Irving, Texas. ExxonMobil is the largest publicly traded international oil and gas company and has a critical need to recruit STEM talent in order to manage and advance an industry-leading inventory of resources. As one of the world's largest integrated refiners and marketers of petroleum products and chemical manufacturers, Exxon Mobil works to attain high quality financial and performance outcomes while maintaining high ethical standards (Exxon Mobil, 2015). Suzanne McCarron, President of ExxonMobil Foundation, has expressed that "The ExxonMobil Foundation is focused on improving science, technology, engineering and math (STEM) education, but we need quality partners such as NACME in order to have a greater impact" (Exxon Mobil Foundation, 2015). President McCarron also stated "When you consider how few minorities there are among engineering ranks in America, it's imperative that we work together to find solutions to increase the opportunities and exposure for students with diverse backgrounds" (Exxon Mobil Foundation, 2015). Exxon Mobil granted $520,000 to the National Action Council for Minority Engineers, a nonprofit focused on increasing the number of underrepresented students who aspire to have careers in engineering. Exxon's goal is to prepare underserved minorities for engineering careers, and it also aims to help advance strategies to encourage middle and high school students toward engineering degrees.

Great Minds in STEM™. Great Minds in STEM is a non-profit organization with an emphasis on STEM educational awareness for students beginning in kindergarten and matriculating through the workforce. The goal of Great Minds in STEM™ is to increase the representation of Hispanics in STEM on a national level. Their model to accomplish this is to link integrated STEM areas of expertise with the population at large (Great Minds in STEM, 2015). Their mission is to (1) inspire and motivate underserved students to pursue careers in STEM, (2) enlighten and engage families, educators, communities and employers to assist underserved students pursuing STEM careers, (3) inspire our nation through recognition of the achievements of Hispanics and other role models in STEM, (4) enable and leverage Hispanic STEM talent to play a leadership role, and (5) collaborate and cooperate nationally within the STEM community (Great Minds in STEM Vision, 2015).

LET'S GO Boys & Girls. LET'S GO Boys & Girls is a 501c3 organization whose mission is to help underserved children become academically successful (Let's Go, 2015). This organization is dedicated to building an academic foundation for elementary and middle school students in the STEM disciplines, using fun interactive activities (Let's Go, 2015). Established in 2009 by Dr. Clark "Corky" Graham, LET'S GO Boys and Girls, Inc., also known as LET'S GO, set forth on a mission to increase the number of STEM professionals from urban underserved communities (Let's Go, 2015). LET'S GO takes to the approach of transforming their STEM community by participating in and reinforcing STEM teaching and learning to elementary and middle school students (Let's Go, 2015).

The aforementioned corporate and foundation sponsored STEM programs share a common mission of providing children the opportunity to experience STEM in a meaningful and tangible way. Although these programs have their particular STEM-related niche, such as sustainable energy or engineering, they are all involved in ways to expose young people to various educational paths and career options in STEM-related areas. These programs have a goal of providing children from underrepresented and underserved groups the opportunity to discover how STEM is applied in everyday experiences.

Conclusion

This chapter provided a synthesis of the literature related to factors that affect URM students' movement through the STEM academic environment. The literature was used to examine and critique the academic environment in which URM must navigate in order to be successful in their pursuit of a STEM degree. These environmental factors include the STEM workforce, URM student preparedness for STEM coursework, access, affordability, URM student social experiences on college campuses, faculty members' role and experience with URM STEM students, and current responses to the pipeline issue. The theoretical framework was designed using a combination of Birnbaum's (1988) Cybernetic Loop of institutional interaction and Marsick and Watkins's (2003) seven constructs of organizational learning to explain, rationalize, and provide clarity to the above described dynamic academic STEM environment.

CHAPTER 3: METHODOLOGY

The purpose of this chapter is to describe the research design, describe the institutions that were examined, and explain how data were collected and analyzed. This chapter is divided into four sections: (1) research design, (2) description of the sample, (3) data collection and analysis, and (4) summary.

Research Design

Qualitative Inquiry

This study utilized qualitative research methodology, a research type used for discovering and comprehending the meaning which individuals or consortia attribute to a social or human issue (Creswell, 2014). A case study method, specifically a multiple-case study approach, was used to determine how select PWIs have learned to become successful in advancing undergraduate African-American students to advanced degrees in Life Sciences. A qualitative case study is a research approach that promotes the investigation of a phenomenon through data gathered from participants in a natural setting in order to examine the phenomenon through multiple lenses to augment comprehension (Baxter & Jack, 2008). Qualitative studies have been used to add to a body of knowledge of an individual, group, or organization; to explore social, political, or similar phenomena; and to investigate the application of theories (Yin, 2009). According to Schramm (1971), the substance of a case study or multiple case studies informs choice, execution, and outcomes of an action.

Multiple-Case Design

The multiple-case study approach allows the researcher to analyze within and across case contexts (Baxter & Jack, 2008). The evidence collected from each sample institution operates somewhat like multiple experiments and therefore allows for replication of the design (Yin, 2009). This study implements Yin's (2009) model for replication in multiple case studies, including (a) the development of the theoretical framework as highlighted in Chapter 1, (b) case selection and data collection protocols, (c) case study data analysis and conclusions for each case (as well as across cases), and (d) the feedback loop representing the intersect of significant findings during each case study (Yin, 2009).

Description of the Sample Universities

Overall, the universities in this study are similar in their structural and functional characteristics. Both are southern flagship universities in their respective states. These institutions were established during the late 1700s to the early 1800s, with admissions of African American students at various times and for various reasons throughout their history. Both universities have similar enrollment numbers, have a substantial research history, and have an associated medical school. Having a medical school is a critical delimiting factor in this study, as life sciences programs are predominate majors for students who want to pursue a medical degree. Institutions with medical schools tend to have an inherent pipeline from undergraduate life sciences departments to medical school, being an attractive choice for many students with interest in medical careers. Having this asset may lead to successful recruitment efforts and increases in retention for students with STEM-related interests. Professional associations that have roots in the life sciences are actively recruiting and retaining URMs with the goal of increasing their professions with quality individuals from underrepresented groups (ASHA, 2016 Retrieved from http://www.asha.org/practice/multicultural/recruit/litreview.htm). Some life science majors, such as biology, have courses of study consisting of courses necessary to gain a strong content foundation to prepare for medical school coursework. Some institutions offer undergraduate-level courses that are similar to the medical school level, such as intermediary metabolism and medical biochemistry, respectively. One important criterion for selection is that both universities are among the top 13 PWIs that are Baccalaureate origin institutions of African-American doctorates in Life Sciences (National Academies, 2011).

The following provides a condensed profile of each sample university:

Upper South University (USU) was established in the late 1700s, and today is a global leader in teaching, research, and service. As the struggle for equal opportunity persisted in American, the first African-American student was enrolled in the early 1950s, after a federal court ruled that the university must allow admittance of black. Displaying decades of progress, during the reporting period between 2002 and 2006, USU was ranked 20th among all universities who advance URM towards degrees in STEM fields (National Academy of Sciences, 2011). Second, USU is a member of the prestigious American Association of Universities (AAU). In 2013 the AAU published a set of guiding principles for the America COMPETES Act 2010 reauthorization, affirming that they will support the America COMPETES Act of 2010. One significant section states

> "This directorate supports research critical to our understanding of how students learn STEM, how best to teach students in STEM fields, and how to increase participation of women and underrepresented minorities in STEM fields."

State University of the Deep South (SUDS), was established in the early 1800s as a way to encourage a community engaged environment. The university dismantled, both structurally and functionally, after the Civil War, by way of many natural disasters. As a result of such turmoil, SUDS faced major enrollment decline leading to the university closing in the late 1800s. To rebound from this decline, SUDS looked to diversity as the answer, as the State leadership developed a pathway to reopen, that included the controversial appointments of African-

Americans to the Board of Trustees, as well as admitting the first African-American students, in the late 1800s. Although this early diverse university was brief, ending shortly thereafter, at the end of the Reconstruction Era, today SUDS is among the top 3% in the nation for the number of African-American graduates. Having not affirmed their support the America COMPETES Act of 2010, SUDS is ranked 25th among the top PWIs that advance African-Americans to STEM doctoral degrees during the 2002-2006 reporting period (National Academy of Sciences, 2011).

There was an attempt to include Presidents Southern University (PSU), an institution that is among the top PWIs that advance African-Americans to STEM doctoral degrees (National Academy of Sciences, 2011). After several attempts to access PSU, without success, it was determined, with advice from the study chair, that PSU would not be part of this study. The effort to access PSU personnel who could inform the research study began in June of 2016, as a colleague at ECU knew a faculty member at PSU who thereby provided an email introduction. An attempt was made to contact this faculty member, but it was discovered that the faculty member was no longer employed at PSU. Next, I sent an introductory email to the department chair of the Department of Biology, inviting members of the faculty to participate in this study; however, I did not receive a reply. Two more contact emails were sent to the chair with no response. Next, emails to the faculty in the Department of Biology were sent to solicit their participation in the study, but with no reply. Next, colleagues from the Department of Biology, as well as the Provost, at the home institution were asked for any contacts they may have at PSU; however, those inquiries were met with no positive response. Faculty at PSU were sent one last participation email that resulted in no reply. As this is a study that focuses on underrepresentation, the Office of Diversity was contacted via email solicitation. There was an indirect response from this office, via forwarding the email to another colleague in that office who then recommended that the invitation to participate be forwarded to another colleague. This resulted in direct contact via an email reply followed by a phone call. During the phone conversation, the PSU employee recommended another individual at PSU who would be more appropriate to interview. I contacted this PSU employee twice, an effort that resulted in no reply. It was finally determined to exclude PSU from the study.

Data Collection Procedures

First, this study illuminated factors, those outlined in Chapter 2, that are impactful in supporting African-American undergraduate students in pursuing doctoral degrees in the life sciences at three select southern Flagship research universities. It is unknown exactly which factors or combination of factors exist at both sample institutions; however, identifying a profile of factors at these PWIs will inform the interview protocol. The categories of factors by which specific evidence was collected, the rationale for selecting such factors, and how that information was collected are as follows:

Factor #1

The number of college readiness or pre-college programs, aimed at impacting and introducing K-12 education to new technologies.

Rationale. Studies reveal that partnership with K-12 school districts and colleges and universities are the most common model for preparing students to enter college (NCPR, 2012).

Collection method. The universities' websites were searched for evidence of pre-college programs, outreach activities with K-12 schools, summer bridge programs, and other forms of preparation activities for K-12 students.

Factor #2

Access and admissions criteria to the university and admission requirements for life science program areas.

Rationale. Academic preparation and admission to colleges and universities are critical components to careers in STEM, and due to deficiencies of pre-college support in science, many URM students begin their college careers less probable to pursue a STEM degree (National Academies, 2011).

Collection method. The universities' websites for the life sciences departments were examined for evidence of admissions standards and requirements.

Factor #3

Affordability of African-American students to flagship universities and financial aid packages to minority students.

Rationale. When examining national programs designed to increase the number of URM pursuing STEM degrees, financial assistance has a positive influence on those students' persistence in STEM programs (Clewell et al., 2005).

Collection method. The universities' and the life sciences departments' financial aid websites were examined for evidence of support for African-American prospective STEM students.

Factor #4

African-American students' Academic Persistence in Life Science program areas.

Rationale. Students who are proactive in their learning process have positively influenced their persistence in STEM fields (Treisman, 1992).

Collection method. The universities' life science departments' websites were explored for confirmation of organized supplemental instruction, group study, student-organizations memberships, and other forms of academic support and social support informed by literature.

Factor #5

Evidence of opportunities for undergraduate research experiences in Life Science program areas.

Rationale. Studies have shown that undergraduate research experiences significantly increase STEM degree completion among URM students (Change et al., 2010).

Collection method. The universities' life science departments' websites, publications, and other available documents were explored for confirmation of organized undergraduate research experiences.

Factor #6

Evidence of opportunities for mentorship experiences with Life Science faculty.

Rationale. Predictors of minority student participation include faculty mentorship opportunities that have impacted URM STEM students' access to STEM support services (Figueroa et al., 2013).

Collection method. The universities' life science departments' websites, publications, and other available documents were explored for evidence of formal and informal faculty mentorship experiences and opportunities, particularly for URM students.

Factor #7

Evidence of amount and degree of corporate and other external partnerships to provide African-American life science undergraduates experience in the STEM enterprise and/or fiscal support.

Rationale. University-industry partnerships have spawned the development of the entrepreneurial university (Clark, 2003; Manuel & Dridi, 2007), where a key component is the ability to develop strategies that enable publication, collaborate with other researchers, and offer co-authorship for students (Manuel & Dridi, 2007).

Collection method. The universities' life science departments' websites, publications, and other available documents were explored for evidence of formal partnerships that have or will have an impact on African-American life science students' persistence, completion, and matriculation to advanced life science degree programs or the workforce.

Factor #8

The amount and trends of Research and Development expenditures in life science areas and education.

Rationale. U.S. R&D investment has been on a waning trajectory, while investment by emerging and developed economies is continuing to prosper (Bhushan, 2015).

Collection method. For each university in this study, all R&D expenditure reports were downloaded from the National Science Foundation to determine how and where each university invested its money.

An in-depth descriptive analysis was conducted for the two sample institutions, examining their archives, websites, reported expenditures, and other available documents.

In addition to the in-depth descriptive analysis, the primary data collected were qualitative data, gathered through semi-structured interviews of the sample universities' Life Sciences departments' leadership, students, and other institutional members. Informants were identified by purposive sampling and selected based on their presumed knowledge to inform the research question. The anonymity of the informants was maintained by the assignment of pseudonyms. Snowball sampling was utilized to identify other informants who had the potential to lend expertise in addressing the research question. The semi-structured interview protocol consisted of approximately 10 questions that were informed by the literature in Chapter 2 and previously described profiles (see Appendix B). The questions were broad yet multifaceted, and probes were utilized to gain further insight or to encourage more discussion. The interview protocol was tested at my local institution by comparable leaders and students whose knowledge and experience could inform the research question. The purpose of testing the interview protocol was to discover any questions that might be problematic or phrased in an abstruse manner. The participants were contacted via email or phone to request participation in the study. The correspondence included information on the topic and purpose of the study, information regarding the IRB and confidentiality, and interview scheduling procedures. Preview of the interview questions was provided upon request of the participant. On the day of the interview, participants were advised of their protection under the law and provided consent forms to be signed. The interviews took place either in person, via telephone, or on Skype, and were audio-recorded using a digital recording device and/or iPhone Voice Recorder as a secondary form of audio-recording. All recordings are stored in a secure locked cabinet.

Data Analysis

Once data were collected and organized regarding the factors, a dataset was constructed using Excel to reflect identified factors, as referenced in Chapter 2, that have positively influenced the advancement of African American students to life science doctoral degrees. Next, the data were scored, a technique that assigns numeric values to a data point in a category (Creswell, 2012). The dataset displays the factors in a way that allowed for scores to be categorically listed (Creswell, 2012). Several descriptive statistics will be determined by each university, and compared to each university, to describe their factors in advancing underrepresentation in Life Sciences departments. These include mean, median, mode, standard deviation, range, and variance for each occurrence identified. However, during the analysis of the factors, it was determined that with such a small number of occurrences between two institutions, counts would be sufficient in supporting the interview process.

All interviews were recorded and transcribed verbatim, then the data were coded and condensed into themes via coding using NVivo qualitative software. Yin (2009) describes five analytic techniques that can be utilized to develop a persuasive case study: pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis. For this study, I utilized pattern matching and cross-case synthesis techniques to analyze the data. Pattern matching is an analytic tool that identifies and compares patterns apparent in the data to assumed or inherent patterns developed by the researcher's experience in the field (Yin, 2009). Patterns were observed within and between cases, leading to reinforced internal validity (Yin, 2009). Predictive patterns were derived from the theoretical framework. Cross-case synthesis was utilized, as it distinctively pertains to multiple-case study research (Yin, 2009). This was accomplished by developing word tables that presented the identified themes from each case, as organized according to the theoretical framework presented in Chapter 1. This technique determines whether shared similarities exist among cases (Yin, 2009). While conducting the analysis, it was determined that other analytic techniques may be needed to analyze the data more accurately. Therefore, narrative synthesis was utilized in order to collectively tell the story of both institutions, concurrently, of how USU and SUDS were successful at advancing African-American students to doctoral degrees in life science areas.

Trustworthiness

Qualitative researchers have developed a unique nomenclature in regards to validity and reliability of a study. The purpose of this nomenclature system is to establish trustworthiness (Lincoln & Guba, 1985). Guba (1981) developed a construct equitable to the quantitative research criteria of internal validity, external validity, reliability, and objectivity. Internal validity, which Guba (1985) refers to as credibility, is the ability to determine if the results are consistent with real-world actuality (Merriam, 1998). This study utilized several techniques to address credibility. First, in addition to purposive sampling, this study used snowball sampling from the purposive group of informants in order to randomize the sample and to nullify researcher bias (Lincoln & Guba, 1985.) I hold two degrees in Life Science fields, BS Biology, MS Cell Biology/Immunology, and given this information, I have developed ideas of culture, norms, and preceptions of how life science departments are organized and function. However, it is limited to my experience in only one institution. Therefore, the aforementioned biases may have limited the initial selection pool of participants, thus snowballing was used to expand the participant pool to individuals outside of my current Life Science construct. Second, triangulation of data was used to balance different data collection methods and sources while taking advantage of their value (Guba, 1981). Data from the university profiles and interview data from administrators and faculty was compared for similarities among the two universities. Third, I performed member checks by inviting informants to review the transcription from their interview to vet for the accuracy of intended meaning. To address external validity, or what Lincoln and Guba (1985) refer to as transferability, so that the outcomes can be applied to other settings, this study developed thick descriptions to describe the phenomenon described in Chapter 1, allowing accurate comparisons of occurrences of the phenomenon at the three sample universities. Reliability, or what Guba (1985) refers to as dependability; occurs when study techniques are employed in a comparable context using analogous methods and study participants to yield similar results. Confirmability, or what Guba (1985) refers to as objectivity, has to do with guaranteeing that the results are due to the expertise of the informants and not that of the researcher. An in-depth description of the methods utilized to collect data, as well as how the data were triangulated, was described.

