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Science Identity and Underrepresented Minority STEM Organizations

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SCIENCE IDENTITY AND UNDERREPRESENTED MINORITY STEM ORGANIZATIONS

by

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ABSTRACT

President Obama indicated that there are twice as many science and technology jobs available in the U.S. as there are workers for those jobs (Office of the Secretary, 2013). To fulfill the need for more scientists and engineers, there must be increased educational support for the nation's underrepresented minority (URM) science, technology, engineering, and mathematics (STEM) students. URM STEM organizations, such as the National Society of Black Engineers and other URM student-oriented organizations that provide academic and career resources, are widely used on college and university campuses across the nation to support these students both academically and professionally. Future developments of URM STEM organizations should be informed by the voices of the populations they serve: the students of URM groups. In fact, a better understanding of URM students' science identities can inform the organizations' efforts to recruit and retain these students in STEM disciplines.

Jones and Abes (2013) expressed that one must understand identity in order to understand college students and their experiences in higher education contexts. Individual students may possess many identities, including a student identity and a race identity, as well as a science identity. The goal of this research study was to explore how URM STEM organizations influence URM STEM students' science identity development. Accordingly, this study employed identity theory as a theoretical framework to answer the following research questions:

1. What is the composition of a URM STEM student's science identity?
2. How do URM STEM students perceive that their participation in a URM STEM organization at a major university shapes their science identities?

In this study, identity theory was used to examine URM STEM students' science identities, the ways they identify themselves as scientists (Malone & Barabino, 2009). We asked URM STEM students who belong to URM STEM organizations on a campus in the Southwestern U.S. to complete an open-ended survey in which they described experiences that have made them feel like scientists, their purposes for joining the organizations, and the specific ways in which they believe the organizations have contributed to their feeling like a scientist. Some of the students who completed the questionnaire were asked to give an interview that focused on their perspectives about how the URM STEM organizations affect their views of themselves as scientists.

Forty-two surveys and eleven interviews were completed by undergraduate and graduate student members of five different URM STEM organizations. All surveyed students are from groups that are traditionally underrepresented in STEM: African-American, Latino, Native American, Pacific Islander, and the female gender. Survey responses were analyzed using a grounded approach in order to determine the specific features of URM STEM organizations that students perceive to affect their science identities.

The results of this study indicate that URM students believe URM STEM organizations make them feel more like scientists by providing opportunities to demonstrate characteristics of scientists (such as being able to showcase their use and understanding of scientific material during research experiences) and participate in activities and events of practicing scientists, such as at outreach events and conferences. The students also perceive an enhancement of their science identities due to the recognition, professional development, networking, and confidence that they obtain as a result of their membership and participation in activities and events presented to them by the URM STEM organizations.

There is a need to produce more talented scientists and engineers to support the future economy of the USA. Additional educational support for the nation's URM STEM students helps fulfill this need; but more importantly, inclusion of more URM students with diverse backgrounds and different perspectives will impact the level of creativity, innovation, and quality of STEM products and services (Denson, Stallworth, Hailey, & Householder, 2015; National Research Council, 2003). Ultimately, a better understanding of how URM STEM organizations can encourage the development of students' science identities can contribute to the recruitment and retention of URM students in STEM.

Key words: science identity, underrepresented minority, STEM, underrepresented minority STEM organizations

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It is not lost on me that this achievement of completing this dissertation and earning the Ph.D. degree is as much my achievement as it is the achievement of my personal network of friends, families, co-workers, and everyone in between. I appreciate what everyone has done for me during this process. To those of you who have drenched me with your wisdom and advice, time after time, I heard you and I thank you. To those of you who shared your food, treats, and nourishment with me over these years, I thank you. To those of you who have loved on my children while I had to study and write, I thank you. And to all of you who have offered encouragement at each step of the way, I thank you.

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I acknowledge my children, Naima and Emerson. Although you have only been on this journey with me for a few short years, I acknowledge that you have also had to make sacrifices for this accomplishment to come to light. We have had to spend precious time apart, which I know is small in comparison to the lifetime we will have together, but it does not make it any less of a sacrifice for you or me. I thank you for being patient with me and for continuing to love on me despite the sacrifices. I want my accomplishments to serve as inspiration for you in your future endeavors, and as a source of strength when you set out to achieve your goals. I love you!

I acknowledge my mother, Erica. As a single mother of five children, your sacrifices are innumerable. I remember the times that you fought for me and my education, the times that you went without clothes and food so that my siblings and I could have those things, and the times when you worked and found a way for us to move to a new neighborhood when our old one became unsafe. And now that I am a mother, I even see how much you sacrificed mentally when you had to worry about your young children walking to and from school by themselves while you had to go to work. I hold my Ph.D. degree in your honor, mom. Please know that those sacrifices have not gone unnoticed and that they have all been worth it.

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Second, I acknowledge my committee members, Dr. David Hatchett, Dr. Dong-Chan Lee, and Dr. Christine Clark. Thank you for helping me see that my work is valuable and can be appreciated by academic professionals of various backgrounds. You have made me think about new ways that my work can make a broader and stronger impact, ways that I would not have considered on my own. So, I appreciate you opening my mind to new ideas and concepts, and in doing so, showing me that you believe in my ability to understand and expand upon your ideas.

Finally, I acknowledge Dr. MaryKay Orgill, my Ph.D. advisor. I know that I have expressed to you in the past that I appreciate about you, but I am not sure that you truly understand what you have done for me. Thank you for taking me on as a student in your group, for being the best academic advisor I have ever had (and I have had my fair share), for being so understanding (especially at times when I did not understand what I was getting myself into), and for being a great example of what it means to be a professor, advisor, mentor, author, etc. The value of your guidance, mentorship, and friendship is immeasurable.

DEDICATION

I dedicate this accomplishment to my beautiful children, Naima and Emerson.

I love you more than you will ever know.

This is all for you.

Love, Dr. Mom

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

When I tell people that I am working on a graduate degree in chemistry, I often get a look of surprise followed by the comment "You must be pretty smart." After hearing this on several occasions, I started to wonder what special abilities I have which help me understand chemistry that many people feel that they do not possess. Based on my personal academic experiences, I have come to the conclusion that I do not possess any special abilities, but I do have a different attitude about chemistry. My attitude toward chemistry, and science in general, is one of capability and confidence. I have always had an interest and aptitude for science. Earning high grades in science, and specifically in chemistry, reinforced my confidence in my abilities to learn and understand complex concepts in science. At this point, I am fully self-assured that I can learn and apply scientific concepts successfully. In other words, I have a positive science identity. Science identity is the awareness of one's competencies and values toward the field of science. My science identity has been under development since I was in primary school, and I have had many experiences since then that have contributed toward the positive development of my science identity.

So what influenced me to pursue a degree in chemistry in the first place? As an African-American female student, statistics would have deemed me an unlikely candidate for a career in the STEM fields. At the time of my high school graduation in 1998, only about 15% of all science and engineering bachelor's degrees were earned by underrepresented minorities (National Science Foundation, National Center for Science and Engineering Statistics, 2013). Fortunately for me, I was unaware of this statistic and I had a great high school chemistry teacher who acknowledged my abilities to learn and understand chemistry and math and nurtured my skills. I recognize how fortunate I was to have that person help me find my path. I also recognize that there are many students who are not as fortunate. Those are the students that I wish to encounter and inspire into pursuing degrees in science in the future. My volunteer experiences within primary and secondary education have made me realize my passion to become an advocate for the advancement of K-16 science education. It is my career goal to motivate and empower underrepresented K-16 students in their scientific abilities and enhance their science identities.

What helped me to persist in the field of science? There are many factors that have contributed to my success in science, all of which have enhanced my science identity in many ways. Mentorship has proven to be an invaluable factor for my success in science. I continue to learn much more about scientific fundamentals and applying them to life from my mentors and mentees than I could ever had hoped to learn on my own. Financial support is yet another major factor in my persistence in science. I have attained a number of monetary awards, including scholarships, fellowships, stipends, and grants, that have paid for all of my science education. Receiving these monies not only helped by alleviating the financial burden of college tuition as well as room and board, but they boosted my science identity because I was being rewarded for my scientific abilities and encouraged to continue my pursuits in science.

Several of the factors that have had great influence on my persistence in science and on building my science identity were introduced to me by underrepresented minority (URM) organizations that have focused on the advancement of URM students majoring in science, technology, engineering, and mathematics (STEM). From personal experience as a URM STEM student, I can attest to the impact that URM STEM organizations can have on the science experiences and science identities of URM students. I know that URM STEM organizations have positively impacted my science identity; however, it is not clear how other URM STEM students perceive these organizations. Thus, this study was designed to obtain URM STEM students' perspectives of the influence that URM STEM organizations have had on their science identities.