Summary

For this study, a multiple-case study approach was used to determine how two select PWIs learned how to be successful in advancing undergraduate African-American students to advanced degrees in Life Sciences. The initial step was to illuminate factors, those outlined in Chapter 2, that are impactful in supporting African-American undergraduate students in pursuing doctoral degrees in the life sciences, at two select southern Flagship research universities. These data were collected by reviewing the universities' websites, archives, and other available documents. Descriptive statistics were used to describe the initiatives undertaken by the sample universities. However, the primary data for this study were semi-structured interviews with life science departments' administrators and faculty. In preparation for a complete analysis, pre-codes were determined using the Marsick and Watkins (2003) seven constructs of the Learning Organization, within the context of Birnbaum's (1988) Cybernetic Loop of institutional interaction.

CHAPTER 4: RESEARCH FINDINGS

Overview

This qualitative research case study reported on interviews with nine participants from two southern state flagship universities concerning how their PWIs have learned to substantially increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Sciences. The participants consisted of junior and senior faculty as well as mid-level administrators who have been key actors in advancing their respective institutions toward progress in addressing underrepresentation in advance life science study. These interviews were approximately one hour in duration using a semi-structured interview protocol consisting of ten questions developed and modified from Marsick and Watkins's (2003) Dimensions of the Learning Organization Questionnaire as well as the literature in Chapter 2 of this study. This chapter will discuss the participants' profiles and the thematic findings of the study.

Institutional Profile

To determine a baseline of activity as described in Chapter 3 of this study, Table 2 displays data relevant to the factors identified in Chapter 2 that have positively influenced the advancement of URM students to science-related degrees. Next, the data were scored, a technique that assigns numeric values to a data point in a category (Creswell, 2012). The dataset displays the factors in a way that allows scores to be categorically listed (Creswell, 2012). No specific descriptive statistics were needed to be determined for each university, as frequencies or counts were sufficient to inform the interview interaction. The counts table for factors influencing success for URM students that are pursuing degrees in science areas of study is highlighted in Table 2, for each PWI in this study. Each numeric value represents a single occurrence, such as an activity or initiative that falls under each factor. For example, this study

Table 2

Frequencies of Factors Influencing URM Student Success in Science Areas

	Institution	
Factor	USU (Frequency of Occurrence)	SUDS (Frequency of Occurrence)
College Readiness or Pre-College Programs, aimed at impacting and introducing K-12	6	5
Access and admissions criteria to the university and admission requirements for life science program areas	5	2
Affordability of African-American students to flagship universities and financial aid packages to minority	6	3
African-American Life Sciences Academic Persistence in Life Science program areas	2	0
Evidence of opportunities for undergraduate research experiences in Life Science program areas	6	1
Evidence of opportunities for mentorship experiences with Life Science faculty	5	2
Evidence of amount and degree of corporate partnerships to provide African-American life science	3	0
The amount and trends of Research and Development expenditures in life science areas and education (in thousands of dollars)	2003-2011 Science $4541417 Education $11,057	2003-2011 Science $260927 Education $6,457

Note. Developed from Expanding Underrepresented Minority Representation (National Academies, 2011).

was able to identify six programs or activities at USU that focused on STEM outreach to the K12 environment.

Participants' Profiles

The following section provides information regarding each participant's institution, academic department, position, duration at the institution and current position, and other descriptive information. This descriptive information is organized and displayed below for each participants' institutional history and perspective (see Table 3).

USU Faculty and Administrators

USU Faculty member 1 is a perceived white male who is a full professor in the Department of Biology. He has been in this position at USU for twenty-five years and was involved as a faculty mentor in several funded programs that address underrepresentation in science areas.

USU Admin 2 is a perceived white male who is a full-time administrator in USU's School of Medicine. He has been at USU for seven years in this position. Although USU Admin 2 has a PhD in a life science discipline, he is one-hundred percent in an administrative role where he leads funded programs to increase the number of post-baccalaureate URM students pursuing a PhD in a life science area, and he leads the K12 outreach program for students interested in a STEM career.

USU Admin 3 is a perceived black female who also is a full-time administrator in USU's School of Medicine. She has been at USU for eight years and leads the school's diversity activities that support URM students pursuing a PhD in a life science area. USU Admin 3 also holds a PhD in a life science discipline and is a product of a URM science pipeline program.

Table 3

Study Participant Profile Summary

Participant Identifier	Institution	Years in Position	Institutional Role
USU Faculty member 1	USU	25	Teaching/Research/Service
USU Admin 2	USU	7	Leadership to increase URM to Life Science PhD
USU Admin 3	USU	8	Leadership to increase URM to Life Science PhD
USU Faculty/Admin 4	USU	36	Leadership/Teaching/Research/Service
USU Faculty/Admin 5	USU	13	Leadership/Teaching/Research/Service
SUDS Faculty member 1	SUDS	1	Teaching/Research/Service
SUDS Faculty/Admin 2	SUDS	44	Leadership/Teaching/Research/Service
SUDS Faculty/Admin 3	SUDS	4	Leadership/Teaching/Research/Service
SUDS Faculty member 4	SUDS	2	Teaching/Research/Service

USU Faculty/Admin 4 is a perceived white male who is a full distinguished professor in a science discipline. He has been employed at USU for thirty-six years in various leadership and administrative positions. At the time of this study, USU Faculty/Admin 4 was the leader of a nationally recognized and replicated STEM program focused on diversity and aimed at preparing undergraduates to be successful students and leaders in pursuing advanced degrees in STEM-related areas.

USU Faculty/Admin 5 is a perceived white female who is a faculty member in the School of Medicine and also an administrative leader. She has been at USU for thirteen years in various positions and has been in the administrative role for four years. USU Faculty/Admin 5 leads efforts in diversity in medical education as well as clinical research.

SUDS Faculty and Administrators

SUDS Faculty member 1 is a perceived black female junior faculty member on the tenure track as an Assistant Professor in the Department of Biology. She has been at SUDS for approximately one year. Even though she is very new to SUDS, SUDS Faculty member 1 has been asked to sit on the diversity committee.

SUDS Faculty/Admin 2 is a perceived white male who is a senior faculty member in the Department of Biology and an administrator connecting science to education. He has been at SUDS for forty-four years in various positions and has served as an administrator for seven years. SUDS Faculty/Admin 2 has been involved with grant programs and initiatives that aim to address underrepresentation in science areas since entering SUDS, both formally and informally.

SUDS Faculty/Admin 3 is a perceived white male who is a senior faculty member in the Department of Biology, in addition to serving as an administrator at the college level. He has been at SUDS for four years. SUDS Faculty/Admin 3 supports the science teaching and learning activities of the unit, including those that address underrepresentation in science areas.

SUDS Faculty member 4 is a perceived Hispanic woman who is a junior faculty member on the tenure track as an Assistant Professor in the Department of Biology. She has been at SUDS for approximately two years. Like SUDS Faculty member 1, SUDS Faculty member 4 has been asked to sit on the diversity committee.

Findings

Six major themes and four sub-themes emerged from the interview data informing how select PWIs have learned to substantially increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Sciences:

1. Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields
    a. Progress in addressing diversity in science fields requires time and brain-space to work together in a consistent, inclusive, structured, and supported manner
    b. Understanding diversity issues in science areas requires open conversation with diverse group members in a safe environment that challenges perceptions and illuminates the problem
2. Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way
3. Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions

4. Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses, and advocacy increases morale
    a. Scientists use the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields
    b. There is no single action that increases representation in science fields; however, a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue
5. Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability
6. Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs

Theme #1

Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields. Every study participant indicated that their institution has a perceived idea of the diversity ecosystem on their campus. These responses varied in point-of-view, historical viewpoint, and their level of engagement at the institution. This theme elicited the most responses from participants and is novel to the initial theoretical framework as mentioned in Chapter 1. Some descriptions linked to this theme include which demographic group is traditionally represented in science fields, the existence of barriers to representation in science fields, increased awareness of a diversity issue in science fields, and why diversity is important. Responses that support this theme are demonstrated most strongly by USU Admin 3, USU

Faculty/Admin 5, SUDS Faculty 1, and SUDS Faculty 2; however, every participant's data included codes related to this theme. USU faculty 3's historical view indicates that there was a pre-existing diversity culture in the life sciences areas:

> And we've certainly come a long way since 2009 when I started this job, when -- when they didn't recognize the names of HBCUs.

This quote indicates progressive movement from a time in USU history when there seemed to have been a lack of awareness of postsecondary institutions that enroll and produce African-American talent. One caveat to this apparent lack of awareness of existence HBCUs, is that USU exists in a state that has a large number of HBCUs, many of which were established at approximately the same time as USU. A discussion regarding how participants perceived diversity on their campus and in the surrounding community illustrated some similarities and differences between USU and SUDS. USU Admin 1 talked about the impact of some of their many funded diversity programs as "seeds to address underrepresentation" when faculty and administrators do not fully support such initiatives:

> …they'd look around at least at the academic research environment at USU, and they would say, "Well, we are really diverse. You know; we've got people from all kinds of different countries, we've got people from lots of different states; we've got people…

USU Admin 1 goes on to describe the difference between the perceived diversity on campus and the surrounding community, stating:

> …but the problem is, like, while it's diverse in certain ways, there are certain groups of people who are represented in certain ways in our population, like here in the south, among academia.

Such a response provides evidence of how USU faculty and staff may operate in two different environments, as USU is perceived as more diverse than the surrounding community in which it exists. Interestingly, SUDS Faculty/Admin 2 draws a contrast between two types of African-American population in the Deep South. He comments that African-American students who perform well in his honors biology courses are not from low-income families, and describes the two populations with the following account:

> We have two African-American societies in the Deep South. We have a prosperous middle class, professionals. Their kids do just as well as the white kids. And then we have the majority of African-Americans that are low-income, and their kids don't do well in school.

This account provided evidence of a perception of academic performance of a diverse population based upon affluence. The response is further supported by SUDS Faculty 1, who shared her view of the culture of higher education institutions as being isolated environments that embrace differences:

> So I feel like universities and colleges are a little bit more accepting of diversity, any kind of diversity you can think of: Religious, ethnicity, sexual orientation, all of that stuff. So sometimes I feel like we're in a bubble at a university.

This particular conversation concluded with SUDS Faculty 1 thinking that universities should be places that are responsive to concerns to address diversity and inclusion. To get a clearer illustration of what the participants perceive as the importance of diversity in general, as well as in the academic science environment, a probing question was interjected. SUDS Faculty 4 shared her view of the value of diversity, from a biologist’s perspective, with the following account:

> You present a biological problem to someone that…has been trained as a physicist all their life, the physicist is going to view it with a novel and different and probably very unique way to look at that same biology problem. And I think this is how innovation arises. So, and by the same token, when you bring people from very different life paths and very different life experiences, they are going to bring a very unique angle to any program or field they are in. And I think this is why it's important.

This sentiment is also shared by USU Faculty/Admin 5, who offered her thoughts on the importance of diversity in science:

> I'm sure you're aware of the studies that say a diverse group of people comes up with a better solution to a problem than a homogeneous group of people even if the individuals in that homogeneous group look like they were more qualified to be in it; right? So I would like to have as many perspectives as possible so we have lots of different ideas. And I think science in general benefits from that. And I think you've heard those arguments before.

The idea that a group of people from different backgrounds and ethnicities will bring new and/or better solutions to problems appears to be a common perception held by participants with respect to the value of diversity in science fields. Aside from the institutional perceptions of diversity in science that participants expressed, some also shared more personal perceptions of diversity in the southern region of the country. Specifically, some were concerned about facing some of the stereotypical ‘in-your-face’ racism. For example, SUDS Faculty 1 came to the Deep South with a preconceived idea of what diversity would look like upon arrival:

> I feel particularly, where I am, in the Deep South, and I'm new to the Deep South. So we haven't, like, explored very much. So I lived in Baltimore, the Baltimore area, for a long

> time. So that was, you know, a little bit different. There, it's incredibly diverse. Of course, in cities, right? In cities. Bigger cities or -- like, Baltimore, DC, New York, those places tend to be a little bit more diverse. But I, I was afraid, moving to the Deep South that it would -- that I would feel it a little bit more than I have, but I don't. So I think it’s pretty representative. I often wonder if it's because I'm on a college campus a lot, where you have lots of different people, international students from all over, that makes it feel like that. Now, I haven't ventured out into, like, more rural parts of the Deep South yet.

SUDS Faculty 1 also expressed the stereotype of those who traditionally were seen as someone that is capable of being a scientist, those who were typically clean-cut white males. After a follow-up probe regarding how informal conversations among colleagues around the topic of diversity in science fields needs to be addresses at all levels in the academy, some expressed how their idea of who traditionally engages in science teaching and research has evolved, by stating:

> Not necessarily the science, but the idea of who can do it, who can do science. Or who can be in these positions or who can be a professor or -- or a research scientist or -- yeah, whatever. Um, and I think more and more people are trying to show, especially, younger children -- so -- because for me it always starts with people seeing -- with kids seeing people in positions that they might desire to have.

This sentiment was also shared by USU faculty 3, who expresses a view of what scientists traditionally look like by stating:

> And so, you know, I absolutely get the fact that if you are a scientist, if you're majority -- from a majority group of neuroscientists and you have been in science, and all you've ever seen are other majority folks, then the bias and the assumption that you have is that others outside of that group are less able or uninterested or not capable. The idea that the -- the

> picture that you automatically assume when you think science is not a person that you haven't seen doing it. And now they've seen a whole lot of other people doing it. And so I think these changes in perspective -- I don't think its serendipity. I think it is exposure, a lot of it. I mean, equal lives in the playing field trying to have a rubric -- rubric and being very intentional and strategic and fair about how we assess applicants.

However, in a conversation with USU Faculty 5, she recalled a time while she was working through graduate school as a time when universities were cognizant of underrepresentation in areas of science:

> Well, so I think that the discussion about underrepresentation has been in the field for decades. I mean since I was a graduate student, I knew that leadership and faculty were aware that the numbers of individuals from those groups were just not representative of their numbers in the population.

USU Faculty/Admin 5 went on to express that even today, underrepresentation in the science fields is still an issue in higher education:

> With respect to minority status, so if 25% of our applicants are African-American, Hispanic, disabilities, Native Americans -- the NIH definition of underrepresented minority -- -- and on average about 25% of our applicant pool falls into that category, then our first-year class should look like that. And so it is not a quota; it is just saying, "This is our expectations. This is our hypothesis, that that's what will happen. If we're unbiased in our evaluation, then that's what we should get at the end."

SUDS Faculty/Admin 2 provided a very early post-civil rights era perspective on diversity in the Deep South, noting:

> When I started, a lot of my colleagues were very skeptical of minority students. It felt like they would be inferior in terms of their abilities and not as well prepared. And one of the things that really changed minds was, um, that in the early years of our programs, the minority students performed as well as the majority students.

This account continued as SUDS Faculty/Admin 2 discussed how the performance of URMs yielded more appreciation by his colleagues for the talent of URMs:

> So part of it was just seeing, "Well, hey. You know, I have had some minority students in my classes, and they have done very well." Right? So that -- that -- without even thinking about it, that changes your perception. Now, I mean, we've had some that didn't do well too, right? And that was reinforce the old stereotypes. But I think the ones that did well were outnumbering the ones that didn't. And, you know, over time I think we won over most people.

SUDS Faculty/Admin 2 described how he identifies URM students who have potential to be successful at matriculating into a PhD program in a science field. SUDS Faculty/Admin 2 highlighted enthusiasm for science, self-confidence, behavior, the content in their application letter that may speak to commitment to studying science, and where they attended school as criteria for success. This suggests that some URM students may perform well and other URM students may not, which could cast a perceived stereotype upon URM students as not prepared for university work. Although SUDS Faculty/Admin 2 shares the fact that some URM students, particularly African-American students, perform well in college science courses, those who do not may be perceived as not having the above criteria for success in science, especially if they attended an HBCU. SUDS Faculty/Admin2 provides evidence of this perception by the following:

> So we have a lot of low quality HBCUs in the Deep South. We have some good ones. But we have learned the hard way that if you take a student from a low-quality school, you got to work a lot harder to get them up to speed because they -- their background knowledge is just not there. And so, you know, that -- that's a particular challenge that we have to deal with.

This comment is significant as the notion that HBCUs produce an academically inferior product, as it relates to the caliber of students prepared to excel in science, was either directly mentioned or alluded to during the interviews with USU Faculty 1, SUDS Faculty/Admin 2, and SUDS Faculty/Admin 3.

Recall that USU Admin 3 talked about a time when her colleagues did not recognize the names of HBCUs, which may have affected the confidence faculty had in URM students selected to work in their research laboratories, as highlighted by USU Faculty member 5, who expressed her observations relating to prospective African-American students:

> So I -- there is a little -- of course, nobody comes right out and says out loud -- "Oh, I don't want to get this student because of their demographics" -- not anymore, anyway. But I think it's more like the undergraduate institution. If they went to a school that the faculty member isn't familiar with, um, you know, it might be a minority-serving institution. Um, for instance, like, University of Puerto Rico. We have a lot of our students that come through the PR system, and it's not a major research university. And so there is certainly a strong preference for having those students spend some summers at a major mainland university. And if all of their research experience was at their home institution, then there is questions about whether they are familiar with the kind of environment that they would encounter when they come here. So I think some of that is

> some -- and there is a book that came out -- I think it was last year -- about graduate admissions and the fact that many faculty at elite institutions are looking at -- for name recognition in the undergraduate institution. Yeah. So I think -- and sometimes that goes with demographic, right? So if they have gone to an HBCU and we are not familiar with the research coming out of that particular school, maybe it is not a big research institution, then there is questions about "How well paired are they?" So it sort of forces students, if they are savvy, to go off campus for their summers to get that. And we certainly value that, um, quite a lot.