It is my belief that the first step toward becoming a scientist is to identify oneself as a scientist. To identify oneself as a scientist means that one has developed a science identity. Studying science identity in my dissertation work is the first step toward a greater understanding of the development of a science identity, which every student will need in order to complete a degree in STEM. The results of this study can inform efforts to encourage students from minority groups that are underrepresented in STEM fields to pursue STEM degrees.

CHAPTER 2 LITERATURE REVIEW

The goal of this study was to gain understanding about the intersection between science identity, underrepresented minority (URM) students in STEM, and the URM STEM organizations servicing those URM students in STEM at the post-secondary level. More specifically, this research project was focused on the perceived influence that URM STEM students believe URM STEM organizations have on their science identity. The literature review begins with an introduction to the concept of identity as it is used in identity theory, the framework that this study employed. It then focuses on the specific concept of science identity, and, finally, on the limited research about the relationship between research URM organizations and the science identity of URM post-secondary students. Figure 1 depicts the topics of discussion within the literature review.

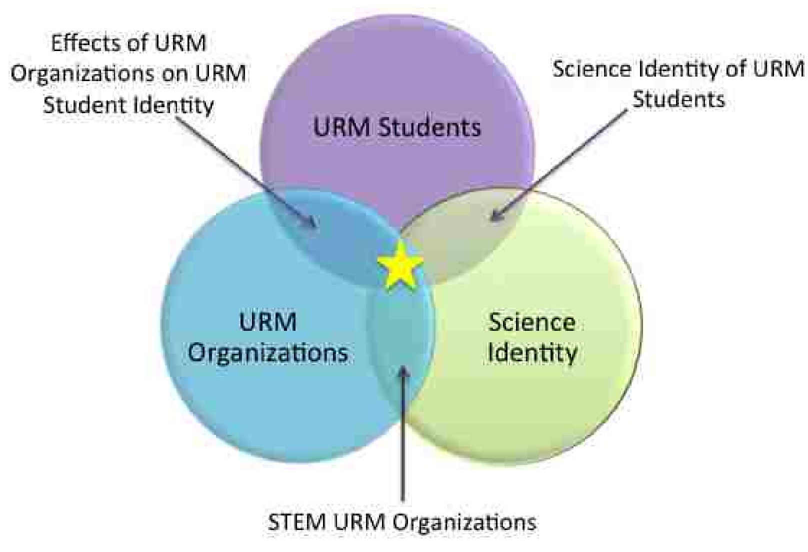

Figure 1. An overview of the literature review for this study. The star in the center represents the main area of focus of this study, which is how URM STEM organizations affect the science identity of URM STEM students.

Identity

What is Identity? Before entering a discussion of identity and identity development, one must understand the difference between some terms: *individual*, *self*, *identity*, and *others*. For the purposes of this study, these terms have specific definitions. An *individual* is a physical person who can be seen, touched, and heard. An individual is a part of a whole society, yet can separate from the whole at their own discretion. Individuals develop a sense of self and their identities.

In order to form an identity, the individual must have an understanding of their self (Josselson, 1994). The *self* is an awareness that an individual has about their being that encompasses all that makes up who they are. The self is a part of an individual, an identity is a part of the self, and an identity is a position held by an individual, which the individual has internally designated themselves to be (Burke & Stets, 2009; Jackson II & Hogg, 2010). In other words, an identity is defined as an individual's self-categorization into a role and incorporation of the meanings of that role into that individual's self (Stets & Burke, 2000). An individual can only possess one self, yet may possess multiple identities within their self (Figure 2).

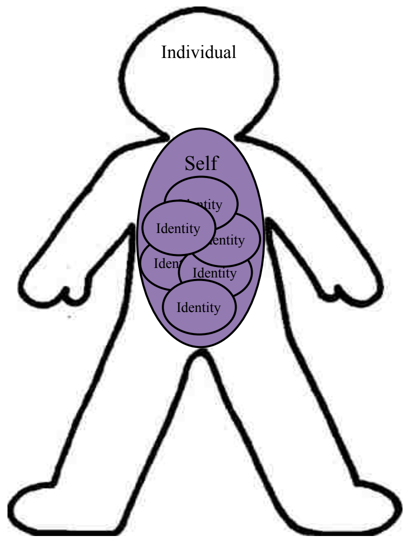

Figure 2. A basic representation of the self and identities found within an individual. (Body outline image courtesy of ClipArt Best (ClipArtBest.com, 2016)).

What an individual learns about their self may both restrict and regulate their identity choices. As an individual moves about in society, they have experiences that allow them to learn about their self. An individual who has their first experience of tutoring a fellow student may learn that they enjoy the experience, which means their self now identifies with being a tutor. The individual who now identifies himself as a tutor may believe the tutor identity means having the ability to understand new concepts completely, and having the ability to teach new concepts to his peers. Yet, that same individual may restrict taking possession of the identity choice of teacher because he believes that requires extensive training and a college degree, both of which he does not possess.

Identity Formation

Identity formation is perpetual (Wenger, 1998). A basic identity formation cycle is depicted in Figure 3. Interactions with other persons mold the identities of individual selves every day. Other persons, meaning other individuals in society, will be referred to as *others* throughout the rest of this dissertation. An identity is formed and reformed through a continual cycle of individual interactions with others, others reacting to the individual and providing validation or degradation, and the individual responding to the others' reactions by adjusting their own actions in order to elicit a positive response toward building their identity.

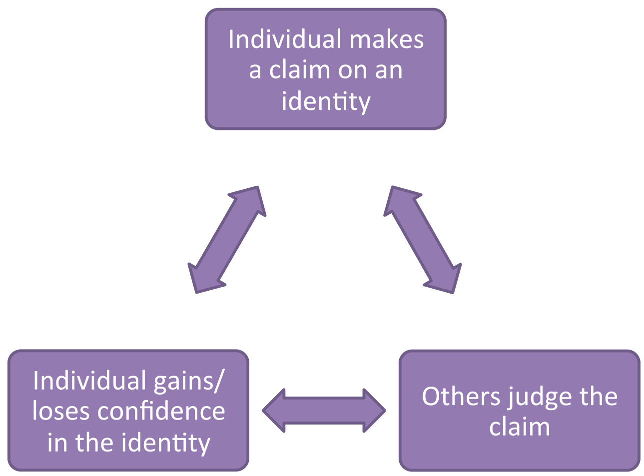

Figure 3. A basic cycle of identity development.

Forming an identity involves gaining awareness of competencies, values, and emotions; the confidence to stand alone as well as bond with others; and moving beyond intolerance for openness and self-esteem (Chickering & Reisser, 1993). These attributes are gained as an individual moves throughout society and participates in interactions with others. A baby boy learns to speak English by interacting with his parents who speak English with him. The English language becomes a part of the baby boy's identity through positive reinforcement from his parents as he uses the language with them.

All identities share a set of characteristics. The general characteristics of identity have been summarized by Malone et al. (2009) as:

- Identity generates at the cusp of society and the individual.
- Identity is contextual, nonessential, and temporally developed.

- Identity entails recognition from others.
- Identity involves possibility as well as attribution.

Each of the four characteristics of identity will now be discussed in more detail using an example individual named Ilene. Ilene is a fictitious individual who is a URM university student that has chosen to major in chemistry.

General Characteristics of Identity

Identity is generated at the cusp of society and the individual. To understand identity, one must keep both the dynamics of the individual and that of social organization in consideration, as identity is the intersection between the individual and society (Archer, 1994). An individual's identity is formed and shaped by interactions with others in society, and those interactions influence the character of society. As an example, an individual woman, a fictitious person whom I have named Ilene, is seeking to be identified as a chemist and exhibits commonly known actions of a chemist, such as taking chemistry courses, performing laboratory experiments, and using the jargon of the subject. She performs these actions with others in a chemistry-focused society of individuals who have expertise in the field of chemistry, such as her more senior peers, her chemistry professors, and her research group's principal investigator. Her interactions with her peers, chemistry professors, and principal investigator will all contribute to shaping Ilene's science identity as a chemist.

As Ilene reveals her identity as a chemist, she is also influencing society's view of a chemist's identity. She continues to reinforce the societal meanings that a chemist identity possesses, such as a chemist engages in chemical research and develops scientific ideas from that research. She is also contributing toward dissolving the societal stereotype that chemists are male. Her display of her identity as a chemist can contribute to changing society's view of a chemist by enhancing currently-existing, societally-accepted characteristics of the chemist identity, or by challenging those accepted characteristics.

Identity is contextual, nonessential, and temporally developed. What makes identity contextual is that the individual's claims on their identity are open for interpretation. The context of the individual's interaction with others in society will determine how others will interpret the individual's claim on an identity. For example, Ilene makes a claim on her identity as a chemist by citing chemistry articles from literature to support her analysis of the data she collected. In so doing, she gains recognition and validation as a chemist from her scientific peers when they show agreement and/or offer constructive criticism of her data analysis. In contrast, when Ilene makes the same claim in the context of a job interview when talking about this same experience with an interviewer, the interviewer may not identify Ilene as a chemist specifically, but as a researcher.

Possession of an identity is not essential for performing the actions that are commonly associated with the identity. A mom cooking dinner is exhibiting the actions of a chef identity, but may not identify herself as a chef. As another example, Ilene may complete coursework in biology as a degree fulfillment requirement, and may demonstrate the actions of a biologist to complete the course, but may only identify herself as a chemist and not a biologist in the field of science.

Identity is a perception of self that is stable yet fragile (Elmesky & Seiler, 2007). Identities are temporally developed, which means that they only exist for a certain amount of time and are not spiritual or eternal. In identity theory, identities are constantly evolving and continuously changing and, therefore, will not last forever. Identities are the outcome of continuous reproduction (Elmesky & Seiler, 2007). They are perpetually being formed and reformed. Others in society influence an individual's identity easily. Interactions with others in society can generate, shape, develop, and potentially extinguish an individual's identity. The individual will always attain new attributes associated with their chosen identity and disregard other less associated attributes as they learn more about the identity they have chosen to exemplify and the shared meanings that society correlates with that identity. Also, over time, society may redefine the shared meanings for an identity, which changes the way individuals will relate with that identity, and, thus, contributes to the temporal nature of identities. For example, in the not so distant past, students seeking the identity of chemistry professor were expected to complete countless hours of bench work and to use quantitative data collection and analysis as their main methods for conducting research. With the field of chemistry education continuing to grow and becoming more accepted and understood in the chemistry society, the identity of the chemistry professor has evolved to include the capacity to conduct qualitative as well as quantitative research.

Identity entails recognition from societal others. Identity serves as a guardian of the integration and continuity of self-experience as well as a mechanism of shared meaning-making with those with whom individuals will live life (Josselson, 1994). In other words, identity is categorized by the ways in which one chooses to participate in society, and how the people of society interpret that participation. That is to say, an individual makes claims on an identity through their actions, and relies on others' judgment of those actions in order to learn the viability of their claim (Brickhouse & Potter, 2001; Malone & Barabino, 2009). The individual's identity is validated when others in society recognize the individual as possessing the characteristics of the identity that the individual has claimed. When Ilene demonstrates her knowledge of chemistry through answering questions in class, she is making a claim as a chemist to her professor. Completing laboratory experiments in her internship as a researcher is another way Ilene makes a claim as a chemist to her principal investigator. The expert others, who are Ilene's professor and principal investigator in this case, validate her identity as a chemist by recognizing and acknowledging her actions as being in alignment with those of a chemist.

Identity involves possibility as well as attribution. Erikson (1959) defined the concept of identity as a feeling of being at home in one's body, possessing a sense of knowing where one is going with an inner assuredness of anticipated recognition from others. Simply put, an individual displays the actions of an identity knowing there is a possibility that others will not acknowledge or recognize their desired identity, yet presents the actions with the anticipation that societal others will associate the attributes of the claimed identity with his or her own identity.

The General Characteristics of Identity in Relation to the Current Study

The four characteristics of identity have been taken into consideration in both designing and interpreting the results of the current study because they explain the expansion of any identity and, more specifically, a science identity. This study is focused on the relationship between URM STEM students' science identities and those students' perceptions of the influences that the URM STEM organizations have on their science identities. In this study, the first characteristic of identity—that identity is generated at the cusp of society and the individual—is important in that URM STEM organizations bring URM STEM students in contact with societal others who will undoubtedly influence the students' science identities. For example, as they participate in the activities of the URM STEM organizations, URM STEM students could have an increased number of interactions with URM STEM peers who will help them gain confidence in their academic coursework, and success in STEM academic coursework positively affects science identity.

The second identity characteristic–that identity is contextual, nonessential, and temporally developed–provides justification for both the existence of URM STEM organizations and for the current study. URM STEM students often stop pursuing STEM degrees in college and opt to pursue non-STEM majors instead (Chang, Kwon, & Stevens, 2016). In choosing to leave their STEM majors, students demonstrate the contextual, nonessential, and temporal nature of their science identities. In other words, they no longer closely identify with their science identities and have taken on different, non-STEM related identities. Retaining these students in STEM-related majors requires encouraging the development of students' science identities in the face of pressures that would challenge these contextual, nonessential, and temporal identities.

The third identity characteristic—that identity entails recognition by societal others—is important to consider in the current study because URM STEM students' interactions with societal others and being recognized by those societal others as a scientist is essential for their uptake of a science identity, particularly with the societal others who are scientific peers and scientific professionals. URM STEM students could encounter scientific societal others more frequently than they would otherwise as they participate in events and activities provided by URM STEM organizations, thereby increasing their opportunities for gaining validation on their claims as scientists.

As for the fourth and final characteristic of identity, involving possibility and attribution, I propose that URM STEM students must first identify themselves as "potential" scientists before they can possess a science identity. Students must gain confidence in their science identities such that they are able to display the actions of a scientist with the anticipation that a societal other will either validate or invalidate their claims of being scientists. A URM STEM student who is a member of a URM STEM organization has the opportunity to validate their claims of possessing a science identity at organizational events.

When a URM STEM student shows up to their first URM STEM organization meeting, they are staking a claim that they belong in the group based on their scientific background, no matter the level of their expertise. As they interact with societal others that they encounter during their time at the meeting, those societal others will give that student validating or invalidating responses to their claim. For example, the URM STEM student who is new to the group will inevitably be asked what their major is. If the student claims a STEM major, the person asking the question can respond by asking the URM STEM student for help with answering a question in which the URM STEM student's expertise would be useful. The person asking the question can choose to believe the help which the URM STEM student is offering is valid, which validates the URM STEM student's experiences in STEM and gives the URM STEM student a sense of being knowledgeable in their STEM field. On the other hand, the person asking the question can determine that the help which the URM STEM student is offering is not valid, walk away, and ask someone else for help. These actions would invalidate the URM STEM student's claim to a science identity. The URM STEM student knew before arriving at the meeting that their science identity would be challenged, and so is aware of the possibility of being validated or invalidated, but makes the claim on their science identity anyway. There are multiple activities and interactions that occur at a meeting of a URM STEM organization. These have the possibility of either validating or invalidating the participating students' science identities. The goal of the current study is to identify, from the students' perspectives, the activities and interactions that support (or do not support) the development of their science identities.

In summary, identity is the way a person understands himself or herself in relation to the past, present, and potential future (Brickhouse & Potter, 2001). An individual draws upon their past experiences to determine what their future identity will be and builds upon that identity with their actions in the present day. In addition, the individual self simultaneously joins the self to society and society to the self when developing their identity (Josselson, 1994). An individual can have multiple identities within their self. One of those identities can be a science identity, which will now be discussed.

Science Identity

What is Science Identity? Malone et al. (2009) suggest that a science identity requires a sense that one is deemed worthy of participation in the science community. I would argue that having this sense of worthiness is the first step toward developing a science identity. Students with science identities possess positive self-images of themselves as scientists (Gilleylen, 1993; Huang, Nebiyu, Walter, 2000; Lewis, 2003).

Carlone, Haun-Frank, and Webb (2011) define normative scientific practices as practices that one is accountable for when looking to be considered competent in a scientific setting. Students with science identities likely exhibit Carlone et al.'s (2011) normative scientific practices. Normative scientific practices include the ways individual members of a scientific community are expected, entitled, and obligated to participate in as science persons, as well as the meanings that the scientific community members make of particular acts of participation (Carlone et al., 2011; Gresalfi, Martin, Hand, & Greeno, 2009). Carlone et al. (2011) identified five normative scientific practices:

1. Asking and answering scientific questions
2. "Messing" about with tools of science
3. Communicating scientifically
4. Making scientific inferences
5. Conducting scientific observations

An individual with a science identity would demonstrate behaviors aligned with these normative scientific practices. Professionals in all of the STEM disciplines demonstrate behaviors aligned with these normative practices. Therefore, for the purposes of this study, the term “science identity” will be used in reference to all STEM identities. For example, if a student declares that they are an engineer, it will be assumed that the student has a science identity.