This skepticism regarding the quality of URMs, and interestingly majority students from Minority Serving Institutions (MSIs), tricked down even to the coursework and testing quality, as USU Faculty member 5 commented:

> Or even sometimes it is coursework. Like, we'll run into situations where students have -- all of their exams were essentially multiple choice. And sometimes these are majority students from large research institutions where nobody wanted to bother to grade essays. And so they have never had to write -- or really analyze a paper. And it's not uncommon for students to come in and they have this huge variation in how much real critical analysis they have been asked to do before at all. So we have a lot of -- or we have tried to develop ways to transition all of our students. But we also recognize that students who come from smaller schools where there wasn't as much research going on around them all the time or where their coursework was a little more rote memorization and a little less analysis are going to have, as you say, some catching up to do.

SUDS Faculty/Admin 2 discussed data regarding the measurement of student performance, using GPA, between URM transfer students from low-performing institutions and those URM transfer students who transferred from more reputable institutions. He provided evidence of a perceived lack of quality of URMs that transfer to SUDS, as related in the following anecdote:

> Um, we were totally surprised that someone who could come from an HBCU with a very good grade point average -- I mean, one of them had like a 3.8 or 3.9. And she -- I don't know your background in biology, but she did not even know that ribosomes are used to make protein. But we found that these three girls that -- that we took in one time had all gotten by because they were really good at memorizing. And they had just memorized stuff. And -- and these particular HBCUs reward memorization. And so you can graduate and not know anything but have done really well by memorizing everything for your courses.

During a discussion of a study conducted by SUDS Faculty member 3 regarding transfer students and math success, he alluded to how URM transfer students may perform:

> I did a study for a proposal a year and a half ago where we were proposing a project to work with a group of transfer students. And we went back and pulled the performance data on three years' worth of students transferring from a local community college, which is right, you know, in this -- right here in the Deep South. And about 50%t of the students coming in took math, took a -- something like a college algebra course their first semester here, which tells you that half of them had not done the math when they were at the community college. And 50% of them either got a D or an F or withdrew. So, you know this is a problem. They can't go on to whatever it is they want to be their major. I don't care what your major is. You're not going on until you succeed in that math course. So, you know, those are just examples of different kinds of programs that are not necessarily explicitly built for minority students, but they are populations that tend to

have higher proportions of minority students. And usually it is one of the justifications for why you should. It is not the only one. This is a problem for all transfer students, but there is a higher proportion of those transfer students that are minority students also.

SUDS Faculty members 2 and 3 seem to share the idea that students from HBCUs, particularly URM students, seem to be ill-equipped for the rigors of introductory level biology. This has shaped a perception of how URM transfer students will perform in their courses.

Sub-theme: Progress in addressing diversity in science fields requires time and brain-space to work together in a consistent, inclusive, structured, and supported manner. As faculty and administrators move beyond their perceptions of what diversity looks like in science disciplines, they seemed to unpack their preconceived ideas about diversity in science fields and reconfigure them using open conversation. In other words, the more frequently team members interact and engage with one another to think about the need to increase diversity in science fields, the more opportunity they have to learn innovative ways to accomplish that with each other. Therefore, references that describe the sub-theme, encouraging collaboration and team learning, are related to collaboratively utilizing atypical thinking methods and working in a culture of collaboration (Marsick & Watkins, 2003).

USU Admin 3 provided data regarding how she and her colleagues learned about diversity in science through consistent communication. In a conversation with USU Admin 3 regarding the interactions she has among her colleagues when addressing diversity and underrepresentation in science fields, she shared her thoughts describing the dynamics of those conversations and how she feels they progressed in order to develop solutions to success barriers for URM science students. USU Admin 3 stated:

> In a word, I would say "encouraging." I'm optimistic. Particularly in this office, I'm surrounded by people who are part of the choir so to say, people who are passionate about graduate education, who are passionate about science, but who are also passionate about diversity and access, overcoming barriers, ensuring that diversity is not mistaken as inclusion. And ensuring that not only students have access, but they have equal opportunity for success.

USU Admin3 discussed a time when she needed to share with her team the value of diversity programs, particularly the programs that exist on their campus, and the success they can engender. She mentioned that she is a product of one such science program aimed at increasing representation. USU Admin 3 recalls a time when she had to inform her colleagues about programs affecting diversity, access, and other barriers:

> And they didn't know what various science diversity programs are available on campus and some of these other initiatives that really focus and help support and build skills for underrepresented students who otherwise wouldn't have these opportunities. And so part of this has been that piece. But another part of that is taking that education that I've gained in those committee meetings to advise undergrads, as they are applying or advise their faculty or the letter writers about what we are looking for, because they don't always know.

Developing this culture of open dialogue had evolved at USU, not only going from very little or no conversation at all regarding URMs in science to open and direct engagement on the matter but to displaying data to support various claims. The situation is explained by USU Admin 3:

> But the conversation has changed. And faculty are looking much more globally -- they aren't assuming that everybody with a great GRE is an outstanding candidate, and they're

> not holding poor GREs against a student. And we moved much more towards holistic evaluation and looking at, especially, what their peers, their colleagues at other institutions, are saying about the potential for this particular student.

USU Admin 3 goes on to talk about the reality of an open conversation about topics that may be uncomfortable for some and sensitive for others, and the manner in which a respected URM colleague should handle such a situation:

> But I've also been pleased that -- and I've worked hard to be collegiate. I mean, certainly be professional, but not for people to feel attacked when I say, "Oh, well, like you can't say that, you can't do that," versus "Well, let's consider this, because we really want to -- we want to think about this in this way. We don't want to hold this against students and blah, blah, blah." Because at the end of the day, if people are going to slip up, I want them to. Because I can't correct it if they don't. Or the chair of the committee can't say anything. We won't know to correct it if the faculty don't feel comfortable enough in that space to be honest about how they are reaching the decisions that they are. I am proud to say that I feel my -- I find that my opinion is very much valued in those meetings, that people turn to me to ask me for my insights.

This quote references some characteristics of collaboration and team learning, such as working together to institute change and using different perspectives to understand an issue. USU Admin 3 described a team dynamic that led to meaningful interaction that was candid yet professional and produced acceptable decisions regarding admissions. USU Faculty/Admin 5 shared a perspective on how the team learns about issues affecting their department, and ultimately how decisions made about student acceptance can affect diversity:

> Show the data to my colleagues, articulate what assumptions people have been making over time, and see if those assumptions hold up.

The emphasis on using data to inform their decisions has impacted the yield from their discussions, as USU Faculty/Admin 5 further explains:

> So one -- there's certainly a variation among faculty in how much they agree with us that the GRE is not a helpful metric. But because they're on a committee of -- they're divided up into four different committees, um, and they have to discuss it in person, then I think there -- the majority opinion is in agreement with the data, which is encouraging because they're scientists -- and they should -- they sometimes come back at us a little bit with our methods. They say, "Well, there is selection bias."

USU Faculty/Admin 5 broadly explains the mechanism of open dialogue and often unfiltered discussion on underrepresentation in science areas as she talks about how some faculty have changed their social constructs regarding URMs in science:

> So we do two things at the beginning of the admissions season during orientation for faculty here on the committee. One thing is we do talk about implicit bias just for a few minutes, mostly to make sure they've heard of it. So, you know, partly because we have been talking about it here. But we're not the only ones talking about it. I mean, it's in the public domain now. Most people are talking about implicit bias and have heard the term. So we talk about it, but we try to talk about it in terms of "How do you approach a decision about a graduate applicant? You know, what -- where might the implicit biases be? And how does one fight against that?" So we have been talking about it year after year after year, um, just too kind of get it in their minds.

This evolution of open dialogue was explained by USU Faculty member 3 while recounting a story about an African-American female prospective student being interviewed by a Caucasian male faculty member:

> But he went on to say that when he had first met with her -- no, when he first got her application, he was talking to a student in his lab about the school that she went to because her overall -- her cumulative GPA was a 3.0 or roughly a 3.0. And the grad student in his lab talked about what a weak school this was. And so the PI -- the faculty had a tremen- -- terrible impression of her academic skills because this was -- it's supposedly a subpar school and she had not done as well. And he went on to talk about this in the committee meeting when we were discussing whether or not to make her an offer. Um, and he went on to talk about how he didn't understand why she would choose to go to this subpar school. And he said something -- you know, we make allowances like this when we consider the quality of the institution or whatever for underrepresented students, but not for -- we don't generally do that for majority students. And, I mean, I'm the diversity director, so I'm like, "What?" And on the one hand I was proud. Because every head in the room was like, "No, you didn't just say that out loud. No, you didn't really think that." Because that is not -- we don't discern -- we have been working hard to move away from those types of distinctions. But at the end of the day, she actually was an underrepresented student.

This quote illustrates how having an environment for colleagues to engage in open conversation allows for exposure of biases that may affect their decisions. Exposing biases is one variable that can be identified and understood to encourage group learning, as further discussed by SUDS Faculty 3:

> Um, they happen in kind of several different ways. I think one is faculty members will just bring up the topic and -- and discuss it in -- usually in response to an event or something that's happened. But those kind of spontaneous discussions happen. Sometimes there are specific programs or seminars or workshops on campus that might stimulate people to think about that. And then there are specific offices, of course, on campus that its job is to, um, is to address those issue.

Conversations framed by specific questions regarding URMs in science and the need for a program aimed at addressing this issue were also highlighted by USU Faculty member 2. When relaying the importance of these types of programs to colleagues who are not as familiar with this issue, USU Faculty member 2 identifies a possible reason for the gap in perception and reality:

> And they'd be like, "Well, you know, I feel like we're already pretty diverse. Why do we need these special programs?" And I'm like, okay. Well, maybe, like, they're not seeing the same problem that I'm seeing because of the way that I've been describing it.

USU Faculty member 1 revealed that this evolving collaborative team-building environment was not always so collaborative. His description of the team environment spawned from a conversation regarding the preparation of a talent pool of faculty who may want to lead some of USU's "diversity in science" programs. At the beginning of USU's diversity work in science areas, the lion's share of the work was led and completed by a small staff, whereas USU Faculty Member 1 voiced a need to recruit more faculty leadership:

> You know, and again, so the faculty and staff, in some ways, have been -- have been -- well, everybody's -- I've met nobody who's not supportive. We used to have a steering committee that was some of the sort of mid-top-level people.

USU Faculty member 1 provided an example that embodied the characteristic of team learning that describes how different approaches of thinking can lead to processes and solutions that support collaboration:

> Well, again, what I would like is, I'd like more faculty involvement, right? I mean, my colleague had an idea, which I'd love to see get implemented, which is that there would be a set of faculty committees. There would be an academics committee; there would be an undergraduate research committee; there would be a programming committee that would deal with things like, you know, educating our students about diversity and about the other kinds of challenges that they're going to face. I mean, again, my colleague spoke very eloquently about this at our faculty meeting yesterday, where I think we're about to extend a faculty tenure-track faculty offer to a young African-American male faculty member. But she was like, you know, "You guys can talk all you want about mentoring, but there's going to be a lot of challenges that this person's going to face that you don't know anything about."

Parties involved in these types of discussions and decisions are multi-disciplinary, from various science departments, as well as from service units of the institution. USU Faculty member 1 discusses the types of partnerships involved in collaboratively addressing diversity:

> So one thing that we could do more effectively but we've done, you know, somewhat effectively, is work with partners inside the university. Right? So we have a great partnership with folks in academic advising. And three of their senior science advisers are designated to be the advisers for our students. Again, Diversity and Multicultural Affairs, the partnership has been sort of on and off, but there's some good people there. We have a very strong relationship with admissions.

This quote echoes the theme of collaborations and teamwork, as described by Watkins. Developing a corps of leaders who can and do promote change at various echelons within their institutions is an effective approach in a bureaucratic and habitually balkanized architecture of higher education, according to Watkins (2005).

Sub-theme: Understanding diversity issues in science areas requires open conversation with diverse group members in a safe environment that challenges perceptions and illuminates the problem. The dynamics of collaboration and team learning seemed to be a product of purposeful conversation about the populations of students that are successful and those that are not successful in science areas. Participants described their collegial interactions as open, occurring in an environment that was safe for sharing (referred to as "brave spaces"), having 'brainstorming sessions for problem solving, and having an opportunity to learn about barriers to success for URM students. The references in this sub-theme map back to the original framework's idea of promoting inquiry and dialogue. For example, USU Faculty member 2 discussed the fact that the proximity and consistency of contact provides an opportunity to communicate and learn from each other:

> You know, there have been a lot more African-Americans in labs lately. A lot of that -- you know, just the program alone, I mean because of the funding, a lot of these guys have been out there in labs. And they wouldn't have been, you know, if there wasn't a program like this. But then what's happened is, um -- like, that's what breaks down people's implicit biases sometimes, is just, like, getting to know people that you haven't interacted with.

This idea of capitalizing on the knowledge gained when interacting with students is further described by USU Faculty 1 during a conversation about losing opportunities to engage STEM students who did not choose to pursue a degree in biomedical sciences, as he states that those students can be mentors for other science programs. To obtain more clarity, I probed by recalling his previous statement regarding relationships and partnerships with other groups on campus for student access, and wondered about asset sharing as a bridge for dialogue. USU Faculty 1 stated:

> What I would like is -- for at least to share knowledge. Right? And also, I mean, again, there often are places where one program can direct students to another program. Right? Several of our kids are McNair scholars now. Right? Certainly some of our kids will be in other programs.

USU Faculty member 3 also shared insight as to what a conversation would look like regarding the manner in which colleagues exchange thoughts and ideas about diverse applicants:

> They used to be, "Oh, well, this is" -- and I'm thinking about admissions committees' conversations, alright, and talking about an applicant. Oh, it used to be harping on the GREs. Everybody's harping on the GREs. And we've moved to a point now -- and my colleague has recently published a paper on how GREs don't matter. From our own data they don't tell us that students are going to be successful. And so we've gone from, "Well, you -- our students are less competitive and we -- we just need to overlook their GREs" to, "Oh, the GREs really don't mean anything. And so let's look -- let's just ignore those for everybody and talk about the quality of this particular student." But the conversation has changed. And faculty are looking much more globally -- they aren't assuming that everybody with a great GRE is an outstanding candidate, and they're not holding poor GREs against a student. And we moved much more towards holistic evaluation and looking at, especially, what their peers, their colleagues at other institutions, are saying about the potential for this particular student.

This particular situation was echoed by USU Faculty/Admin 5, who also discusses the manner in which colleagues exchange ideas and views, which sometimes leads to a modification of their perceived social and academic constructs regarding URM students. He explained:

> Our admissions process involves 60 faculty on average because we're processing 12 to 1,300 applications a year with this big umbrella structure for our PhD admissions of 14 different programs all doing their admissions together. There's certainly a variation among faculty in how much they agree with us that the GRE is not a helpful metric. But because they're on a committee of -- they're divided up into four different committees, and they have to discuss it in person, then I think the majority opinion is in agreement with the data, which is encouraging because they're scientists -- and they should -- they sometimes come back at us a little bit with our methods. They say, "Well, there is selection bias."

Engaging in these types of mulit-faculty interactions, where faculty operate in an environment that allows for the open flow of ideas and comments, may expose biases but also allow for an opportunity to make this process part of the culture of admissions. As previously explained in the major theme of this section regarding perceptions of diversity, USU Faculty member 3 talked about how certain colleagues had percecived the quality and talent of URM from MSIs as being sub-standard. This conversation continued as USU Admin 3 explained how, during a selection committee meeting, a faculty advisor expressed his view that exceptions were made for URMs and not majority students, causing USU Admin 3 and others on the committee to react with noticeable surprise and disapproval. However, it was the next statement by USU Admin member 3 that enforces the sub-theme of promoting inquiry and dialogue:

> But I say all that to say what happened next. A couple of days later, the chair of that committee went and talked to him about how inappropriate that was and how these are the things that we are trying to focus on with the quality of our students. And whether this student were underrepresented or not, we don't judge anybody by the access that they have. And we don't hold it against them. What has she done -- whatever she had access to, what has she done with it? What has she achieved? And what has she accomplished? And that is the lens through which we want to assess our applicants.

Similar scenarios were identified at SUDS, as explained by SUDS Faculty member 2, who communicated how he and his colleague became the catalyst for the sort of productive interdisciplinary dialogue that can bring about positive change in how the faculty perceives URM science students:

> When I started, a lot of my colleagues were very skeptical of minority students. It felt like they would be inferior in terms of their abilities and not as well prepared. And one of the things that really changed minds was, um, that in the early years of our programs, the minority students performed as well as the majority students.

By encouraging open conversation in a safe space, obstacles outside of the realm of academics often emerge at other institutions that have not yet evolved their environments to promote conversation with students from different groups. SUDS faculty discovered that some URM students at other institutions needed support in areas beyond academics to better acclimate to their environment, as SUDS faculty member 2 describes:

> That's sort of a joke because I go to these conference where is there is other programs like ours. Like, you know, there is one in Iowa. And they say, "Well, you know, a big issue for us is, like, we bring these students in, where can they get a haircut?" Right? I was

> like, "We don't have those issues." We have a very integrated community. Everybody is -- is comfortable with the environment here. So we don't really have to have that issue discussed. We do bring in role models who are minority faculty to talk about life after graduate school, things you do.

Creating an environment where open and clear discussion may be facilitated among students and faculty provides an opportunity to highlight challenges that URM students may be experiencing both inside and outside of the classroom.

Theme #2

Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way. During the study, every participant provided data related to having a mechanism to perpetuate and build upon collaborations and discussions, as highlighted above. References to this theme described a learning environment that is embedded in the operations of each campus's science diversity activities, with new knowledge from those learning experiences used to advance the diversity mission. Evidence in support of this theme was demonstrated most strongly by USU faculty, but significant responses were also provided by SUDS faculty. Most references to this theme were provided by USU Faculty member 3, who mentioned how she and her colleagues face challenges and barriers to URM science students' success:

> And if we want to overcome those barriers and make things better, we've actually got to change the institution as well. And so -- and we get into those conversations about diversity versus inclusion. And, yes, we have a diverse group. But are they respected equally? Do they have the same voice as everybody else? Do they feel that they have the

> same voice and opportunity as everybody else and -- and that everyone at the table and everyone in the environment values what they have to offer and listens to what they have to offer?