Identity forms the framework for the individual’s adulthood (Josselson, 1994). It bridges the individual with society, and childhood with adulthood (Josselson, 1994). In other words, an individual begins forming their identities in childhood, and those identities are carried with them throughout adulthood. Life-world experiences that occur before the age of 14 are the major determinant to the pursuit of studying science (DeWitt et al., 2013). When a high school student decides she wants to become a scientist, she is likely to continue to attain the qualities of a scientist as she moves into adulthood. To do so, she may take extra science courses in high school, choose a science-related major in college, set a goal of obtaining a career in science, and seek out mentorship from an accomplished scientist. All of these actions will create more opportunities for interactions with scientific others, and those interactions will strengthen her science identity.

Performance of science in younger grades is necessary for the development of a science identity (Carlone & Johnson, 2007; Jackson & Suizzo, 2015); however a primary grade level student’s enjoyment of “doing” science does not ensure that the student will uptake a science identity (Archer et al., 2010). “Being a scientist” means a science identity has been acquired. Archer et al. (2010) argue that young students who enjoy “doing” science may not uptake a science identity because doing so would clash with their intensely held masculine or feminine identities. For example, a young student may have a masculine identity as a sports athlete. He may choose not to identify himself as a science person if he believes that being a science “nerd” would clash with his “jock” identity.

In addition, mastery of scientific content knowledge also does not indicate the uptake of a science identity (Barton & Brickhouse, 2006; Carlone, 2004). Other more salient identities may cause a suppression of or disregard for a science identity. Carlone (2004) illuminated the fact that girls seeking to maintain a good student identity will perform well in their science classes but resist the uptake of a science identity or any identity that they perceive will be a threat to their more salient good student identity. Nevertheless, science identity development is perpetual and continuously evolving. A student's science identity can change and evolve over time just as any other identity (Aschbacher, Li, & Roth, 2010). All societal factors have the potential to support or degrade the science identity development of any student.

A person is considered to have taken up a science identity when they claim themselves as a science learner, as someone who knows about science, as someone who uses science, and as someone who contributes to science (Fraser & Ward, 2009; Schon, 2015). An individual can be recognized as a scientist if he or she talks, acts, looks, and interacts in alignment with historical and prototypical ideals of a scientist (Carlone & Johnson, 2007; Malone & Barabino, 2009). In other words, an individual with a science identity has built a relationship with one or more scientific disciplines (Li & Loverude, 2013).

In this study, I assumed that anyone who uses scientific methods has the potential for possessing a science identity. In other words, I assumed that the participants of this study can have a science identity if they have declared a major in a STEM field. An individual with a science identity would demonstrate behaviors aligned with Carlone et al.'s (2011) normative scientific practices, which were presented earlier in this section. Students majoring in any of the STEM fields will demonstrate normative scientific practices multiple times throughout their coursework, research experiences, and extracurricular activities. For example, students majoring in mathematics or a technological field such as computer science are using tools of science every time they use their programming and mathematics knowledge to solve a problem. Engineering students continuously make scientific inferences and conduct scientific observations when they design and conduct experiments, as well as when they analyze and interpret data. Therefore, the students who participated in this study were expected to have science identities because their chosen majors in STEM require that they demonstrate normative scientific practices.

Science Identity for Underrepresented Minority (URM) Students

Ethnicity plays a significant role in identity formation in schools (Brickhouse & Potter, 2001), which leads to ethnicity playing a significant role in science identity formation in schools (White, Altschuld, & Lee, 2006). Students' science identities are shaped by classroom structures that may or may not resonate with the students and their cultural dispositions (Elmesky & Seiler, 2007). When their science experiences resonate with their personal life experiences, the students' science identities expand. This remains true for students with ethnic backgrounds that tend to be underrepresented in the STEM fields, commonly referred to as underrepresented minority students.

For the purposes of this study, underrepresented minority (URM) students are defined as those who are underrepresented in the STEM fields. These students have cultural and ethnic backgrounds that include African-American, Hispanic, Native American/Alaskan Native, and Pacific Islander heritages. The gender included in the URM category is female. URM students' backgrounds and heritages inescapably influence their science identity development. Previous research has identified a number of societal factors that encourage science identity development for URM students, which will be discussed in the section that follows. Although some of these factors also have a positive influence on the science identity of students in general, the narrative below will focus exclusively on the factors that positively influence URM students, as they are the target population for the current study.

General Introduction to Factors that Positively Affect the Science Identity of URM Students at All Education Levels

A small number of research studies has described a variety of factors that positively influence the science identity development of URM students. For example, studies with Latino undergraduate students found that, among other things, family and community support, receiving college preparation in high school, and having caring and kind teachers contributed positively toward students' success in their science and engineering majors (Brown, 2002; Jackson & Suizzo, 2015; Johnson, 2007). Achieving success in STEM contributes positively to science identity formation by building the confidence of the individual who experiences that success. Other research studies of African-American science students uncovered similar factors contributing positively to their science identity development. An inherent motivation to succeed in science, proper college preparation, possession of aspirations in science, and continual familial support facilitated the persistence of African-American senior undergraduate science students at a predominantly white university (Johnson, 2007; Russell & Atwater, 2005). Also, a demonstrated competence in science and mathematics at the pre-college level is characteristic of the science identity of African-American students who have successfully navigated the science pipeline (Chang, Eagan, Lin, & Hurtado, 2011). More recently, Jackson, Galvez, Landa, Buonora, and Thoman (2016) reported that a perception of the ability to use science as a means to help reach their pro-social goals, such as giving back to the community, has a positive impact on the science identity of URM students. Table 1 lists the factors that were mentioned in the literature to have a positive effect on the science identity development of URM students at all academic levels. The factors that are known to encourage science identity development of students in general are provided for reference.

Table 1
Factors that positively affect the science identity development of general and URM students at the primary, secondary, and post-secondary levels

Factors affecting science identity development	For the URM student	For the general student
An emotional connection to the subject	X	
Apprenticeship		X
Coaching		X
Demonstrated competence in mathematics and science	X	
Extra-curricular activities involving science (not associated with school)		X
Faculty-student interactions	X	X
Familial (STEM) role models		X
Familial support	X	X
Having an honors program at school	X	
Having caring, kind, teachers	X	
Having challenging and interactive curriculum	X	
Having small class sizes	X	
Home environment	X	
Inherent motivation	X	
Internship		X
Living in small communities	X	
Media	X	
Receiving information	X	X
School STEM experiences	X	
School support	X	X

Strong pre-college preparations	X	
Tutoring		X

Factors that Positively Affect the Science Identity of URM Students at the Post-Secondary Education Level

Reinforcing URM STEM students' science identities aids in their retention in STEM (Estrada et al., 2016; Snyder, Sloane, Dunk, & Wiles, 2016). Therefore, it is imperative to know the factors that positively affect the development of URM STEM students' science identities. Table 1 lists factors that positively affect the science identity of primary, secondary, and post-secondary URM students. This was done to show the breadth of the research results that are currently available which pertain to factors influencing the science identity of URM students. However, for this study, the factors particularly affecting the science identity of post-secondary URM STEM students are of greater importance. According to the research literature, the four factors that have the greatest positive impact on post-secondary URM STEM students' science identities are (1) school support and supportive teachers, (2) familial support, (3) mentoring, and (4) research experiences, each of which will be discussed in the sections that follow. With the focus of the current study being on the effects of URM STEM organizations on post-secondary URM STEM students' science identities, research related to the influence of similar programs ("STEM enrichment programs") will also be presented.

School support and supportive teachers. Students will use the reactions of others to judge the viability of their science identities. If an individual has the desire to identify herself as a chemist, then she must have a relationship with communities of practice where one does chemistry (Aschbacher et al., 2010). If students are not given the opportunity to engage in practices that promote the gaining of science knowledge and science identities, then they will not be able to see themselves as science community participants (Carlone, 2004).

Identity within a society, or a community of practice, is deepened by competence and positive assessments by one's self and others (Aschbacher et al., 2010). Scientific research and laboratory experiences provide opportunities for a student to deepen their science competence and receive positive assessments toward their science identity development. Science identity development occurs during research and laboratory experiences (Malone & Barabino, 2009). Therefore, apprenticeship or internship opportunities are instrumental in the persistence of high achievers in science. These opportunities tend to put the science identity-seeking student into direct contact with scientific others and potential scientific mentors, such as university faculty members.

Faculty-student interactions play a critical role in the science identity development of science students in general (Carlone & Johnson, 2007; Chang et al., 2011; Hurtado et al., 2011). In order for young students to be able to imagine themselves as scientists, they must have the ability to take up a science identity that can be recognized and accessed by others (Barton & Brickhouse, 2006). Having a science mentor provides the student with ample opportunities to enhance her science identity as the mentor serves as a scientific other who can validate her claims to a science identity, and as a scientific other who can present opportunities to engage in science practices that can build her scientific competence, including laboratory experimentation and explaining experimental results to scientific others.

URM students who are acquiring a science identity need to feel that they are a part of the scientific community. Students who are aspiring scientists rely on the judgment and invitation of practicing scientists throughout every phase of the science education and career process (Lewis, 2003). Without being accepted into the community of practicing scientists as capable science students and mentees, it is difficult for underrepresented minority students to become scientists, as they are not identified nor validated as scientists in this situation. Being recognized by faculty members as a science person is critical for URM individuals' maintenance of a science identity at the post-secondary level. Post-doctoral fellows', undergraduate, and graduate students' self-rated science efficacy is significantly improved with research and mentoring experiences with faculty members (Hurtado et al., 2011). The more URM students feel, think, act, and are recognized as a "science person," the more likely they are to identify with a science field (Carlone & Johnson, 2007; Chang et al., 2011). This has been affirmed by Chang et al. (2011) who found that

> by increasing students' tendencies to feel, think, behave, and be recognized by meaningful others (e.g., faculty role models and mentors) as a 'science person', URM students stand a much greater chance of believing in their abilities to succeed in the sciences. (p. 3)

Familial support. Identities are produced through practices, relationships, and interactions within specific sites and spaces (Archer et al., 2010). Scientific communities that support URM science students' science identities can include spaces and communities where science is supported, although not necessarily practiced. Family, peer, and faculty support play key roles in URM science identity development and academic success (Chang et al., 2011; Hurtado et al., 2011). One major factor associated with the backgrounds and heritages of URM students that influences their science identities are the people they know and interact with on a daily basis, their societal others, who includes relatives, peers, and teachers, and others who may or may not be scientific others. Non-scientific others, such as the student's parents, significant other, and extended family, will be significant to the science identity of the student in ways that are and are not related to science. Students acquiring a science identity not only need to be recognized by scientific others, but also by non-scientific others who understand and can acknowledge the efforts of the science identity-seeking student as scientific in nature. Being recognized as a science person by friends and family members positively affects a URM student's science identity.

Mentoring. Guidance and support are significant in the academic and social integration of post-secondary URM STEM students, making these factors essential for science identity development (Wade, 2012). Guidance and support are often products of mentor-mentee relationships between a URM STEM student and a scientific other in their scientific community. That scientific other can be a peer student, an upperclassman, or a STEM professor, to name a few (MentorNet, 2008). Mentors and mentees can meet in informal settings (URM STEM organization meetings, and formal settings (organization conferences). A mentor-mentee relationship is often established and facilitated by URM STEM organizations. For example, when the organization connects a URM STEM student with a faculty member for a research opportunity, or when URM STEM students are brought together for an organization meeting and decide to form a study group with each other to help one another succeed in their STEM coursework (Lane, 2016).

Mentoring can lead to academic success, as URM STEM students have shared in a previous study (Kendricks, Nedunuri, & Arment, 2013). A study conducted by an external program evaluator was commissioned to understand why mentoring was consistently rated by URM STEM students as having the largest impact on their academic success (Kendricks et al., 2013). The study examined the post-program satisfaction surveys completed at the end of each academic year by URM STEM student participants of a STEM enrichment program at a university designated as a historically black college and university (HBCU) that serves predominantly African-American students. The URM STEM students' academic performance in STEM was also evaluated against their mentoring experiences. This STEM enrichment program's model of mentoring used structured mentoring sessions in supportive environments where the URM STEM student participants were allowed opportunities to share their academic, social, and cultural experiences amongst themselves and supportive faculty. The findings show that students attributed academic success to effective faculty mentoring.

The academic support that mentors can offer includes one-on-one tutoring, advice on course preparation, and help with finding study groups. Study groups are created when students come together for the purposes of studying and assisting each other with the goal of completing homework, getting advice from others about STEM courses to increase the students' odds for success in challenging STEM courses. Students from URM groups are less likely to form study groups and may find it difficult to break into established cliques, so having a mentor that can facilitate networking for the URM STEM mentee can break down some of these barriers to their academic and career success (Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; May 2003).

The professional development that mentors can offer includes providing advice on career preparation, assistance with resume writing and building, and facilitating opportunities for scientific skill development, such as research experiences. In their study of the mentoring experiences and career development of highly successful Latina scientists and engineers, San Miguel et al. (2015) relayed how these URM STEM women believe that their success in STEM would not have been possible without the guidance, encouragement, and support of their mentors and their broader support system of scientific and non-scientific others. The URM STEM women of this study said that the support of their mentors boosted their confidence to pursue higher education and higher positions in the workplace, and this increased confidence in STEM is evidence of their science identities being enhanced. In the end, San Miguel et al. (2015) found that successful Latina scientists and engineers credited mentors for inspiring their post-graduate pursuits in STEM.

Research experiences. Chemers, Zubriggen, Syed, Goza, and Bearman (2011) have determined that research experiences enhance URM STEM students' science identities. In a more recent research study, Beals (2016) reported that research experiences involving hands-on, high level research impacted URM STEM students' academic growth, sense of accomplishment, confidence in themselves, and their attitude about STEM, which are all factors that can affect their science identities. In other words, research experiences strengthen URM STEM students' beliefs in their abilities to perform in a STEM environment, and the increased self-confidence leads to further development of the URM STEM student's science identity (Ghee, Keels, Collins, Neal-Space, and Baker, 2016). In fact, other researchers have found that participation in research experiences broadens URM students' interests and goals in STEM (Prunuske, Wilson, Walls, Marrin, & Clarke, 2016; Thiry & Laursen, 2011).

Lane's (2016) dissertation research determined that undergraduate research experiences buttress science identity development. In her research, Lane (2016) sought to understand how a STEM enrichment program facilitates college readiness and retention of URM students in STEM. A STEM enrichment program is described in the research study as a program designed to reduce attrition of URM STEM students by providing structured programming such as academic advising, mentoring, and tutoring. STEM enrichment programs often feature research experiences as part of their comprehensive approach for URM STEM student success. The author used qualitative methods to examine and analyze the strategies and practices of one STEM enrichment program that serves up to fifty URM STEM students at a time. In her study, the author found that undergraduate research experiences serve as STEM identity development catalysts. In their research experiences, the participants of her study were able to demonstrate their knowledge and understanding of STEM material, use scientific tools to complete tasks in the laboratory, and gain recognition for their research. As a result of their research experiences, the participants made gains in their STEM-related competence, recognition, and performance, all of which are factors that Carlone & Johnson (2007) named as components of a science identity.

STEM Enrichment Programs

There is a lack in the literature of research focused on how URM STEM organizations affect the science identity of post-secondary students. However, a review of literature detailing the effects of STEM enrichment programs on post-secondary URM STEM students' science identities is appropriate for this study because STEM enrichment programs and URM STEM organizations are similar in their mission and approach toward fostering the retention of URM students in STEM. Both STEM enrichment programs and URM STEM organizations offer services that support URM STEM students' academic success, such as tutoring, academic counseling and advising, and study groups. However, there is a primary difference between the two. The primary difference between STEM enrichment programs and URM STEM organizations is that STEM enrichment programs provide, and often require that their students attend, academic courses that are designed to prepare the student for the rigorous coursework that they have ahead of them. For example, the STEM enrichment program known as the Meyerhoff Scholars program has a mandatory pre-freshman summer bridge program in which students will take for-credit and non-credit courses in science, math, and the humanities. By attending these courses, the Meyerhoff Scholars Program participants will be better prepared "scholars for the new expectations and requirements of college courses" (University of Maryland, Baltimore County, 2018).

Two nationally recognized STEM enrichment programs, the Meyerhoff Scholars Program and the National Science Foundation's Louis Stokes Alliance for Minority Participation (LSAMP) program, have been of particular focus in past research due to their high level of success over the recent decades (May, 2003; Shehab et al., 2012).Typically, these STEM enrichment programs are viewed as successful models of some of programs that best support URM STEM students while those students work toward their STE degrees. The STEM enrichments programs' success is measured by the number of URM STEM students that they have been able to help graduate with STEM degrees and have encouraged to enter STEM graduate programs and careers (May, 2003; Steele, 2010).

The research on the Meyerhoff Scholars and LSAMP programs has primarily been carried out to inform educators, post-secondary institutions, and the administration of other STEM enrichment programs of the methods used to best support URM STEM students. For example, in her dissertation research, Lane (2016) used a qualitative approach to understand the strategies and practices of a STEM enrichment program that facilitated college readiness and the retention of URM STEM students at a large predominately Caucasian university. She used interviews, focus groups, observations, and documents to identify the strategies and practices that best support science identity development for URM STEM students. She found that practices of the STEM enrichment program that built competence and confidence or that provided praise and celebration acted as catalysts for STEM identity development. She also found that undergraduate research experiences similarly acted as catalysts for STEM identity development.