This comment seemed to indicate the effort towards creating more opportunities to engage with colleagues and the continuous need for everyone to have a safe space to share. Having this type of environment seemed to evolve from a setting that was more restrained in discussions of diversity and inclusion in an atmosphere where sensitive issues around ethnicity, performance, and acceptance are often on the agenda. The notion is emphasized by USU Admin 3, as she highligted the lack of her colleagues' awareness of the diveristy around them, not just in their own state, but on their campus, as well:

> …they didn't recognize the names of HBCUs. And they didn't know what [science diversity program 1] and [science diversity program 2] and some of these other initiatives….

USU's science diversity programs 1 and 2 follow national models, and in their own right have earn national recognition. Given these accolades, many USU faculty and staff who work with prospective URM science students are unaware of their existence and prestige. Another example of organized faculty interaction to learn about and discuss diversity in science comes via faculty professional development opportunities, such as hosting guest lecturers who focus on the area of diversity and inclusion in science areas. USU Faculty member 1 describes the process by which he is engaged to participate in such opportunities:

> And then, now, five years ago I get an -- our whole -- our whole faculty gets an e-mail, right? Mike Summers is going to come from UMBC and he's going to give a talk about, you know, potential for a new undergraduate program increasing diversity. I'm like, "I

don't have anything booked in that time. I'll go hear this guy's talk." Right? And -- and it was phenomenal, right, because he talked about the Meyerhoff program. And, you know, the way he talked about it was not just anecdotes, it was data, right? Because the great thing about that program is its data driven. So -- so I went to that talk and I'm like, "Oh my God, I've got to be involved in this.”

This particular talk provided opportunities to learn about URM science student program development:

> And he had been talking to HHMI about why -- why is the Meyerhoff so successful and why can't anybody else be successful.

The above examples were also highlighted at SUDS, as SUDS Faculty Member 3 described how he and his colleagues regularly learn from each other about the factors affecting URM success in the natural science areas:

> Um, so I've -- I've found the conversation here at SUDS to be very similar to every other institution I've been at, that those conversations do happen. Um, they happen in kind of several different ways. I think one is faculty members will just bring up the topic and -- and discuss it in -- usually in response to an event or something that's happened. But those -- those kind of spontaneous discussions happen.
>
> Sometimes there are specific programs or seminars or workshops on campus that might stimulate people to think about that. And then there are specific offices, of course, on campus that its job is to, um, is to address those issues. Um, so I -- I see those conversations kind of happening at those multiple levels a lot of times. It is not unusual. And I don't think it is a whole lot different here than it is anywhere else.

Learning about possible funding opportunities to support diversity work seemed to be an important factor in building a sustainable institutional infrastructure that embedded communication mechanisms to maintain the flow of new knowledge and best practices regarding URMs in science. These types of formal learning opportunities in the areas of diversity and inclusion seem to be part of the learning culture at USU. USU Faculty member 3, during a conversation regarding her role on admissions committees, explained the process of educating research faculty about how their opinions and biases may affect admissions decisions:

> And I'm in the admissions committees. We also have our diversity in science programs that provides additional support and programs and opportunities for students to be part of. And faculty are becoming aware of this, and they have benefited from their students participating. And so that's another positive associated with a diverse population. I think -- I think one of the other pieces though, um, USU annually has what we call THINKposium. It's a -- supposed to be a combination between a symposium and a think tank, right? They came up with this term. It has historically been organized by the Office of Diversity and Multicultural Affairs, which is the big arm that oversees diversity for the campus. And it's a -- it's a one-day symposium centered to think something relevant to diversity and inclusiveness and da, da, da.

USU Faculty member 3 goes on to describe how USU utilizes faculty who have expertise in diversity-related areas and supports professional development opportunities. Some activities are part of the aforementioned THINKposium that may provide insight on variables affecting decisions by individuals or committees that have more of a social impact:

> And a few years ago, I want to say maybe three years ago, the speaker, who is faculty in psychology here at USU, done tons of research on implicit bias, right? So he gave a talk.

> Well, he gave a lecture. A lot of people I know weren't thrilled about the structure. But as a scientist I loved it. Right? Data-rich about what implicit bias -- what implicit bias is, what it does, how we all suffer from it.
>
> A couple of examples where the group -- audience participation. And I don't think there could possibly be a person in that room who didn't understand what implicit bias was, how it impacts us, how we've got to work hard against it. And one of the people there was my boss. She attended the [THINKposium]. And she is a research scientist. She's a biochemist, right? She's our director. And she became a believer, right? And -- because he had all that -- in addition to saying what we believe, he had the data, right? And so it was very eye-opening that with the data, right, it's not just we aren't -- we aren't saying these things because it warms our heart or it's the right thing to do.

This combination of a formal meeting and a think tank format was supported by statements provided by USU Faculty member 1, where he describes the interdisciplinary collaborative partnership inside USU needed to support URM science students:

> So we have a great partnership with folks in academic advising. And three of their senior science advisers, right, are designated to be the advisers for our students. Right? So they don't get just random science advisers. You know, what classes you should take and so on.

This multidisciplinary approach to learning seems to be part of the culture of learning about diversity and inclusion in the science areas at USU, bringing together faculty from research sciences with administrators to better understand the issues surrounding URMs who are pursuing careers in science, as well as to make adjustments based on new knowledge. This notion is supported by USU Faculty/Admin 5 during a conversation about how the very nature in which scientists learn can directly affect how they make data-driven decisions regarding admissions:

> So we're scientists; you're scientists. Scientists value fairness and common sense and logic. And logic says that the scientific workforce should look like the population. And if it doesn't, then we should do something. We should figure out why. We're scientists. We should discover why that is. And we should challenge our assumptions when we think about admissions and what the best way to train somebody is. So my particular, um, favorite thing to do is collect data -- show the data to my colleagues, articulate what assumptions people have been making over time, and see if those assumptions hold up.

USU Admin 3 solidifies this process by describing how a suggestion by her supervisor provided an opportunity to exchange information and be persuasive regarding the work that takes place to increase representation in science areas:

> And she talked about the fact that one of the places that they have been most effective in educating faculty and getting some buy-in, is 10-, 15-minute little snippets in the faculty meetings and the departmental meetings, where all of the faculty are required. And -- and the faculty -- the chair says they're going to come and they are going to talk about this. And whether they want to be there or not, they're required to be there, and they have to listen.

USU Faculty/Admin 5 describes a different venue where the exchange of ideas and data about URM student success can not only improve URM student outcomes and address the diversity of faculty in science areas. Attending conferences allows for opportunities to build a support network with various leaders from different colleges and universities, who may have a similar vision to address underrepresentation in science areas, or with those who wish to move in that direction. She states:

> So, you know, and I go to conferences that are related to graduate education and I see the same people, you know, my counterparts, Ellis or Vanderbilt or places like that. And we'll sit around and brainstorm. Like, "What are we going to do about faculty diversity? Because I think most of us recognize that -- that we can -- we've done better jobs getting diverse graduate students. And now we're doing well getting them to graduate. But it didn't automatically turn into the faculty diversity problem solved.

USU Faculty/Admin 5 highlights the role that attending conferences can play in providing leaders an opportunity to learn from colleagues about common issues and build relationships. She did, however, point out that these annual conferences usually host the same participants, those who already understand the problem with underrepresentation but are faced with the reality of returning to their home campus to engage in the challenging and slow-paced work of institutional change.

Theme #3

Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions. Emerging from the data are references that indicate the existence and development of formal and informal systems to collect data and share the findings with colleagues. As mentioned above, having data available for review provides support for discussion and decision making. Data were said to contribute to institutional learning regarding diversity in science areas at these select institutions. All but one participant provided references to a system to capture and share learning regarding how to impact underrepresentation in science areas. References to this theme map back to “create systems to capture and share learning” of the framework for this study. SUDS Faculty Member 3 discusses how the faculty population distribution in the science areas does not reflect the demographic distribution of their class diversity distribution, which affects faculty recruitment:

> It's very clear that we're -- we're trying to put the advertisements out in in venues that would reach minority populations so that at least they know about it. We have to report the numbers that are in the pool, the initial pool, and the numbers that are in each of the stages where you narrow it down to -- to the final -- you know, ultimately to the final candidate that gets the job offer. So, you know, it is one of those things where if you know it's being measured and being watched, you tend to pay a little bit more attention about it.

This example illustrates the challenges that institutions have in the recruitment of URM science faculty; moreover, this issue highlights the need to require a specific form of data collection and presentation. The above reference also highlights the differential between the number of URM faculty and the student population and how that impacts the discussion during faculty search committee proceedings. SUDS Faculty member 3 also emphasized how their understanding of diversity altered the data they acquired during faculty search committees:

> And over a period of years, probably almost all faculty members are going to cycle through at least one search committee, if not several. So, you know, within a year or two, pretty much everybody in the faculty will have been exposed to this as an explicit conversation as part of that training. And it's happening on a continuous basis, too. Every search committee goes through this. And that means every time you're on a search committee, you're going to be exposed to it again. So, it's not the first time. And it may

> not be the fiftth time. It may be even more than that. So I -- you know, I think that's a good thing in terms of continually revisiting it, keeping it towards the forefront of thoughts and ideas and discussions. It does come up in faculty meetings. Um, you know, it is not just a rubber stamp kind of thing. It actually is discussed as we talk. You know, the search committee, for example, meets with the faculty at the point where we are deciding who to bring on campus.

The open and direct conversation about candidate review is a way to collect qualitative data and share that data in real-time situations while the search committee is convening. These formal and informal systems were used when discussing student recruitment and retention, particularly URM students, in the science areas. In this same artery, USU Faculty member 3 discussed a process during faculty admissions committee orientation that allows the committee to make digital remarks and share data and opinions with the committee regarding student candidates:

> The system that we use for reviewing applications used to be the faculty could just go into the system and look at the PDF and download it. But what we would have in meetings was spreadsheets. Student name, GPA, GREs, pretty much the numbers. Right? And around about that time, the office invested in creating a database, right? And so now what we did away with the spreadsheets. And so now what we see in the meetings are who the letters are from, who are the names of letter writers. There is -- you can click on and see the comments that the initial faculty reviewers gave and their scores.

USU Faculty member 3 goes on to discuss how an evolution from focusing on the traditional quantitative metrics that flood the application for admissions has changed the weight of those types of metrics to increase the weight of some qualitative metrics. USU Admin 3 states:

But when you are reviewing in the meeting, you have to go and click on the PDF to look at the application. So the first thing that they see and that they are inundated with is not the quantitative metrics that we know don't reflect the quality of the student but it -- very significantly biases you for or against the student based on quantifying -- looking at those numbers. And so we changed what they see first, and what they see most often. Again, the scores are there, and they are in the application but -- and so it forces them -- you know, when you go on the application, the GREs and the GPAs are on the first couple of pages. But so you keep flipping and you see the CV, and you see their statement of purpose, and you see the letters. And so you really can't just -- it's no longer as easy as it was to just focus on those quantitative numbers, which -- which faculty are very comfortable with. And so it's not a quick and easy, anymore.

This example illustrates progression from a traditional numbers-driven system to a more comprehensive system that includes contextual information, which has been a factor in USU's learning how to organize and disseminate data that will provide a complete profile of prospective students, particularly for URMs. Interestingly, several participants shared remarks that indicated the need to assess, revise, and remodel their current systems of learning. These include the development of various faculty committees, attendance at seminars and workshops, development of inventories and surveys, and publication of research on topics related to diversity and inclusion. Part of developing systems and processes for collecting and using information at times comes from interdisciplinary engagement among units within an organization. This notion was highlighted during a discussion with USU Admin 2 regarding how he and his colleagues function as "scientifically trained administrators," meaning that part of their role is to mediate between admissions, the research faculty, and the students. This unique design of leadership appeared to provide USU Admin 2 an uncommon vantage point from which to collect information that may bridge the gap between the research mentor and the success of their students. For example, USU Admin 2 described how anecdotal evidence can be used to gain a clearer understanding of mentor and student issues:

> Because we can speak the language of the advisor, and we can be, you know, sympathetic to their needs and understand their needs. But also we -- you know, we know the students well, and we kind of know their needs. So I think it gives us more credibility with the faculty mentors by having that background.

This example highlights distinctive structure for USU's diversity and inclusion programs, and how learning from experience has allowed USU to increase URM science students' progression through the higher education pipeline. Another example was provided by USU Faculty member 2 during a discussion regarding funded program outcome data:

> But we haven't done a good job of translating these relationships and these pictures on the wall to actual hard data that we can then present to people that we're trying to convince or we're trying to bring on board like -- like these other faculty out here. So that's something we've started doing more of is -- is actually doing research on some of these things.

These examples provide supporting evidence of the existence of systems, either formal or informal, that are part of how organizations assimilate understanding. Further, they illustrate the importance of disseminating data to promote gains in the representation of minorities in science areas.

Theme #4

Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have *responses, and advocacy increases morale*. The supporting data for this theme was referenced by 89% (8 out of 9) of the participants making references to a leader or leaders within their organization advocating for the exploration of issues related to underrepresentation in science areas and providing support and direction to these efforts. Participants identified a number of leadership behaviors, including managing turnover, advocating for student merit, strategic budgeting, fiscal planning, providing faculty with professional learning opportunities, building a culture of trust, and encouraging and cultivating an environment for the discovery of new knowledge for impacting underrepresentation is science areas.

USU Faculty member 1 described the history of the department's development of its premier program to increase underrepresentation in science areas and the amount of time it took to create a team of staff and faculty who could move the program forward, particularly as employees departed:

> There was -- there has always been a lot of turnover at -- I mean, there was a huge amount of turnover at the top of the University right when this thing started. I mean, thankfully the new chancellor, provost, and dean of the College of Arts and Sciences all have been super supportive. That didn't have to happen. … Now a year and a half ago, we started expanding the staff pretty -- maybe two years ago now, right. We started expanding the staff. We now have four staff members instead of one, which is what we had for the first two and a half years.

To gain more understanding of what was being described as "super supportive," I probed with a follow up question regarding how USU Faculty 1 and his program colleagues are supported and incentivized for engaging in science diversity activities. USU Faculty 1 indicated that no financial incentive was provided to faculty, but the staff and the program structure did receive financial support. This includes wages and new positions, as highlighted by USU Faculty 1:

> And then again, we were so focused on just, you know, giving these kids the kind of academic support that they needed, that some of the other things fell by the wayside. Now a year and a half ago, we started expanding the staff pretty -- maybe two years ago now, right. We started expanding the staff. We now have four staff members instead of one, which is what we had for the first two and a half years. So now I think we are doing a better job.

The aforementioned process illustrates not only the importance of leadership to the continuity of a program designed to advance URMs in science but the degree to which support for such initiatives led to a thriving program when institutionally championed, from the grassroots to executive leadership. However, this is not always a painless and seamless process of learning what is necessary to be successful, particularly as it relates to personnel. USU Faculty member 2 candidly talks about a somewhat dark time when he was considering leaving USU, due to a declining level of support:

> So I feel -- I feel like I have been through -- over the last seven years, I've been through times when I didn't feel as confident that, you know, if we said "this is what we need" or "this is what we think needs to be done," and there was a monetary need for it -- or a monetary – a requirement to do it, I wasn't sure if that was gonna happen. And, yeah. I mean, that -- one, I think that hurts morale quite a bit. I think from the people on the ground running the programs, you know, I think not feeling supported. Like if -- if the money -- and I think this is a thing that can happen in -- in academia and in these big research institutions, is you've got the figurehead -- no, I don't want to say they are

> "figureheads," but the leaders on the top, like the chancellor level who will say, this institution, we are committed to diversity, we are committed to making sure every student, blata, blata, blah. But if there's nobody money behind that, I mean, then it doesn't.

This comment highlights the importance of leadership in the sustainability of a diversity program, as well as the impact on job satisfaction and retention of employees. USU Faculty member 3 expressed concern that leaders might not always be responsive to particular requests or recommendations, noting:

> A few years ago I was not optimistic about higher-ups implementing priorities and changes and recommendations.

USU Faculty member 3 goes on to discuss her relationship and interaction with the supervisor of her unit:

> So I didn't think she was part of the choir. I mean, she's the PI on all of these two big diversity grants and stuff, and I was not sure. And then I came to learn -- and this is -- this has been -- it was extremely educational for me, and this was in comparison to the person before her in the position, who was obviously very much part of the choir, and understood the goals of these programs and -- and very much -- we had her buy in, right? … I mistook her questions about what we were doing and why we were doing it as antagonistic to the mission, versus someone who was less aware and less educated and simply wanted to learn. Right? And -- and so that was a learning moment or several learning moments for me because I'm like, "Wait, you're the PI. You're supposed to be -- you're the one in my corner." Up against the world, right? And I mistook some of that for questioning the value versus wanting to better understand so that she can be an advocate

to her peers and colleagues, who she knows are also gonna have the same questions. And she wants to have those answers.

This anecdote displays the critical role strategic leadership plays in how organizations can affect the progress made by previous learning goals in the advancement of URMs through the science pipeline, and the consequence that open and honest communication may have on the success of a diversity program. As described by Watkins and Marsick (1996), strategic leadership, employed to understand an issue, will consider calculated methods to utilize learned facts to initiate transformation or alter the current course of the organization. This dynamic was described by USU Faculty member 3:

> She's also very strategic in building bridges, and gleaning support, right? And across the board she's involved in BBSP; she's involved in our diversity programs. And through all of these entities and all of this infrastructure, she has -- and with all of the chairs of all the different PhD programs that are affiliated with our diversity programs, she's developed a rapport, a level of trust, a level of confidence and commitment that they had in her, which I think bleeds into these other matters related to diversity and other things that maybe someone who didn't have that level of credibility, that history of achievement, might not have.
>
> And so she's got their trust. She's one of them because she's a PI. She's a research faculty, right? She's got her own lab, her own grants. And I think all of that taken together benefits all of these programs, and all of the individual initiatives that she is trying to advance, including diversity and inclusion.