Underrepresented Minority (URM) STEM Organizations

For the past several decades, the call for increased representation of minorities and women in STEM has been answered, in part, with the inception and development of race-based programs and student-run organizations at the post-secondary level (May, 2003; Shehab et al., 2012). URM STEM organizations are student-run organizations that focus on the retention and persistence of students who are majoring in STEM fields and who are from ethnic and gender groups that are consistently underrepresented in the STEM fields. URM STEM organizations endeavor to foster the success of URM STEM students through academic support (such as tutoring, study groups, peer support), professional development (such as networking, mentorship,), and career readiness development (such as conferences, workshops, research experiences). In other words, URM STEM organizations are aimed at preparing post-secondary URM STEM students for their future careers in STEM.

URM STEM organizations are designed to assist the post-secondary student who has already declared their major in STEM, with the understanding that the students' declaration of their major is evidence for their interest in STEM. Therefore, URM STEM organizations offer more career-related resources versus academic resources. The URM STEM organizations represented in this study (the Multicultural Program, the National Society of Black Engineers, the Society of Women Engineers, and the Society of Hispanic Professional Engineers) also focus on providing career services and resources for their students. The Multicultural Program provides "minority groups with essential information, exposure, educational opportunities, and materials in preparation for careers in engineering and in the rigorous [STEM] disciplines and construction management for graduation and employment" (University of Nevada, Las Vegas, 2018b). NSBE boasts that it trains its members "in the essential skills for their professional lives," such as leadership (National Society of Black Engineers, n.d., p. 2). The mission for the Society of Women Engineers includes helping women achieve their full potential in engineering careers and leadership (Society of Women Engineers, 2018, May 2). Also, the Society of Hispanic Professional

Engineers list many career-related benefits with membership, such as lifelong networking opportunities with high profile professionals and scientific others, internship opportunities, career training, and tips on resume writing and interview skills, to name a few (Society of Hispanic Professional Engineers, 2018).

Science Identity and Underrepresented Minority (URM) STEM Organizations

If support from schools, teachers, families; mentors: and research experiences have a major influence on the science identity of URM students before college, then it stands to reason that these factors will continue to have an influence on URM students' science identity progression in college. URM STEM organizations at colleges and universities can provide and facilitate the promotion of similar supportive environments for undergraduate and graduate students, and post-doctoral fellows.

Historical ideals of the identity of a scientist can affect the formation, or deformation, of the science identity of potential future scientists (Brickhouse & Potter, 2001). Students carry models of a good science student that they have derived from the media, their peers and families, and their in-school and out-of-school science experiences (Carlone et al., 2011). Traditionally, the identity of a scientist included being a nerd-like, older Caucasian male who wears a white lab coat with a pocket protector and works in a laboratory for hours and hours each day. This traditional science identity would not be how many URM students would identify themselves, which would make it harder for them to relate to being a scientist. Students who do not identify with the traditionally-accepted traits of a scientist would have a harder time relating to the identity of a scientist, which may lead to feelings of inadequacy in science disciplines, making it difficult for them to develop a relationship with any science discipline or a science identity. Therefore, those students will need some specific interactions with scientific others in order to foster their science identity development (Merolla & Serpe, 2013). As previously mentioned, some of those specific interactions include becoming a part of a scientific community of practice, being recognized and supported in scientific learning and endeavors, and being given the opportunity to engage in scientific practices.

For students in college, there are resources on campus that are put in place to help them succeed and graduate in their chosen fields of study. Underrepresented minority students who have chosen to major in STEM fields may have URM STEM organizations as resources on campus. Many of these URM STEM organizations are nationally recognized for helping students succeed and obtain careers in STEM fields. These organizations offer several common services such as tutoring, scholarships, career advice, and leadership opportunities. URM organizations also provide the scientific interactions with scientific others that URM students need to support their science identity development.

Negative experiences leave devastating effects on the development of scientists in general, including, and perhaps especially for, URM students. To combat these negative experiences, university and college campuses have employed URM organizations to provide an avenue of support for URM students of all science disciplines. Participation in URM organizations and differences in their backgrounds significantly impact the persistence of women and minorities in STEM (Griffith, 2010). Retention of well-prepared African-American, Latino, and Native American Indian students in college is achieved when universities provide these students with settings that promote academic achievement associated with non-White racial identity, support for community and family ties, protection from stereotype threat, and rich advising aimed at helping students understand how college works and how to navigate a racially charged atmosphere (A. Johnson, 2007; J. Johnson, 2016). For decades, URM organizations have been used to provide all of these resources for minority college student success, but evaluative research on these programs has been limited until recently. Quantitative surveys have been conducted to determine what parts of these URM organizations are most used and wanted by the student members. However, no qualitative surveys or qualitative research studies have been conducted to obtain the students' perceptions of the URM organizations and how those URM organizations have affected their science identities. The current study, which examined the science identities of URM STEM students and how these are influenced by URM organizations, informs science education research as well as higher education's role in the development and growth of URM scientists.

Justification for Current Project

In his 2012 State of the Union Address, the United States of America's (USA) President Barack Obama remarked there are twice as many science and technology jobs available as there are workers who can do the job (Office of the Secretary, 2013). There is a need to produce more talented scientists and engineers to support the future economy of the USA. To fulfill this need, there must be more educational support for the nation's URM STEM students. A better understanding of URM students' science identities can inform the recruitment and retention of URM students in the STEM fields.

There are a number of factors that can positively and negatively influence students' science identities. For URM STEM students at the post-secondary level, URM STEM organizations can be one of these factors. However, little is known—from the students' perspectives—about the specific components of URM STEM organizations that positively influence students' science identities or how students believe those components affect their science identities. The impact of URM STEM organizations on URM STEM students' science identities needs to be better understood (Ong, Wright, Espinosa, & Orfield, 2011).

The literature review presented here is brief simply because there is a short supply of research studies focused on gaining a deeper understanding of the science identity of URM students. In fact, to my knowledge, there are no research studies focused on qualitatively assessing the effect of URM STEM organizations on URM students' science identities from the URM STEM students' perspectives. Furthermore, there are currently no research studies that are aimed at combining these topics until now. The current research study addresses this gap in the literature by explaining how URM STEM organizations affect the science identity of their post-secondary URM student members, as told from the URM STEM students' perspectives. This information will be of use to educators, regional and national science foundations, URM STEM organizations, students, and all with a vested interest in increasing the participation of URM groups in STEM fields.

CHAPTER 3 THEORETICAL FRAMEWORK

Identity Theory

Identity theory provides a basis for understanding the relationships between the individual and social structure, and how each influences the other. In other words, identity theory postulates that the individual can affect general society in such a way that it can alter the standards of society, and society can affect the individual's identity in such a way that it can incite change in the individual's identity. Identity theory may be applied in research as a theory and as a theoretical framework in order to better understand how society and the individual self affect one another. It is derived from the perspective of symbolic interactionism and, more specifically, structural symbolic interactionism. The concept map in Figure 4 depicts the features of identity theory that guided the current project.

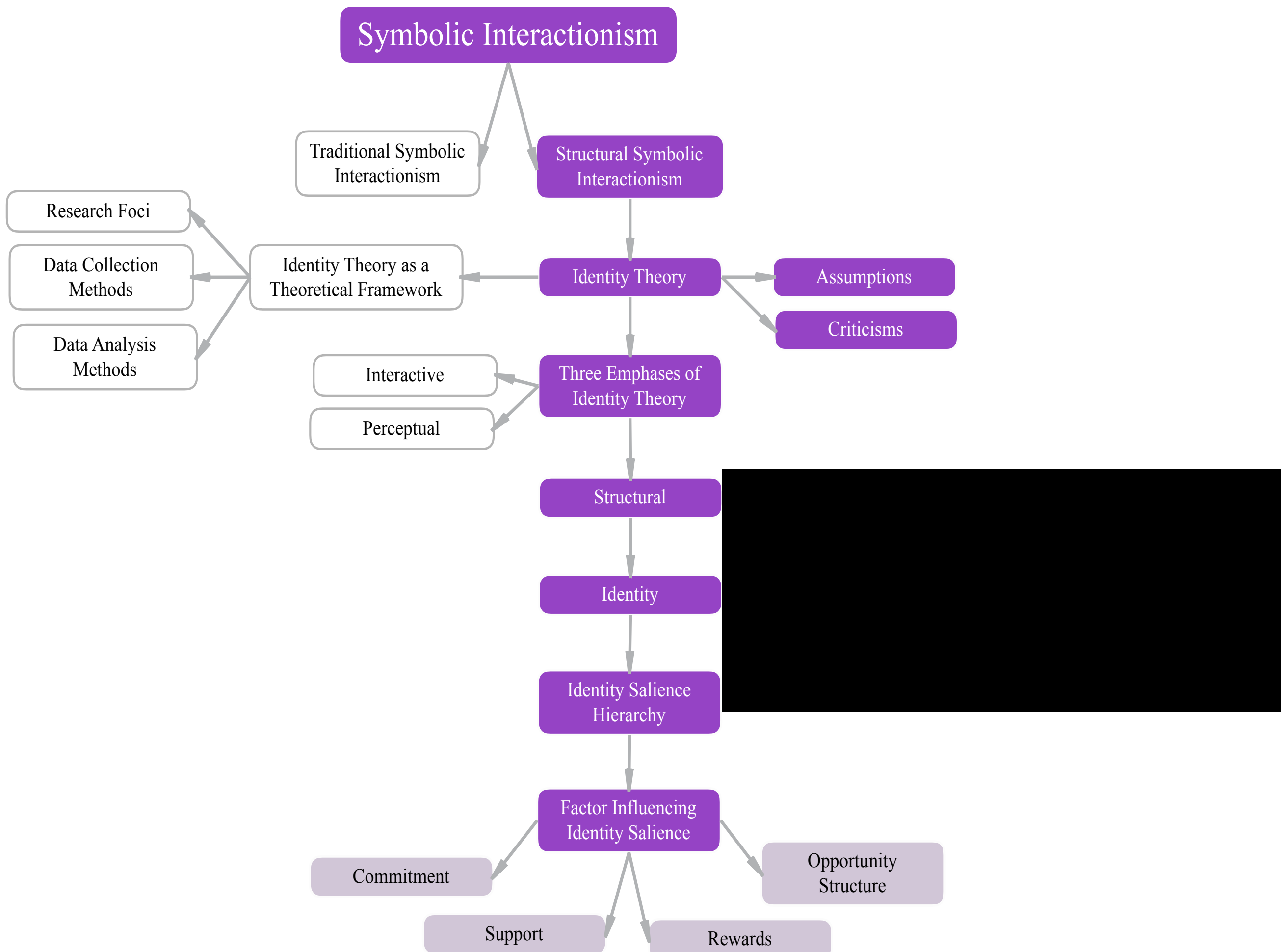

Figure 4. Concept map of the relationship between symbolic interactionism and identity theory. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study.

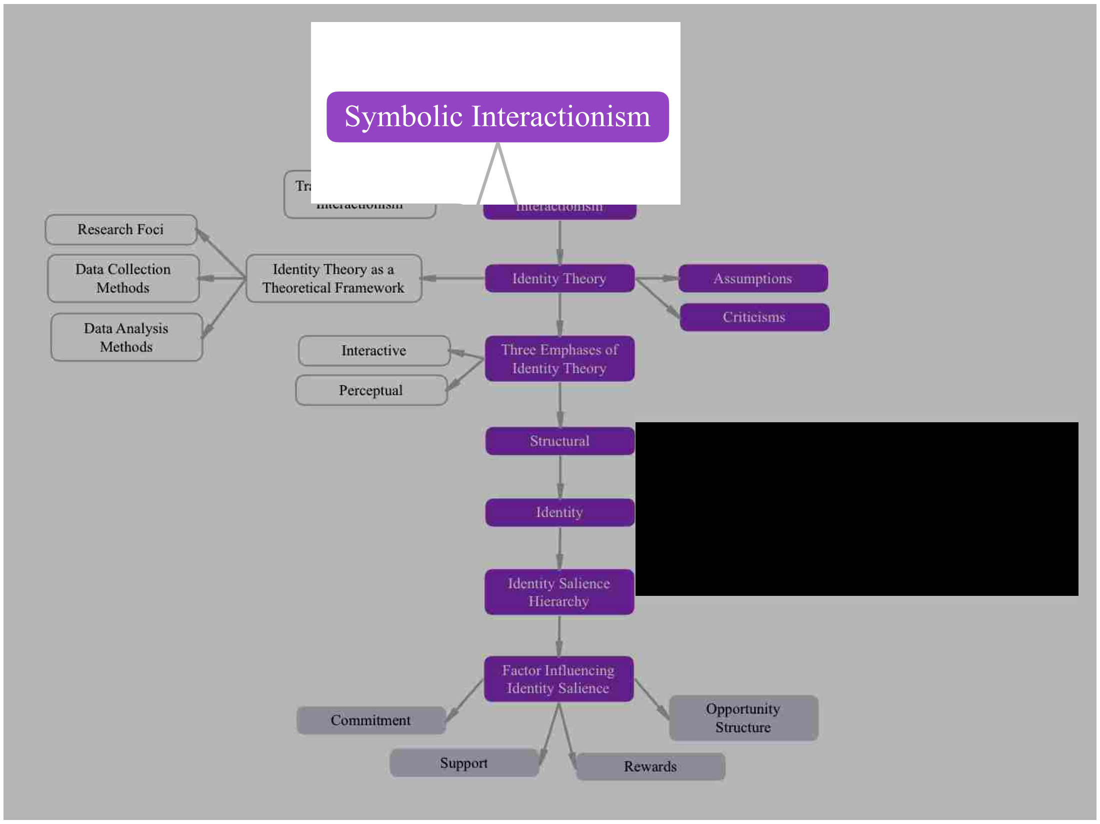

Figure 5. Concept map of the relationship between symbolic interactionism and identity theory-Symbolic Interactionism. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Symbolic Interactionism.

Symbolic Interactionism. The history of identity theory begins with symbolic interactionism. Herbert Blumer (1962) used the term "symbolic interaction" to succinctly denote George Herbert Mead's (1934) perspective on human interactions. Symbolic interactionism (SI) refers to the character of human interaction that is based upon the shared use of symbols. Spoken words, physical gestures, and written characters are all examples of shared symbols. A couple of individuals speaking to each other in the language of Spanish would be interacting using the Spanish words as their shared symbols. Shared symbols and their meanings arise from social interactions.

SI theorists believe that society affects social behavior by influencing the individual (Hogg, Terry, & White, 1995). In identity theory, an individual is a human person who is among many human persons, yet is able to separate from other human persons as an individual. A group of human persons make up a society. Individuals are considered to be products of their interactions within society. For example, society has established that the actions of a "good" student include going to school regularly, being respectful toward one's teachers and peers, completing all assignments, and earning top grades. An individual who wants to become a good student will learn these established actions, adopt them as their own, and demonstrate them. The individual will receive the praise and acknowledgement of their actions that a good student would expect, and will gain an identity of being a good student. The individual ends up with a sense of self that includes the confidence of knowing they are a good student.

More importantly in SI theory, the mind of the individual is capable of reflexively viewing and treating oneself as an object and a subject. This reflexivity allows individuals to create an identified self that can be validated by others. The identified self is created through the social interactions of the individual in conjunction with the individual's capability of viewing himself or herself as an object. An inanimate object, such as an apple, has a name and a place in society that can invoke shared meanings and ways in which persons in society will act toward it. Persons who have had experiences with an apple before will see another and act toward it as a piece of nourishment, and so will eat it. Just like an inanimate object, an individual human person, whom we will refer to as Ilene, can be seen as an object. The difference between Ilene and the apple is that Ilene can learn her name and her "meaning" to others in society whereas the apple cannot. Ilene can also view herself as an object whereas an apple cannot. With learning how she is perceived by others, what she "means" to others through her societal interactions, she develops a self. In SI, the individual can view the self through the eyes of others in society (Jackson II, 2010). The individual can accept and/or transform how society has defined their identity based upon how they interpret society's meanings of their identity traits and how they predict others will respond to their actions.