Establishing relationships, obtaining support, and advocating for diversity programs in the sciences is a hallmark of a strategic leader. Part of this support comes in the form of personnel, as USU provided a new position, in an executive role, to express institutional support for equity, diversity, and inclusion, according to USU Faculty/Admin 5. SUDS Faculty member 3 describes how faculty perceive the degree of support from the administration at SUDS:

> Um, boy. Well, so at the heart of that might be a -- a -- what is a common kind of mistrust of the intentions of the administration from the faculty point of view to begin with. There is also -- tends to be a -- a common assumption that -- that things are being dictated from the top down to the faculty from the administration to begin with. Um, I -- I don't think faculty members are necessarily totally convinced that administrators listen to -- to what their recommendations are on anything, much less in this area. And -- and in a sense, when you're getting into that kind of an administrative hierarchy kind of question, I think most of the mandates about minority status and -- and inclusion in positions is coming from the top anyway.

This testimonial demonstrates the importance of establishing trust with the faculty as a necessary strategy to sustained programming aimed at increasing representation in science areas.

Sub-theme: Scientists use the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields. Emerging from the data was the sub-theme of scientists using the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields. This sub-theme materialized through references from 89% (8 out of 9) of the participants and was framed by a common nomenclature as well as by using the conceptual tools of science, such as organization, systems thinking, and the scientific method, to link science and diversity. Evidence in support of this sub-theme includes references to critical analysis, minority status, data-rich learning, understanding demographics, the science environment, campus climate, diversity solicitation, and the diversity reputation of the institution.

During a conversation with SUDS Faculty member 1 regarding how she and her colleagues engage in conversations about what the science environment looks like demographically, she gave the following account:

> Not necessarily the science, but the idea of who can do it, who can do science. Or who can be in these positions or who can be a professor or -- or a research scientist or -- yeah, whatever. Um, and I think more and more people are trying to show, especially, younger children -- so -- because for me it always starts with people seeing -- with kids seeing people in positions that they might desire to have, but, you know, maybe they don't want to do it because they don't see anybody that looks like them. So I think more and more people are getting -- anybody can do it. Anybody. No matter what you look like or how old you are, how much money you have or don't have. If you're interested in science, if you're a hard worker, if you're smart, if you interact with people well, then anyone can do it. So just that it's not, like, this club that is special for, you know, a particular group.

This excerpt describes the impact of discussion among faculty that leads to redefining characteristics of who a scientist is or can be, and this changing narrative among colleagues has the potential to translate the narrative being disseminated to students. The narrative is also carried forward by USU Faculty member 2, as he describes the type of interaction among his colleagues when they discuss diversity in science and the importance of defining the issue or problem. The following account illustrates a conversation regarding how faculty see the issue of underrepresentation in science areas:

> And so one thing, I guess, we have talked about as a group or at least has been helpful, especially for me, is identifying -- being more specific about what the problem is. And the problem is that, you know, certain groups like African-Americans, Hispanics, are greatly underrepresented, if you look at the numbers in PhD programs and postdoctoral positions, especially in faculty positions. It's so much less than, you know, in the general population. You know, comparatively, if you look for, you know, the percentage of Asian-Americans or Indian-Americans in faculty positions and in our student body, it's overrepresented from what you know, the citizens of the south. So I think that's been helpful also in framing the conversation and being more specific about, "All right, here's the problem we've observed, and now here are the ways we address it." And so, you know, I mean, one thing you can do, like with, you know, programs like ours, these sort of diversity initiatives, is sometimes you can appeal to people's emotions and their heart.

In developing a language of diversity in science, it is important to realize the impact that words have to influence change, to systematically analyze data, and to use that data to inspire leaders to want to participate in the sensitive dialogue. Contributing to the development of a language of diversity and science are references that indicate that scientists work and exist in a systematic and often logical environment. This notion was emphasized by 89% of the participants. For example, during a conversation about PhD program completers and how faculty advisors may be able to identify them, SUDS Faculty member 2 stated:

> Um, one thing is enthusiasm about science. Um, self-confidence, how they carry themselves. Um, what their -- what their letters say about them in terms of their commitment and drive.

SUDS Faculty 2's account provides a view of what one scientist believes are characteristics that a scientist should have. This description of a scientist is further elucidated by USU Faculty/Admin 5, who discusses the discrepancy between the science workforce and the general population:

> We should discover why that is. And we should challenge our assumptions when we think about admissions and what's the best way to train somebody.

SUDS Faculty 1 shared a perspective that is a common paradigm in science, that of cause and effect, as an example of how institutions respond to addressing underrepresentation, as well as the idea that universities in particularly are inherently more accepting of diversity and inclusion than other entities, by the following account:

> So when I was in Baltimore, it was during part of that time -- the most recent time was during the riots after Freddie Gray's death. So there was a lot of responsiveness after -- from the university after that happened. And, well, because it was like the riots and protests were happening, like, right in that same area. And, um, there are a good number of African-American people and students and faculty members at Hopkins whom, you know, spoke up about it.
>
> There were lots of town hall meetings, university meetings with students and faculty and staff. And then there were a lot of initiatives that kind of grew after people spoke up after that time.
>
> And you can see every time that something happens in the world, with respect to, you know, something -- a regular occurrence of black men being shot and killed by police officers, there's always, like, right after that, there's always some -- either an email from the president of the university that states their position on diversity and inclusion and

> listening to the community and trying to interact with the community. So it does seem to be that every time that something happens, there is some response by the university.

The cause of a seemingly unjustifiable incident involving race resulted in the effect of dialogue to bring a sense of understanding of how and why this event could have occurred. Also, developing a common nomenclature might provide comfort to those who are apprehensive about engaging in a social issue, as highlighted by USU Faculty member 3:

> And I think historically in the realm of science, scientists historically are antisocial, don't want to engage on a personal level; they only want to do the work; they want to talk about the data; they want to analyze the data.

As this process becomes more prevalent, particularly around shared interests in science areas, conversations that at first may be uncomfortable or sensitive could become less distressing and may lead to positive change. However, this language used in describing the way of a scientist is somewhat a result of the environmental climate in which scientists must evolve and thrive. SUDS Faculty member 4 describes her experience with URMs at other institutions and the need for mentorship:

> I cannot speak for all the other departments that I have been to because the mind frame was very different. Harvard was a medical school. And it was, you know, postdoc – sink or swim type of lab environment. Hopkins was more basic science. Like, for example, my PI did not believe in taking any undergrads into the lab to work with us because she thought it would be a waste of our time as grad students. So it was very different. Every place has been different. I would say Brown University was actually the one place where they really work very hard with their undergrads. So it was kind of a mix – kind of a mix between the Hopkins and the Harvard experience. Because you had the professors – you

> know, we had all this biomedical research, but then you have a good focus on undergraduates. And I really liked that, you know, that mentoring. But I think here -- I think in general a lot of my colleagues are very aware of this, and they are quite enthusiastic. Many labs have many, many undergrads in their labs. And they are very enthusiastic. Especially having [our diversity program] is like a pretty big thing, you know, trying to recruit underrepresented minorities to that. And also just, you know, trying to help. Right? The only difficulty is that, you know, we have, like, over 600 undergraduates. And we are 140 faculty.

Faculty learned to talk about diversity issues in the sciences in part by mentoring URMs in specialized areas of science. The development of a language of diversity in science is part of the process that not only addresses the issue of underrepresentation in science areas but also creates a culture where colleagues continuously learn and make changes that improve the access and experience of URMs pursuing a degree in life sciences.

Sub-theme: There is no single action that increases representation in science fields; however, a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue. Also emerging from the data was a sub-theme related to the processes involved in increasing diversity in science fields of study. This sub-theme articulates the mechanisms that lead to the increase of URMs, particularly African-American students, in life science areas of study. This sub-theme was referenced by 56% (5 out of 9) of the participants and touched on the general process of diversifying in life science areas, the role of diversity within the organization, relationship building, diversity in faculty ranks, and the deficiency of role models and mentors for faculty and students in the life science areas. SUSD Faculty/Admin 3 talked about the impact of solid partnerships among neighboring

HBCUs and technical/community colleges, which generally do not have robust research agendas but do have a talent pool that could contribute to the diversity at a PWI. The conversation began with a description of a partnership program that hosts URM students from surrounding HBCUS for a residential interdisciplinary research experience on aging-related issues. To sustain such partnerships, formal agreements are established in order to ensure goals are being met, particularly the goal of addressing underrepresentation in life sciences. SUDS Faculty/Admin 3 explained:

> And there are general articulation agreements between the four-year schools in the state and these two-year – they are called technical colleges here. They tend to be a higher proportion of minority students in those technical colleges to begin with. And the ones that are nearby here, there are large numbers of students that transfer from those in into SUDS. So when you look at the population of transfer students from the technical colleges, there is a high proportion of minority students. And it turns out to be one of the major feeders of minority students into the student population here.

This account illustrates that diversification can be supported by programmatic interventions among regional partners with mutually agreed upon goals and formal learning opportunities that are an important component of the formula to increase diversity in science areas. This is also part of the mechanism at USU in order to develop a system to transform the institution from one of low URM participation in the life sciences to being a national leader in that area. USU Faculty member 5 explained this process during a conversation regarding formal learning experiences for faculty around diversity issues:

> We're not the only ones talking about it. I mean, it's in the public domain now. Most people are talking about implicit bias and have heard the term. So we talk about it, but we

> try to talk about it in terms of "How do you approach a decision about a graduate applicant? You know, where might the implicit biases be? And how does one fight against that?"

The open exchange of thoughts and ideas drives the diversification process, as highlighted in several instances at both institutions around faculty diversity in the life sciences as well as URM faculty involvement.

During a discussion of formal versus informal collegial discourse opportunities regarding diversity, SUDS Faculty member 1 explains the process faculty experience when recruiting for committee participation for science programs that have an emphasis on URM student selection:

> So it's so far been informally. More formally I've been asked to be on a diversity committee. There is a woman from Peru, a Peruvian woman who is here. A young woman. So she started two years ago. And I started in August here. Okay. So we were both on that email to be asked if we wanted to be on this diversity committee. And I -- this is increasing the numbers of underrepresented people in sciences, in the research sciences in particular, and also women. And kind of getting children interested in sciences has been one thing that I've been very interested in.
>
> So I said I would like to do it. But in the back of my mind, I would say, but it shouldn't just be us that are asked to do it. It just should be the responsibility of everybody. It should be something on everybody's mind. But I don't feel -- since I just started in the department, I don't feel comfortable enough yet to say that thing. But it's certainly something I do intend to bring up as I get a little bit more sure-footed here.

This excerpt illustrates a strategy used to increase minority participation by recruiting minority faculty to become actively involved in the process of diversifying areas within the natural sciences. Part of the formula to lead in the area of increasing URM participation includes support for faculty at all levels (junior and senior faculty) to be prepared to achieve tenure and promotion while engaging in diversity opportunities outside of research science. This suggests that this formula may have various levels of success throughout different science disciplines. For example, USU Faculty member 4 discusses how he has learned about issues affecting diversity in science areas over his 36 years as a career educator:

> It's pretty well known that science and particularly physical sciences has been an area which has suffered from lack of diversity from -- basically forever, and still suffers from lack of diversity. From a purely economic standpoint, if you look at the numbers of positions -- the numbers of jobs that are going to be available over the next 10 years or so in science, and you look at the demographic cross-section of the US, the only way we are ever going to be able to fill those positions is to tap into human resources of all types. So that's one reason diversity is important, because diversifying science is important. The other point is that if you have a difficult problem to solve and you bring in 10 people that have been all trained, grown up, had cultural backgrounds, had all the same experiences over similar experiences or very similar experiences, and you provide them with a problem, they are all going to look at it most likely a lot the same way. And so you are going to have one point of view trying to solve a difficult problem. Whereas, if you bring people of lots of different backgrounds, different cultural experiences, different socioeconomic experiences, different experiences of all types to have them look at a problem, they are going to look at it from lots of different directions. And so not everybody is going to think inside the box about how to solve a problem. There will be

> people that are thinking outside the box relative to how to -- to solve that problem, to come up with a much more robust -- more robust solution.

This excerpt exemplifies not only the need for a diversified population within the academy, particularly in science areas, but also the economic impact of a diversified workforce and its contributions to the success of organizations, which need to maintain a talent pool of skilled recruits. One crucial aspect of developing the diversity talent pool in science has to do with identifying and engaging URM faculty who can act as leaders and mentors to URM students. For example, SUDS Faculty 1 described being the usual target for solicitation when a minority is needed to engage with URMs students who have interests in science areas, and she indicated a desire to be incentivized for consistently answering the call to be the “storefront” for minority science interests:

> Of course, I would like some incentive. Right? Of course, I would like some incentive. But the personal incentive is incredibly strong for me. So I -- I mean, at some point, I will have to, like, say no to things. And I will, because that's just how it goes. But I wish other people would be more interested and have also this kind of personal -- feel, like, this personal pull to do these things, and not just the underrepresented folks.

During this same exchange, SUDS Faculty 1 talked about the time she was recruited to SUDS and was asked whether she would like to talk to a faculty member in the African-American Studies Program:

> I know that when I interviewed here, my host did ask if I wanted to speak to someone in the African-American Studies Department. And I was like, "Yeah, sure." I mean, I'm glad he asked me. It was nice because then, of course, I can get a perspective from somebody else about the university, like, you know, the real deal about the university. So I was

happy that he asked about that. So that -- you know, I think that was on his radar, which is good. But I don't think that's necessarily true of the majority.

So there are -- in our department, there is a thing where all junior faculty have a more senior faculty member that is their mentor. So there is that. And it's semiformal. There's no real paperwork, but the chair has been like, he said, so let's talk about who you think should be your mentor. We'll talk about it, and you can ask that person, and da, da, da, da, and then follow up with me later and let me know who you've decided to be your mentor. So every junior faculty has a senior faculty mentor. So with respect to the science, he said, "When you think about that person, think about somebody that might be, like, applying for the same types of grants that you are, have experience with those grants, so that you can, you know, shoot them your stuff and have them look over it and give you suggestions."

During a discussion about the disproportionately low number of URM minority faculty in the science areas and the need to address faculty diversity, USU Faculty/Admin 5 observed:

The next challenge, I think, is going to be really doing something about faculty diversity. I think this is actually in NIH's goal, that the reason why they want to incentivize us as a community to fix the representation problem at the PhD level is an assumption that that will fix the faculty representation. It hasn't done that yet. So that's one of our next goals is to try to make sure that at least some of the students who graduate from USU are feeling prepared that they are -- they can stay on a track towards a leadership role in science. And academics and industry. So that's something that we -- you know, that's a stated reason for having the programming in the first place. It isn't just fairness and logic. It's, you know, there is an expected downstream outcome that I think nationally hasn't happened yet.

And there is lots of discussions about well, why? You know, now we've got more PhDs, but we're not seeing them, at least not at Research 1 institutions. I think that a lot of PhDs that have been granted in the last, say, ten years to African-Americans and Hispanics, they often come back to -- if they came from an HBCU or a minority-serving institution that's where they go back, because that's home and they want to give back to go that community. And that's great.

These comments demonstrate the importance of a long-range approach to building diversity among faculty in the science areas. Developing this critical mass of URM professionals is part of departmental and institutional planning that leads to an increase in retention among URM graduates in the life science areas.

Theme #5

Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability. Lastly, this study's data demonstrate evidence of the theme that substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability. Eighty-nine percent of the participants supported the idea of a shared concept of diversity in life science areas, where their participation provides a level of accountability (Marsick & Watson, 2003). The responses vary in range from grassroots initiatives to network support, and from advocacy to institutional awareness. During a conversation regarding leadership and support for diversity programs and how that affects the incentive structure and process for participating faculty, USU Faculty member 1 explained:

> So this was a total grassroots, we're just going to do this. No one, no one, except for the employees, has received any compensation in any way including release time. Except I think -- well, I think Joe did, right. Because it, I think, it was part of his job. But he had other jobs.

This comment alludes to faculty taking ownership of diversity initiatives without any incentive to participate other than seeing this type of work as important to the students, faculty, and the institution. The importance of seeing the fruit of the faculty's efforts manifest into student success outcomes tends to be a driving force toward a shared idea, as explained by USU Faculty member 2:

> So I think one thing that drives us a little bit is, and this has been, I think, more and more has been true for me, is thinking about these programs and thinking about this effort we put in and looking around and seeing, like, the problem, that we see and why we are devoting all this effort to it. And I think for me, like, trying to use more precise language about what we're actually trying to do and why. And so, I think one thing that happens is, there's been a tendency to talk about diversity initiatives. Like, we want to diversify science.

One approach to transfer the motivation acquired through grassroots success to senior-level institutional leadership is to continuously share the successes that build a good reputation for the diversity work and the teams involved. This method is highlighted by SUDS Faculty member 2 during an explanation of how the organization's leadership responds to a recommendation from the faculty in addressing diversity in the life sciences and how the faculty perceives the organization's response:

> So I have a good reputation with the university. The administration knows who I am. They respect what I've done. They like the fact that I'm bringing in big grants from NIH. They like the fact that, um, we have been highly rated by Diversity Magazine, right? And the university itself has just hired a chief diversity officer. And this year they moved him to being a vice provost and put that office in the provost's office. So the university is committed to diversity. And, um, you know, just like you were told if you want to know something about diversity in the biological sciences, you better talk to me.

This sentiment is further endorsed by SUDS Faculty member 2, as he passes the vision of diversity in life sciences to the student body, thereby empowering students to take an active role in their academic direction:

> But, for my colleague and I -- my partner in this -- success to us means that we empower the students we work with to choose the right path that's for them. So if it becomes obvious that you're not a good candidate for a PhD program, then we'll help you find a path that will work for you. And if we can help you find that path, that's success for us even though it is not counted for NIH as a success.

Part of the process of empowering faculty to facilitate change in an area where African-American students are not traditionally well represented (the life sciences) is to provide opportunities to interact with URM students and prospective faculty. The following account provided by SUDS Faculty member 3 underscores an opportunity to give faculty tools to address URMs in life sciences:

> And over a period of years, probably almost all faculty members are going to cycle through at least one search committee if not several. So, you know, within a year or two, pretty much everybody in the faculty will have been exposed to this as an explicit

> conversation as part of that training. And it's happening on a continuous basis, too. Every search committee goes through this. And that means every time you're on a search committee, you're going to be exposed to it again. So it's not the first time. And it may not be the fifth time. It may be even more than that. So I -- you know, I think that's a good thing in terms of continually revisiting it, keeping it towards the forefront of thoughts and ideas and discussions.

All of the accounts in reference to the theme of empowering people toward a collective vision, as indicated in Marsick and Watkins (2003), support a definition of the collective actors being responsible and accountable in delivering and maintaining a vision in order to make informed decisions.

Theme #6. *Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs*. Emerging from the interview data were references that corroborated the existence of various types of programs that are designed to advance students, particularly URM students, through the pipeline of prepared individuals who can enter doctoral programs in science areas. This sub-theme was referenced by 89% of the respondents and includes testimonials regarding federally funded programs, model programs, program support, and partnerships with diversity units and/or MSIs.

During a conversation about the dynamics of interacting with colleagues when talking about underrepresentation in science areas, SUDS Faculty Member 4 stated:

> And I think in terms of trying to address it as part of an institution, we have different programs. Like, for example, we have [a diversity] program. So it -- basically, to help underrepresented minorities, prepare them for a professional school, right? We also have a lot of different summer programs in different departments to try to recruit

> underrepresented minorities that are going to go to professional school so that they can get a summer research experience. Because that is something that, you know, medical schools, graduate schools, they look for people that have that experience. There is also, as an institution, the McNair Scholar program for the summer, which I was part of last year.

A colleague of SUDS Faculty member 4 also highlighted the prestigious the McNair Scholars program, but in addition mentioned another well-known program that supports URM student success in science areas, the TriO program. SUDS Faculty member 3 explained:

> So here, specifically thinking about minority students, there are a fairly large number of programs for undergraduates ranging from the TRiO programs, McNair Scholars, a number of other programs -- most institutions have programs like this. They have a different name here than at other places. But there is some outreach programs to high schools. Those are institution programs that rely on faculty members to essentially volunteer to do things for them. To either help in a summer program and give a lecture or two or maybe take a student in their lab for the summer. And they will usually get a little bit of compensation for it. You know, maybe 500 or a thousand dollars for supplies, that kind of thing.

Even though the monetary incentives may be small, they tend to pay off in great dividends to the institution and the students they serve later in the program’s lifetime. This process is underscored by USU Faculty/Admin 5, who discussed how the concern about underrepresentation in the sciences had been on the radar of the institutional leadership and faculty during her time in graduate school:

> And that, coupled with NIH in particular and NSF and other parts of the government and even some foundations making the same recognition and saying, "Well, we need to try to

> do something about that," and then providing some financial incentives, frankly, to say, "Okay. Well, whatever you've been doing isn't working, so let's give you some incentives toward -- like, in terms of fellowships and training grants and educational grants to try to make a difference there." So this has been going on since I was a graduate student. That's when I first learned about it. We have an IMSD grant that's a significant financial asset to our overall graduate training infrastructure. So it's important that we continue to have successes there to maintain that.

Programs such as these are pivotal in contributing to the success and matriculation of URMs to advanced degrees in science areas. SUDS Faculty member 1 enforces this idea during a discussion about her experiences dealing with graduate students who participated in programs designed to increase representation in science areas:

> The goal is to get them into a PhD program. So I think several of the students end up matriculating the PhD program here. And so we have this kind of, like, they were here for the program, and they're here as graduate students. And they all have this kind of -- the same kind of goals of increasing diversity in the STEM fields. So I think that having that perpetually going on is like a thing that makes the nonminority folks say, "Oh, you know, this thing is real important. And it's not just happening in a year or two and then it stops. But, you know, it persists, and it's important."

During a conversation about opportunities to secure funding for programs that support URM students pursuing science-related degrees, USU Faculty/Admin 5 alluded to the need to revisit and modify such programs:

> So we are now having brainstorming sessions and saying, "Okay. What have we done well? What is the next step, right? What's the next level? How do we make this program,

> you know, move to the next level? If we've had some successes, that's great, but we don't want to “rest on the laurels.” And, frankly, from my point of view, I want to do something new once in a while. I don't want to just cycle through the same, you know, activities all the time. So there is some continuous, like, evaluation, asking our students, "Does this particular element of the programming actually help, or is it a waste of time from the students' point of view?"

USU Faculty/Admin 5 is describing the need for continuous program evaluation, as well as the necessity of developing a process to receive feedback from participants regarding their experience and the perceived effectiveness of the program in advancing URM students to advanced degrees in science areas.

Cross-Case Analysis

To understand how and to what extent USU and SUDS have learned to advance African-American students to advanced degrees in Life Sciences, the case studies were analyzed to determine the similarities and differences among the major themes that exist between the two institutions. These are displayed in Table 4.

Summary

Chapter 4 presented institutional profiles highlighting factors that are impactful in supporting African-American undergraduate students in completing science related degrees, as well as analyzed interview and observational data that yielded the themes and sub-themes that addressed how these two PWIs have learned to substantially increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Science. These themes and sub-themes were presented in detail. Moreover, a cross-case analysis comparing and contrasting the institutions’ experiences was presented in tabular form. Chapter 5 will discuss the

Table 4

Cross-Case Analysis

Theme	Similarities	Differences
Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields	The diversity history of the institution and its faculty, administrators, and students frame the baseline for its diversity constructs but has been used to learn how to improve.	The culture of inclusive excellence has evolved faster at USU; therefore, learning from these preconceived ideas of diversity seems more embedded in its culture.
	Both institutions realize the traditions, stereotypes, and implicit biases, particularly in the sciences. Both institutions see HEIs as places that are traditionally accepting of diversity.	USU faculty often perceived their institution as a very diverse place, including the town where the university resides; SUDS faculty also perceived their institution as diverse. However, that diversity diminishes beyond the walls of the SUDS campus, as the remainder of the city in which SUDS is located is less significantly less diverse.
	Both institutions expressed a lack of confidence in students' ability to succeed in the sciences when they transferred from HBCUs and other MSIs.	

Table 4 (continued)

Theme	Similarities	Differences
	Both institutions have faculty and administrators who have been employed for several years at their respective universities. Starting their education careers during the early post-civil rights era provided a framework for their understanding of diversity and inclusion and shaped their initial thoughts and ideas about who is traditionally underrepresented in science fields of study.	
Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way	Both institutions have formal systems of collegial dialogue and interaction that encourage learning about diversity issues and possible solutions.	
	Both institutions take advantage of participation on selection committees for prospective students as an opportunity to engage in dialogue surrounding demographics and performance in science areas.	
	Both institutions have engaged in conversation regarding traditional notions of a successful scientist and how these notions have impacted diversity in science areas as well as admission decisions.	Only USU utilizes formal faculty professional learning opportunities on topics specific to diversity issues, such as implicit bias training.
		Only SUDS referenced being endorsed by a diversity journal.

Table 4 (continued)

Theme	Similarities	Differences
	Both institutions have centralized offices of diversity.	
	Both institutions continue to learn about the lack of URM participation in the life science areas via faculty search committee work and the lack of diversity in faculty application pools.	
		Only USU mentioned a call for state-wide joint grant research proposals aimed to recruit students, particularly URMs, with an emphasis on academic success. This is an opportunity to learn from other institutions.
Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses, and advocacy increases morale		Only USU mentioned direct support from the chancellor and the power of the Office of the Chancellor.
	Both institutions expressed at least minimal support for faculty and staff to engage in activities that support URM students' success in science areas, such as supplies for their labs.	Only USU talked about occasions when a lack of incentives challenged the morale of the team. The threatened exodus of highly trained and engaged staff seemed to cause the institution's leader to listen and recognize the need to act or risk losing team members.

Table 4 (continued)

Theme	Similarities	Differences
		Only USU shared information regarding institutional support to enhance leadership for diversity by hiring a senior-level administrator to focus on diversity in the academic unit.
	Both institutions developed a common language when continuously discussing and learning about diversity in the science areas.	
	Both institutions referenced a formal and informal systematic process for addressing the lack of representation in the science areas, both for students and faculty, with an eye toward increasing representation.	Only USU mentioned the link between increasing diversity in the academic science areas and the need for meeting workforce development needs. This was identified as one reason for URM funded science interventions.
Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions		
Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability	Both institutions have the support of initiatives to address underrepresentation in the sciences, thereby cultivating a common vision while maintaining a system to revise and adjust.	

Table 4 (continued)

Theme	Similarities	Differences
	Both institutions have a process of sharing information regarding the success of their science diversity programs.	
Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs	Both Institutions highlight funded programs as a means of empowering participants to increase representation in the science areas.	Only USU mentioned that these types of pipeline programs see reward often after students complete the programs and become part of the academy, bringing with them the vision for increasing representation in the sciences and the credentials that will empower them.

findings of the study, the theoretical and applied implications of the findings, and recommendations for future research.

CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

The intent of this study was to explore how USU and SUDS learned to significantly increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Sciences. More specifically, this study explored the relationship among academic leaders and faculty that has led to interventions, the establishment of coalitions, and institutional support to address underrepresentation in Life Science areas. The stage for this study was set by the 2011 National Academies report on expanding minortiy participation in the STEM areas, wherein it was stated that only 3.3% of Native Americans and Alaska Natives, 2.7% of African-Americans, and 2.2% of Hispanic and Latino Americans 24 years of age had been confirmed for their first degree in a STEM field (National Academy of Sciences, 2011). A more current report by the National Science Board (2016) of NSF calculated that for the reporting year 2013, 8.4 % of African-Americans, 0.6 % of Native Americans and Alaska Natives, and 9.9 % of Hispanic and Latino Americans earned a bachelor’s degree in science or engineering areas (National Science Board, 2016). First, the study identified the set of factors each of the two PWIs has utilized, those cited in the 2011 National Academies report that are known to be beneficial in advancing URM undergraduate STEM students to doctoral training in Life Sciences. This study also examined how institutional change influenced USU and SUDS as learning organizations. The testimonies from faculty and administrators who have worked in this space and have been instrumental in developing a mechanism to learn from success as well as failure as it relates to advancing URMs to advanced degrees in Life Sciences provided an in-depth understanding of their processes.

The design of this study was a qualitative multiple case-study that was used to determine how select institutions learned to be successful at advancing undergraduate African-American students to advanced degrees in Life Sciences. First, the factors (outlined in Chapter 2) that are impactful in supporting African-American undergraduate students in pursuing doctoral degrees in the life sciences were identified and collected for USU and SUDS. These data were used to establish a profile for USU and SUDS and were collected by reviewing the universities' websites, archives, and publicly available documents, as well as state and federal databases. Descriptive statistics were determined to describe which factors USU and SUDS established or have implemented. These data and the resulting profiles were used to inform discussions with participants during the collection of primary data. The primary data for this study were obtained by conducting semi-structured interviews with life science departments' faculty and administrators. Pre-codes were established using Marsick and Watkins's (2003) seven constructs of the Learning Organization, within the context of Birnbaum's (1988) Cybernetic Loop of institutional interaction. New themes and sub-themes also emerged from the data.

Summary of Findings

Six major findings, or themes, and four minor findings, or sub-themes, resulted from an analysis of the data from this multiple case study of the processes used by two PWIs in learning how to produce a significant number of African-American students who matriculated to obtain doctoral degrees in science areas. An outline of the findings, in thematic form, that demonstrates how select PWIs have learned to substantially increase the numbers of African-American students who have advanced to complete doctoral degrees in Life Sciences is as follows:

1. Attitudes towards diversity in science fields are shaped by assumptions, personal comfort talking about diversity, traditions, norms and biases, as well as population mirroring in science fields
    a. Progress to address diversity in science fields required time and brain-space to work together in a consistent, inclusive, structured and supported manner
    b. Understanding diversity issues in science areas requires open conversation with diverse group members in a safe environment that challenges perceptions that leads to enlightenment of the problem
2. Learning about issues affecting URM students and faculty success in science fields utilized data and training from inter/intra-institutional processes as well as exchanging best practices in an inclusive way
3. Learning to increase representation in science fields needed ways to collect, measure and share information in order to present assumptions and challenge conclusions
4. Learning to increase representation is science fields required trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses and advocacy increases morale
    a. Scientists used the tools of their trade to learn, understand and respond to the issue of underrepresentation in science fields
    b. There is no single action that increased representation in science fields, however a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue
5. Substantially improving underrepresentation in science areas is brought into fruition with collective and unified focus on outcomes and accountability

6. Sustained impact to increase representation in science areas requires external funding support for activities that specifically focus URMs

The findings display, to some degree, a sequence of events that synthesizes into a narrative expounding how USU and SUDS were able to create an environment where a significant number of African-American students completed doctoral degrees in life science areas. This narrative begins with both institutions articulating prominent assumptions and cultural norms related to underrepresentation in science areas. The faculty and administrators provided evidence of preconceived ideas about URM students, particularly those who transferred to their institutions from an HBCU, as those transfer students tended to arrive with a stigma of poor academic performance. Participants identified barriers and challenges that limit a diverse representation of individuals in science fields, and discovering such barriers and challenges has heightened the participants' attention to diversity issues in science fields and increased their understanding of why diversity is important to the advancement of scientific knowledge. Contributing to the faculty members' and administrators' preconceived constructs of diversity in science areas are historical and cultural notions of who traditionally becomes a scientist. Faculty and administrators were able to address their predetermined viewpoints of what diversity in science fields looked like. They interacted and engaged with each other in a manner that led to rigorous reflection and conversation that yielded adjustments to cultural norms in science areas. These conversations also eventually led faculty and administrators to recognize the need to increase diversity in science fields, which included learning about unusual or innovative ways to collaboratively achieve more diversity in science related degrees. As promoters of increasing representation in science areas, these faculty members and administrators developed and maintained mechanisms to work in partnership to address their perceptions of diversity in science subjects in order to gain a better understanding of the issue and to discuss possible solutions. The participants highlighted the importance of focused dialogue that was open, data driven, and direct. Participants emphasized the importance of creating an environment where they felt safe discussing sensitive URM-related issues, such as the idea of students from HBCUs not being academically prepared for rigorous research, without fear of retribution. Participants indicated that having a system in place to continue to learn from failures and successes, as well as having a way to disseminate those findings, helped to increase diversity in science areas. For example, the development of implicit bias training for student selection committee members provided tools to inform participants about implicit biases, increase participants' personal awareness of them, and provide action plans to help move past them. Participants illustrated a learning atmosphere, which is now part of the culture of the sample institutions, where diversity initiatives and programs aimed at science fields addressed barriers and challenges to URM success in those areas. The unique make-up of the study participants provided an opportunity to discover how research scientists use information, learn from data, and address their diversity-related hypotheses. Study participants recalled using conventional practices that were commonly used to collect information, such as admissions applications and interviews, but recognized the need to adopt unconventional means of information gathering, including changing the order in which formation is received. The enhancement of information access and the use of novel ways to present information advanced the quality discussions and informed decisions. Participants described how data were used to help all members of the institution learn about diversity issues in science fields of study. To deepen the footprint and sustain progress of initiatives and activities to increase representation in science fields, participants explained that supportive leadership seemed to be a linchpin between institutional support and grassroots operations.

Participants described leaders who promote diversity activities in science fields but also must manage during difficult times. From addressing staff turnover to creatively establishing incentive structures, participants identified leadership behaviors that yielded a culture of confidence that their leadership would work towards an environment of open communication that led to increasing URM students in science fields. The development of these environments, though challenging in their establishment, thrived as participants learned that they, as scientists, communicated with a common language. They spoke in terms of systems thinking and solving problems using the scientific method, which led to drawing comparisons between investigations in research science and addressing diversity issues. Participants described the primary characteristic of this common communication system as the use of reliable data. The inquisitiveness of scientists and the collegiality of scholars fostered the conversations that concentrated on the lack of URM students who successfully complete science degrees. This open dialogue began to establish an ecosystem where opportunities to learn about the importance of diversity in science areas, as well as how to positively impact the deficiency of URM students who are achieving in science subjects areas, are part of the culture.

Implications for Theory and Practice

The findings of this multiple case-study provide several inferences that affect the theoretical framework, as well as how the characteristics of a learning organization can be implemented in the everyday operations of higher education institutions. As themes emerged from the data, the theoretical framework that was initially used for this study was modified to more precisely articulate the story of how two southern PWIs were able to increase the number of African-American science degree completers who went on to obtain a doctoral degree in a life science subject area. The findings from this study suggest that PWIs that are successful at advancing African-American students to doctoral degrees in life sciences use their collective ideological constructs of what diversity is and what it looks like in science areas of study, learn from each other and share data, establish a common language to continue the learning process, find support to facilitate URM student success in the science areas, and provide tools to disseminate a model of success.

Theoretical Implications

The theoretical framework for this study focused on the ever-shifting temperament of higher education institutions as they are prompted by various stimuli to which they must react. The initial theoretical framework (see Figure 1) for this study was an integration of Birnbaum's (1988) Cybernetic Loop of institutional interaction and Marsick and Watkins's (2003) seven constructs of organizational learning. This framework initially aimed to describe how higher education institutions, as learning organizations, navigate an ever-mutable environment within the cybernetic process. In addition, Birnbaum (1988) sees higher education institutions as cybernetic, or as a system whose operations are governed by vertical feedback mechanisms that are fortified by the institution's structure and by horizontal feedback mechanisms embedded in its social scheme. During the analysis of the findings, however some of the emergent themes and sub-themes were able to map back to the original theoretical framework, while others were novel and outside the bounds of the seven constructs of organizational learning. To better illustrate how these emergent themes and sub-themes represent the seven constructs of organizational learning, they were assigned to a particular learning construct, whereas the other themes and sub-themes were provided new construct descriptors (see Table 5):

Table 5

Emergent Themes and Sub-Themes Linked to Marsick and Watkins Constructs of Organizational Learning or New Construct Descriptor

Theme/Sub-theme	Descriptor
Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields	Perception of diversity
Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way	Create continuous learning opportunities
Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions	Create systems to capture and share learning
Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses, and advocacy increases morale	Provide strategic leadership for learning
Scientists use the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields	Establish a language of diversity
There is no single action that increases representation in science fields; however, a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue	Process for diversifying
Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability	Empower people towards a collective vision
Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs	Funded programs for URM development

1. Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields; Perception of diversity
    a. Progress in addressing diversity in science fields requires time and brain-space to work together in a consistent, inclusive, structured, and supported manner; Encourage collaboration and team learning
    b. Understanding diversity issues in science areas requires open conversation with diverse group members in a safe environment that challenges perceptions and illuminates the problem; Promote inquiry and dialogue
2. Learning about issues affecting URM students and faculty success in science fields is facilitated by data and training from inter/intra-institutional processes, as well as by exchanging best practices in an inclusive way; Create continuous learning opportunities
3. Learning to increase representation is science fields requires ways to collect, measure, and share information in order to present assumptions and challenge conclusions; Create systems to capture and share learning
4. Learning to increase representation is science fields requires trust and support for faculty and students to operate in an environment where opinions are valued, concerns have responses, and advocacy increases morale; Provide strategic leadership for learning
    a. Scientists use the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields, Establish a language of diversity

b. There is no single action that increases representation in science fields; however, a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue; Process for diversifying

5. Substantially improving underrepresentation in science areas is brought to fruition with a collective and unified focus on outcomes and accountability; Empower people towards a collective vision

6. Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs; Funded programs for URM development

The above themes and sub-themes link to constructs, both original and new, to provide context for a new model to describe how interventions that advance African-American students to doctoral degrees in Life Sciences shaped select Predominantly White Institutions as learning organizations? (see Figure 2). The following sections focus on the unexpected themes and sub-themes: Perceptions of diversity, the language of diversity, the process of diversification, and funded programs for URM development.

Perceptions of diversity, particularly in science areas, were significant to the participants' overall understanding of the issue of underrepresentation in science fields of study. Perceptions of diversity contributed to this new model by taking into account the previous experiences of the faculty members and administrators. According to Mezirow (1997), adults over time accumulate life experiences built around associations, concepts, values, feelings, and conditioned responses which serve as reference points that characterize their worldview. Mezirow (1997) further explains that these reference points serve as the architecture for assumptions through which we learn about our experiences. The emergence of this theme was unpredicted. It can be inferred that the appearance of this theme was due in part to conversations in which actors learned to

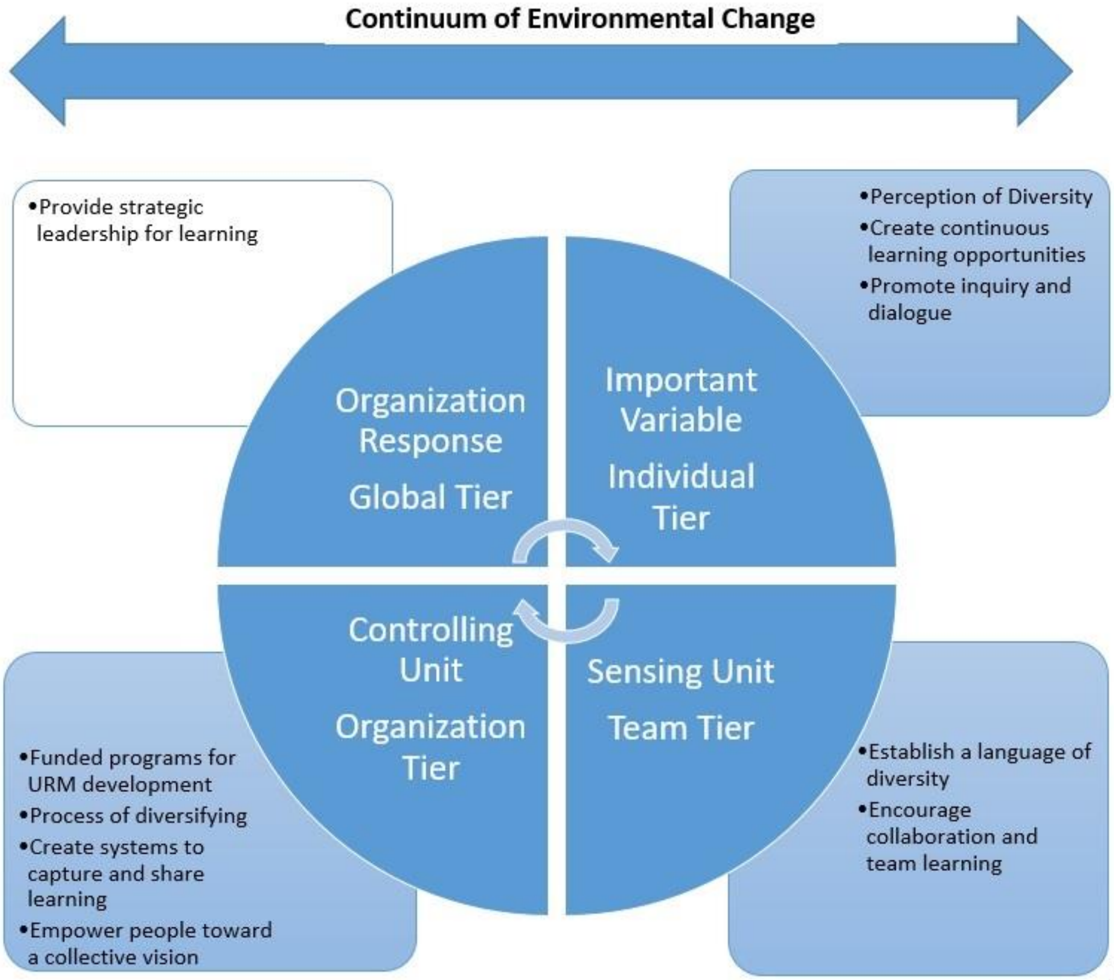

Figure 2. Revised Theoretical Framework.

diversify the science departments within their institutions. These conversations included self-reflective elements that highlighted participants' unique histories related to race, diversity, and inclusion, both in science fields and in their own lives before working at their universities. These histories could act as a catalyst or impediment to realizing the need to increase representation in science fields of study or to participate in activities to address it. These perceptions set a baseline against which faculty members and administrators can engage in meaningful dialogue, share experiences and other data, and develop a strategy to increase representation in science areas.

It became clear during the analysis that all of the participants, who are also trained research scientists, played a significant role in how they learned about underrepresentation in science fields of study and developed their approaches to addressing barriers to URM student success. The participants established a language of diversity, particularly when discussing diversity issues in the context of increasing representation in science areas. Working toward the establishment of a common language has been studied in other fields. For example, Jette (2006) describes an effort to develop a universal language related to disablement and the challenges of a process of creating a common language framework to discuss physical therapy research and clinical interventions. Jette (2006) notes that having the capacity to communicate with team members and having those communications appreciated among various related professional sectors is essential to the science and application of physical therapy. Throughout this progression of establishing a common language for diversity in science fields of study, the faculty members and administrators in the present study began to develop a particular nomenclature or terminology that has continuously enabled the discourse and learning about how to continue to increase the number of URM students' completed degrees in science areas. USU Faculty/Admin 5, for example, characterized scientists as logical, data-driven, and enthusiastic about challenging researchers' assumptions. The appearance of this sub-theme is possibly due to the participants' comfort with the study researcher, as I am also a trained biological researcher; all participants expressed in various ways an ease in talking about specific rigors of science coursework and the challenges of thriving in a research laboratory. USU Faculty/Admin 5 even acknowledged our shared academic training by saying "So we're all scientists; you're a scientist." Establishing a common language to discuss diversity issues in science fields appears to have been fundamental to the success of the study institutions' ability to sustain a successful path to increasing representation is science fields and improving their processes to advance URM students to post-baccalaureate science degrees over time.

The sub-theme of establishing a process for diversifying science departments was not totally unexpected, particularly for participants who are research scientists and who embrace systems thinking and the scientific method; however, the extended time that it took to build relationships among various people and departments was unanticipated. Reaching out to other institutional units, such as the diversity office and the office of admissions, seemed to be part of the process to increase representation in science field, as the participants realized they needed expertise in areas outside of academic science. Their methods have provided a roadmap to consistently assess their efforts and adjust diversity initiatives as they move forward. Using data from the evaluation of their efforts was part of a systematic process to diversify science subject areas. As the pool of science majors became more diversified, this sign of progress was used to build coalitions between and within institutions in order to achieve further success. Although gains have been made, much more attention is needed to address the lack of diversity in the science faculty ranks.

The study institutions were able to maintain thier success in large part through external support for science diversity initiatives. Support programs that focus on URM development were specifically designed to support pre-college readiness, to provide academic and social support, and to ultimately establish a pipeline of prepared URM students who can pursue advanced science degrees. As previously mentioned in this study, much has been written about the importance of funded programs aimed at supporting URM students completing science degrees, from tuition support to undergraduate research opportunities. Financial support remains crucial for large institutional programs and initiatives. There was no reference to the receipt of corporate or individual gifts, foundation funds, or institutional funds to either maintain or advance activities to increase representation in science fields. Given the highly competitive environment of federal grant proposals submissions, as well as the shrinking funding allocations for many federal agencies, the lack of multiple streams of funding to continue providing impactful diversity science programs could set their course towards an unpredictable existence.

Implications for Practice

Comprehending how two southern PWIs learned to be among the top institutions in the country in preparing a significant number of African-American students to matriculate to doctoral degrees in life science areas is critical to meeting the need for talented people to fill a much-needed workforce, both now and for years to come. These practical implications were extrapolated from the case study data.

Both USU and SUDS faculty members and administrators expressed how their life experiences, both academic and non-academic experiences, played a role in what they believed an inclusive and diverse environment should display versus what they actually witnessed at their respective universities. Many of the participants recall experiences that contributed to their perception of diversity, particularly in science areas of study, which provide context regarding the manner in which they discuss the lack of representation in science areas, as well as how they articulate the overall contributions diversity offers to an organization's success. It is plausible to have open conversations, perhaps led by a trained mediator, who can then determine a baseline of the teams' experience and comfort in engaging in diversity issues, particularly as these issues relate to URMs in science fields of study. Also, emerging from the data were several references to implicit bias training, where participants in the training are informed about what implicit bias is and is not, as well as how to recognize those biases that have been part of one's perception of people from different groups. It was also highlighted that there are implicit biases at work in student selection committees and faculty screening committees. Utilizing an implicit bias inventory tool could be part of all new employee orientation sessions for those participating in reviewing and/or selecting prospective students or employee candidates. Another tool to advance the conversation regarding how to increase diversity in science areas was highlighted by USU Admin 3, who provided evidence to support the idea that progress in diversifying science fields requires time and "brain space" to work together in a consistent, inclusive, structured, and supported manner. She described an encounter in which she acted as a "brave agent" to expose a colleague's racial bias toward an HBCU. The presence of at least one "brave agent" – a faculty member of administrator – could serve to reveal stereotypes or discriminatory behaviors in the conduct of enrollment committees and faculty search committees.

The data also yielded evidence that some faculty members have preconceived ideas of URMs who transfer to USU and SUDS from HBCUs as being "below board." This issue could be mitigated by developing more meaningful partnerships with HBCUs that include exchange programs, faculty sharing programs, and summer research programs. This would provide an opportunity for faculty members at PWIs to be directly involved with partner HBCUs to explore teaching and learning in the science areas, to share best practices, and to learn about HBCUs in general. However, PWIs should note that this type of involvement in the academic process is not a rescue mission but an opportunity to learn about the academic traditions of HBCUs. Using partnerships as an opportunity to learn about URM students with interests in science careers could pay substantial dividends for PWIs, as most African-American PhDs in science or engineering received their undergraduate training at an HBCU (National Academies, 2011).

Another sub-theme emerged that emphasized the terminology that faculty members and administrators in the science areas use to communicate the issue of underrepresentation in the science areas of study. This was a critical component that helped in team learning as well as student success. Developing a glossary of terms may be helpful in mapping science learning outcomes and expectations to an understanding of the social barriers that have blocked qualified URM students from being successful in science programs of study. A common language is important in learning how an organization can grow and develop new knowledge that will provide a framework to address new issues as well as develop new faculty and administrators.

Finally, another critical component that emerged during data collection was the needed support for URM students in the sciences. Primarily, this support came in the way of externally funded programs, from agencies such as the National Science Foundation and National Institutes of Health. With the uncertainty and decreases in federally funded projects, building a collaborative, multidisciplinary research agenda addressing underrepresentation in the science areas may increase the probability of receiving a funded award. Taking advantage of what USU and SUDS have learned and how they learned to increase the amount of African-American students completing doctoral degrees in life science areas can be used to align common goals, resources, activities, customer segments, and outcomes.

Recommendations for Future Research

Several findings from this study are worthy of further exploration that are supported by the literature as it relates to (1) higher education institutions as a learning organization and (2) increased representation in science areas of study. By employing both qualitative and quantitative research design methods, more can be learned about how certain PWIs continue to be successful in advancing URM students through the STEM pipeline, and why certain PWIs continue to fall behind in increasing diversity in their science departments.

First, this study could be continued by replication to a larger sample of institutions by region to determine whether institutions organized by region – such as cohorts of PWIs in the New England, Middle Atlantic, East Central, Midwest, Heartland, Southwest, Rocky Mountain, and Pacific Coast states – learn differently as it relates to increasing representation in science areas. These regions have particular economic niches, education systems, histories, and population compositions.

Second, there were four new themes or sub-themes that emerged from the data that could not be transferred into a pre-code that was determined by the initial theoretical framework, thereby providing an interesting research agenda that would benefit from a qualitative research methodology to determine whether these new codes play a more significant roles in HEIs operating as learning organizations, particularly for units that are STEM related. These themes or sub-themes are as follows: Attitudes towards diversity in science fields are shaped by assumptions, personal comfort in talking about diversity, traditions, norms, and biases, as well as by population mirroring in science fields; Scientists use the tools of their trade to learn, understand, and respond to the issue of underrepresentation in science fields; There is no single action that increases representation in science fields; however, a holistic and systematic series of actions designed to address diversity at all organizational levels provides impact on the issue; Increasing minority representation in science areas requires external funding for activities that specifically focus on URMs. Given these emergent themes and sub-themes, developing a framework for the top ranked HBCUs who have led the way for African-American students to obtain a doctoral degree in a life sciences field would provide a sample of institutions to compare against this study's sample institutions. An analysis from this type of study could provide insight in determining whether top ranked HBCUs function as learning organizations when preparing URM students to pursue life science fields of study or whether they function is a different manner, particularly given the different cultures of HBCUs and PWIs.

Finally, the topic of this study could be restructured to fit a quantitative study that could utilize Marsick and Watkins' (2003) Dimensions of the Learning Organization Questionnaire. This instrument asks participants to respond to the questions in the context of how their organization shows value in learning and how learning is organized (Marsick & Watkins, 2003). This instrument can be modified to reflect the unique environment of science departments and the nature in which their faculty and administrators view the learning process. Quantitative methods would increase the number of data points that would allow the results of the study to be generalized to the overall population. The results from a study of this nature might have a broader impact on the goals that may be included in a regional institution's strategic plans and might further inform public policy, impact human resource policy and procedure, and impact admissions policy and procedures.

Summary and Conclusion

This chapter has recapped the purpose of this study, the research design, a summary of the findings, implications for theory and practice, and recommendations for future research. In conclusion, this study provides findings that partially upheld the initial constructs of a learning organization. Faculty members and administrators from the two select PWIs all had preconceived ideas of what diversity is, what diversity at their institution was and how they perceive diversity at their institution currently. Furthermore, exploring these perceptions of diversity, particularly in the science areas, provides instances that encourage collaboration and team learning. Continuous encouragement and engagement in group thinking about diversity in science areas led to increased opportunities for cross-examination of peers during critical discussions about diversity in science areas. Learning is part of a continuous, dynamic, and organic environment where faculty members and administrators engage in formal and informal learning opportunities to gain a better understanding of the condition of diversity in science areas of study on their campuses. As scientists, the faculty members and administrators understand the importance of data collection and analysis and have developed mechanisms to capture and share results. Throughout this process, faculty members and administrators develop into leaders at various levels to advocate for the purpose, impact, and support of activities that increase representation in science areas of study. This process allows for the development of an informal language, one that fuses traditional science terminology with nomenclature that speaks to the concepts of diversity and inclusion; therefore, a hybrid language is used to share information and make decisions regarding best practices for increasing representation in science areas of study. Over time, faculty members and administrators developed a process to diversify life science areas by articulating the role that diversity has within each organization and its respective science unit. Faculty and administrators built a culture where the use of open, constant communication, conversations about various biases, and the presentation of information in a scientific manner allowed for teams to collectively acknowledge and take responsibility for the vision of increasing representation in science areas of study. Lastly, to maintain success, long-term external funding is critical to the vision of increasing representation in science areas of study.

The implications for theory and practice that are informed by the findings of this study include a model for how certain PWIs learned to be successful in advancing African-American students to completing doctoral degrees in life science area. This study's findings offered an alternative representation of the framework of this study (see Figure 1), that preserves some of the original descriptors of the framework while adding new descriptors from the emergent themes, such as the following: attending to perceptions of diversity, establishing a language for diversity in science areas, and developing a process for diversifying and establishing funded support programs for URM student development in science areas. The findings from this study have implications for practice that involve trained mediation to provide implicit bias training.

The idea that URMs from HBCUs are academically unprepared for the rigors of graduate work presents an opportunity for partnerships with HBCUs to explore why faculty members and administrators at PWIs hold this perception of URMs from HBCUs and how to correct for this damaging stereotype. As the study institutions developed language for diversity in science areas, by using terms and tools during conversations that are often used during the practice of scientific research, this may be an opportunity to establish a specific glossary of key terms that expedites the interaction and progress of dialogue and decisions related to supporting URM students enrolled in science areas of study.

In conclusion, this study explored how select PWIs learned to prepare and advance a significant number of African-American students to complete doctoral degrees in life science areas of study. In order to continue in this positive upward trajectory of success, institutions must understand their own culture as it relates to diversity on their campuses, continue to openly discuss the issue of underrepresentation in the science areas, share data regarding diversity in all areas and perspectives, and obtain support to ensure URM students have every opportunity to be successful at PWIs.

REFERENCES

Allen-Ramdial, S., & Campbell, A. (2014). Reimagining the pipeline: Advancing STEM diversity, persistence, and success. *Bioscience, 64*(7), 612-618.

America COMPETES Act of 2007, 1,2,3,4,&5 U.S.C. §§ 1001-8008. (2010).

American Association for the Advancement of Science. (2001). Annual Report 2001. Washington, DC: Retrieved from: https://www.aaas.org/sites/default/files/AnnualReports/2001/report.pdf

American Association for the Advancement of Science. (2012). Building a global knowledge society: Science communication and collaboration AAAS Annual Report 2012. Washington, DC: Retrieved from: https://www.aaas.org/sites/default/files/AR_2012.pdf

Arendale, D. (1997). Supplemental Instruction (SI): Review of research concerning the effectiveness of SI from The University of Missouri-Kansas City and other institutions from across the United States. Tucson, AZ: Retrieved from http://files.eric.ed.gov/fulltext/ED457797.pdf

Argote, L. (2013). *Organizational learning: Creating, retaining and transferring knowledge* (2nd ed.). New York, NY: Springer.

Argote, L., Denomme, C., & Fuchs, E. (2011). Organizational learning across boundaries: The effect of geographic distribution on organizational learning and knowledge transfer. In M. Easterby-Smith & M. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (pp. 656–684). Chichester: Wiley.

Barlow, A. E. L., & Villarejo, M. (2004). Making a difference for minorities: Evaluation of an educational enrichment program. *Journal of Research in Science Teaching, 41*(9), 861-881.

Barton, P. E. (2003). Hispanics in science and engineering: A matter of assistance and persistence. *Education Testing Service:* Princeton, NJ.

Bauer, K. W., & Bennett, J. S. (2003). Alumni perceptions used to assess undergraduate research experience. *Journal of Higher Education*, *74*(2), 210-230.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559.

Benderly, B. L. (2007). Rising above "The gathering storm". *Science*. doi:10.1126/science.caredit.a0700179

Birnbaum, R. (1988). *How colleges work: The cybernetics of academic organization and leadership*. San Francisco: Jossey-Bass

Boulding, K. E. (1956). General systems theory: The skeleton of science. *Management Science, 2*, 197-208.

Burke, R. J., & Mattis, M. C. (2007). *Women and minorities in science, technology, engineering, and mathematics: Upping the numbers*. Cheltenham, UK: Edward Elgar.

Cannady, M. S., Greenwald, E., & Harris, K. N. (2014). Problematizing the STEM pipeline metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce?. *Science Education*, *98*(3), 443-460. doi:10.1002/sce.21108

Center for Institutional Data Exchange and Analysis. (2000). 1997-*2000 SMET retention report*. Norman, OK: University of Oklahoma.

Chang, M. J., Cerna, O., Han, J., & Saenz, V. (2008). The contradictory roles of institutional status in retaining underrepresented minorities in biomedical and behavioral science majors. *Review of Higher Education, 31*(4), 433-464.

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching, 51*(5), 555-580.

Coleman, A. (2002). “Diversity in higher education: A continuing agenda,” *Rights at risk: Equality in an age of terrorism.* Report of the Citizens’ Commission on Civil Rights. Washington, DC, p. 73.

Clewell, B. C., & et al. (2005, November). Evaluation of the national science foundation Louis Stokes alliances for minority Participation Program (Final Report). Washington, DC: The Urban Institute, p. 38.

College Board. (2010). Program research and publications. Retrieved from https://www.collegeboard.org/

College Board. (2012). Program research and publications. Retrieved from https://www.collegeboard.org/

Council on Competitiveness. (2008). Retrieved from http://www.compete.org/

Crespo, M., & Dridi, H. (2007). Intensification of university-industry relationships and its impact on academic research. *High Educ, 2007*(54), 61-84.

Creswell, J. W. (2014). *Research design qualitative, quantitative, and mixed methods approaches* (4th ed., p. 304). Thousand Oaks, CA: SAGE Publications.

Dill, D. D. (1999). Academic accountability and university adaptation: The architecture of an academic learning organization. *Higher Education, 38*(2), pp. 127-154. Retrieved from http://link.springer.com/article/10.1023/A:1003762420723

Exxon Mobil. (2015). About us. Retrieved from http://corporate.exxonmobil.com/en/company/about-us

ExxonMobil Foundation and National Action Council for Minority Engineers. (2015). Retrieved from http://news.exxonmobil.com/press-release/exxonmobil-foundation-and-national-action-council-minority-engineers-partner-increase-

Fleming, J. (1984). *Blacks in college: A comparative study of students' success in black and white institutions*. San Francisco, CA: Jossey-Bass Inc.

Fries-Britt, S. (1998). Moving beyond black achiever isolation: Experiences of gifted black collegians. *The Journal of Higher Education*, *69*(5), 556-576.

Ford Motor Company. (2015). What sustainability means to us. Retrieved from http://corporate.ford.com/microsites/sustainability-report-2013-14/people-workplace-employees-stem.html

Garvin, D. (1993). Building a learning organization. *Harvard Business Review, 71*(4), 78-91.

Great Minds in STEM. (2015). About us. Retrieved from http://www.greatmindsinstem.org/about-us/about-us-home

Great Minds in STEM Vision. (2015). Vision and mission. Retrieved from http://www.greatmindsinstem.org/about-us/mission-and-vision

Handelsman, J., Ebert-May, D., Beichner, R., Bruns, P., Chang, A., DeHaan, R., & et al. (2004). Scientific teaching. *Science, 304*(5670), 521-522.

Hathaway, R. S., Nagda, B. A., & Gregerman, S. R. (2002). The relationship of undergraduate research participation to graduate and professional education pursuit: An empirical study. *Journal of College Student Development*, *43*(5), 614-631.

Herrera, F. A., & Hurtado, S. (2011, November). *Maintaining career aspirations in Science, Technology, Engineering, and Mathematics (STEM) among college students*.

Honda, M. (2008). *Rep. Honda introduces bill to make American students competitive*. Online press. Retrieved from http://honda.house.gov/index.php?option=com_content&task=view&id=161&Itemid=10

Hrabowski, F., & Maton, K. (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.

Hurtado, S., Han, J. C., Saenz, V. B., Espinosa, L. L., Cabrera, N. L., & Cerna, O. S. (2007). Predicting transition and adjustment to college: Minority biomedical and behavioral science students' first year of college. *Research in Higher Education, 48*(7), 841-887.

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education, 50*(2), 189-214.

Iverson, S. V. (2007). Camouflaging power and privilege: A critical race analysis of university diversity policies. *Educational Administration Quarterly, 43*(5), 586-611.

Jaeger, A. J., Eagan, M. K., & Wirt, L. G. (2008). Retaining students in science, math, and engineering majors: Rediscovering cooperative education. *Journal of Cooperative Education and Internships, 42*(1), 20-32.

Jette, A. M. (2006). Toward a common language for function, disability, and health. *Physical Therapy, 86*(5), 726-734.

Kinkead, J. (2003). Learning through inquiry: An overview of undergraduate research. *New Directions for Teaching and Learning, 93,* 5-17.

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4*(4), 298-310.

Kuenzi, J. (2008). Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action. Congressional Research Service.

Labov, J. B. (2004). The challenges and opportunities for improving undergraduate science education through introductory courses. *Cell Biology Education*, *3*(4), 212-214.

Let's Go Boys and Girls. (2015). About. Retrieved from http://www.letsgoboysandgirls.com/about/

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual Reviews of Sociology*, *14*, 319-340.

Lien, B. Y., Hung, R. Y., Yang, B., & Li, M. (2006). "Is the learning organization a valid concept in the Taiwanese context?" *International Journal of Manpower*, *27*(2), 189-203.

Loo, C. M., & Rolison, G. (1986). Alienation of ethnic minority students at a predominantly White university. *Journal of Higher Education*, *57*(1), 58-77.

Lumina Foundation. (2009). Strategic plan. Retrieved from https://www.luminafoundation.org/

Malcom, S. M., Chubin, D. E., & Jesse, J. K. (2004). *Standing our ground: A guidebook for STEM educators in the post-Michigan age.* Washington, DC: American Association for the Advancement of Science.

Marsick, V., & Watkins, K. (2003). Demonstrating the value of an organization's learning culture: The dimensions of the learning organization questionnaire. *Advances in Developing Human Resources*, *5*(2), 132-151.

May, G. S., & Chubin, D. E. (2003). A retrospective on undergraduate engineering success for underrepresented minority students. *Journal of Engineering Education*, *92*(1), 27-40.

National Academy of Science. (2011). *Expanding underrepresented minority participation: America's science and technology talent at the crossroads.* Washington, DC: The National Academies Press.

Planty, M., Hussar, W., Snyder, T., Provasnik, S., Kena, G., Dinkes, R., KewalRamani, A., & Kemp, J. (2008). The Condition of Education 2008 (NCES 2008-031). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC.

Madsen, P. M., & Desai, V. (2010). Failing to learn? The effects of failure and success on organizational learning in the global orbital launch vehicle industry. *The Academy of Management Journal, 53*(3), 451-476.

Maton, K., & Hrabowski, F. (2004). Increasing the number of African American PhDs in the sciences and engineering. *American Psychologist*, *59*(6), 547-556.

Miner, A. S., Kim, J. K., Holzinger, I. W., & Haunschild, P. (1996). Fruits of failure: Organizational failure and population-level learning. *Academy of Management, 1996*(1), 239-243.

Mezirow, J. (1997). Transformative learning: Theory to practice. In P.C. Editor, *New directions for adult and continuing education*. New York: John Wiley & Sons, Inc.

National Center for Education Statistics. (2008). *Digest of Education Statistics*.

National Science Foundation. (2004). Division of Science Resources Statistics, Academic Research and Development Expenditures: Fiscal Year 2004, NSF 06-323, Project Officer, Ronda Britt (Arlington, VA 20006); www.nsf.gov/statistics/nsf06323/tables.htm

National Science Foundation. (2005). National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine Rising above the gathering storm: Energizing and employing America for a brighter future. National Academies Press. Washington, DC.

National Science Foundation. (2007). Division of Science Resources Statistics. *Top 50 baccalaureate origin institutions of 1997-2006 black Science & Engineering doctorate recipients*.

Nelson, D., Brammer, C. N., & Rhoads, H. (2007). A national analysis of minorities in science and engineering faculties at research universities. Retrieved from http://www.aaas.org/news/releases/2007/media/1031diversity_report.pdf

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.

OECD. (2012). Education at a Glance 2012: OECD Indicators, OECD Publishing. Retrieved from http://dx.doi.org/10.1787/eag-2012-en

Office of the Press Secretary. (2007). *Fact sheet: America COMPETES Act of 2007, President Bush signs legislation sharing goals of his American Competitiveness Initiative.* Washington, DC.

PUWL. (2018). Purdue University-West Lafayette. Retrieved from http://www.purdue.edu/mep/

Science and Engineering Indicators 2008. (2008). National Science Board. Retrieved from https://wayback.archiveit.org/5902/20160210152939/http://www.nsf.gov/statistics/seind08/

Science and Engineering Indicators 2014. (2014). National Science Board. Retrieved from https://wayback.archiveit.org/5902/20160210152939/http://www.nsf.gov/statistics/seind08/

Schuman, H., Steeh, C., Bobo, L. D., & Krysan, M. (1998). Racial attitudes in American: Trends and interpretations, Revised Ed. Cambridge, MA. *Harvard University Press*.

Scott, W. R., & Davis, G. F. (2007). *Organizations and organizing: Rational, natural, and open systems perspectives*. Pearson/Prentice Hall. Upper Saddle River, NJ.

NCSU. (2018). North Carolina State University. Retrieved from https://www.engr.ncsu.edu/wmep/mep/

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday/Currency.

Senge, P. M. (2000). *Schools that learn: A fifth discipline field book for educators, parents, and everyone who cares about education*, New York: Doubleday.

Seymour, E. (2001). Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education*, *86*(1), 79-105.

Seymour, E., & Hewitt, N. C. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Siegel, D. J. (2006). Organizational response to the demand and expectation for diversity. *Higher Education, 52,* 465-486.

Siegel, D. J. (2010). Why universities join cross-sector social partnerships: Theory and evidence. *Journal of Higher Education Outreach and Engagement*, *14*(1), 33-61.

Sitkin, S. B. (1992). Learning through failure: *The strategy of small losses. Research in Organizational Behavior, 14,* 231-266.

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*(4), 434-452.

Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education, 94*(1), 87-102.

Starbuck, W. H., & Hedberg, B. (2001). How organizations learn from success and failure. *Handbook of Organizational Learning and Knowledge;* M. Dierkes, A. Berthoin Antal, J. Child, and I. Nonaka (Eds.); (26), Oxford University Press.

Tracey, T. J., & Sedlacek, W. E. (1985). The relationship of non-cognitive variable to academic success: A longitudinal comparison by race. *Journal of College Student Personnel, 26*, 405-410.

Treisman, U. (1992). Studying students studying calculus: A look at the lives of minority mathematics students in college. *College Mathematics Journal, 23*(5), 362-372.

Tsui, L. (2007). Effective strategies to increase diversity in STEM Fields: A review of the research literature. *The Journal of Negro Education, 76*(4), 555-581.

U.S. Census Bureau. (2000). *The black population: 2000*. Retrieved from https://www.census.gov/prod/2001pubs/c2kbr01-5.pdf

U.S. Department of Education, National Center for Education Statistics. (2006). The condition of education 2006 (NCES 2006-071). Washington, DC: U.S. Government Printing Office.

Watkins, K. E. (2005). What would be different if higher educational institutions were learning organizations? *Advances in Developing Human Resources, 7*(3), 414-421.

Watkins, K. E., & Marsick, V. E. (1996). *In action: Creating the learning organization*. Alexandria, VA. American Society for Training and Development.

Watkins, K., & Marsick, V. (1993). Sculpting the learning organization: Consulting using action technologies. *New Directions for Adult and Continuing Education*, *1993*(58), 82-90

White House. (2010). Retrieved from http://www.whitehouse.gov/the-press-office/president-obama-expands-educate-innovate-campaign-excellence-science-technology-eng

Wilhelm, S. (2015). Boeing Co. and family give $30M to create massive STEM training program at Museum of Flight. Retrieved from https://www.bizjournals.com/seattle/blog/techflash/2015/07/boeing-co-and-family-give-30m-to-create-massive.html

APPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · **www.ecu.edu/irb**

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Shawn Moore
CC:
David Siegel
Shawn Moore
Date: 11/14/2016
Re: UMCIRB 16-001892
INCREASING AFRICAN AMERICAN STEM PROFESSIONALS

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 11/13/2016 to 11/12/2017. The research study is eligible for review under expedited category #6, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
Interview Protocol	Interview/Focus Group Scripts/Questions
recruitment email	Recruitment Documents/Scripts
Recruitment Tool	Additional Items
Shawn Moore informed consent document	Consent Forms
Shawn Moore Proposal	Study Protocol or Grant Application

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

APPENDIX B: INTERVIEW PROTOCOL

Interview Protocol to determine how the establishment of these factors have influenced these select PWIs as learning organizations:

Please provide:

- Your name
- The name of your institution
- The name of your department
- Your current position at the institution
- The number of years you have served in the above position

1. In thinking about diversity and underrepresentation in your department, talk about how colleagues learn from each other about this issue. Describe what this process looks like?
    a. Explain why you feel this may be important to learn about, why?
    b. Describe any feeling of competitive pressures from agencies (within or outside your organization) to address representation in Life Sciences?
2. Please describe how teams of colleagues in your department revise their thinking as a result of group discussion and information collection, as it relates to diversity and underrepresentation in Life Sciences?
    a. Were these outcomes expected or serendipitous?
3. Talk about the perceptions colleagues have in your department regarding the degree of their confidence that the organization/department will act on their recommendations regarding how to address underrepresentation in Life Science areas of study?
4. Describe systems to measure gaps between current and expected outcomes to increase URM students in Life Sciences.
5. How does your organization/department measure time investment and other resources invested on activities related to increasing URM students in Life Sciences?

a. Describe how your organization/department recognizes individuals or groups for taking initiative to address underrepresentation in Life Sciences?
b. How does this reflect in their T&P process?

6. Talk about how your organization/department supports colleagues who take calculated risks related to addressing underrepresentation in Life Sciences.
    a. Talk about the expectations the organization/department has in order to provide that support.
7. Describe the relationships/partnerships your organization/department have with external stakeholders to meet the mutual needs related to representation in STEM and the STEM enterprise?
    a. Describe the communication process the organization/department engages in with the community?
8. Can you explain how your organization/department leaders are continually looking for learning opportunities to address the lack of diversity in STEM fields of study, particularly Life Sciences?
    a. Are there any networks that have been created to engage in data collection regarding this topic? Who are the players involved? What are the dynamics of the network?
9. Describe how URM students were involved in any of processes or activities discussed thus far.
    a. Given the disparity in URM in science fields, did the students share insight on the issue from their perspective? Did those perspectives mesh with that of the faculty and staff?
    b. Talk about the degree of success and or failure in developing these student interactions.
10. Is there anything else you would like to talk about regarding our conversation?