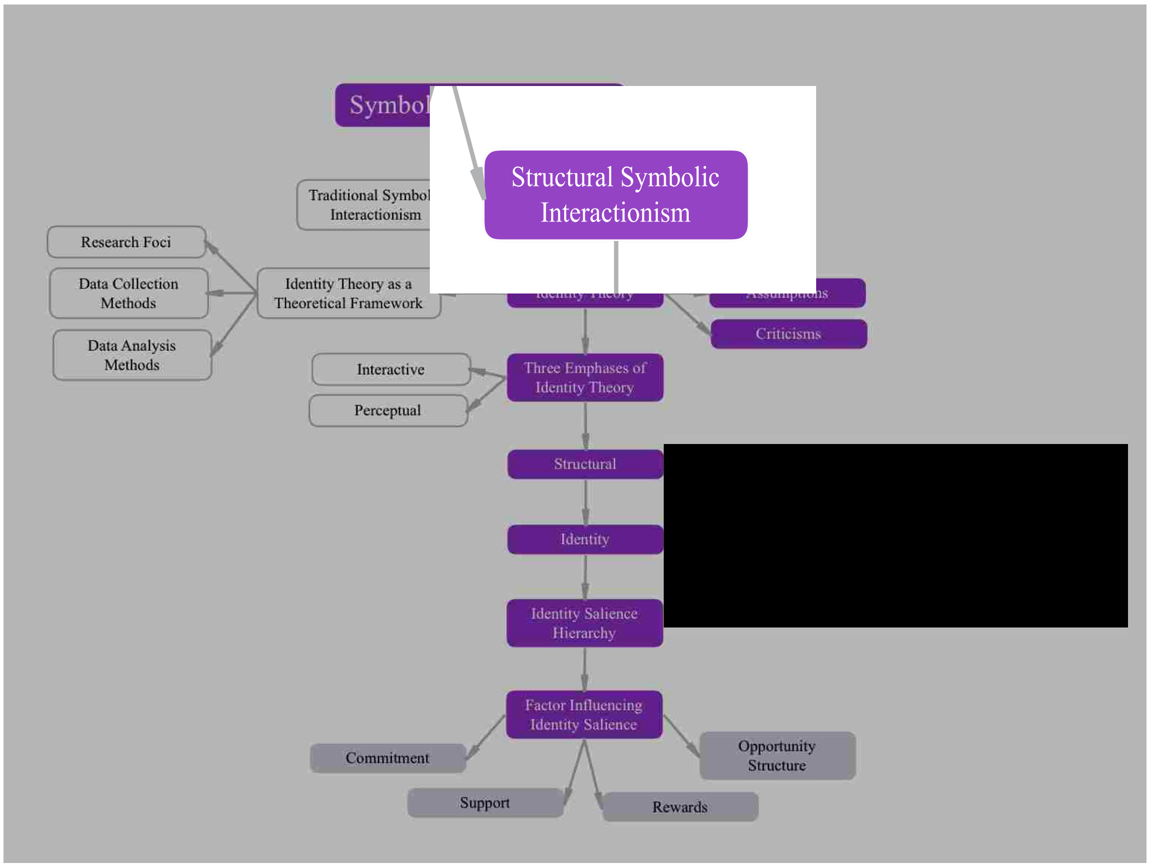

Figure 6. Concept map of the relationship between symbolic interactionism and identity theory-Structural Symbolic Interactionism. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Structural Symbolic Interactionism.

Traditional and Structural Symbolic Interactionism. Research on SI has been taken into two different directions (Figure 4). The first direction is referred to as traditional symbolic interactionism (TSI), and the other is structural symbolic interactionism (SSI). TSI and SSI share the perspective that studying individuals' definitions and interpretations of themselves, others, and their situations will lead to a better understanding of social behavior (Burke & Stets, 2009). Although they share this commonality, TSI and SSI have several differences regarding the role of social structure in understanding individual selves and social behavior, in the use of prior theory, as well as in the development of theory.

In traditional symbolic interactionism, social structure is not in a fixed, organized state as in structural symbolic interactionism. In other words, TSI theory ascribes to the idea that social structure is in a state of flux, continuously changing and evolving, and is always in the process of being created and recreated by the influences of the interpretations, definitions, and actions of individuals (Burke & Stets, 2009). The goals of individuals are not attained completely on their own, or by the actions of others, because they are continually influenced by the social structure. TSI follows the belief that theory cannot be created to explain social behavior, and social behavior is unpredictable (Burke & Stets, 2009). With the belief that social structure is always in flux, and that social behavior cannot be predicted, it is hard to conduct research from the TSI perspective because there is no stable reference point from which concepts can be measured. TSI is used in research to describe and further understand, as opposed to explaining and predicting, human behavior.

To explain and predict human behavior, structural symbolic interactionism depends on the patterns and stability of social structure. Contrary to TSI, in SSI, social structure is stable, organized, and durable, as reflected in the patterned behaviors of the individuals (Burke & Stets, 2009). SSI assumes that social structure is preexisting, and that individuals learn to conform themselves to roles within the social structure through socialization with others. If Ilene wants to be viewed as a scientist, then she acts as society expects a scientist will act and she learns from interactions with scientists. Following these principles and taking Kuhn's (1964) lead in believing that the individual is guided by a core "self" allows structural symbolic interactionists to create theories and make generalizations about the individual self and society. With the ability to apply scientific methods to conduct research and produce sufficiently reliable data and conclusions, SSI has provided a foundation upon which identity theory has been established.

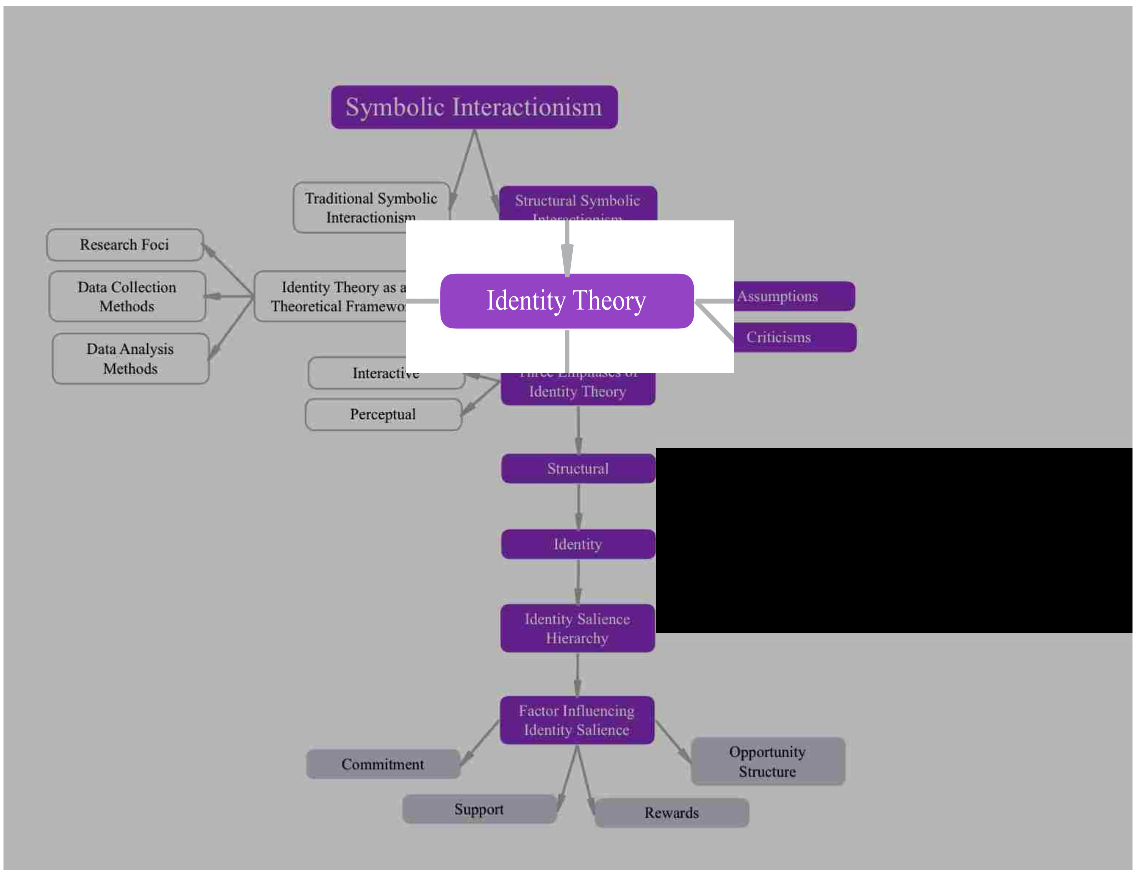

Figure 7. Concept map of the relationship between symbolic interactionism and identity theory-Identity Theory. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Identity Theory.

Identity Theory for This Study. Identity is a theoretical construct, and identity theory is a particular view of this construct. Identity theory is a philosophical and sociological framework that is characterized by the quest to understand how an individual identifies with society. Identity theory is used to explain the behaviors of an individual, and differs from social identity theory, which is used to explain intergroup behaviors (Stets & Burke, 2000).

Gee (2000) describes identity as what it means to be a certain kind of person. That certain kind of person possesses one or more identities that dictate how they respond to situations in which they find themselves, allowing them to learn by participation in the moment (Kane, 2011). Each identity possesses characteristic role behaviors that an individual uses to determine their behaviors toward situations. For example, considering a female chemist as a certain kind of person, she possesses at least two identities: one being a woman and the other being a chemist. When she is preparing to conduct a laboratory experiment, she will tap into her chemist identity, the one that has gone through chemistry-related training and schooling, to understand the problem, suggest a hypothesis, perform the procedure, and analyze the resulting data.

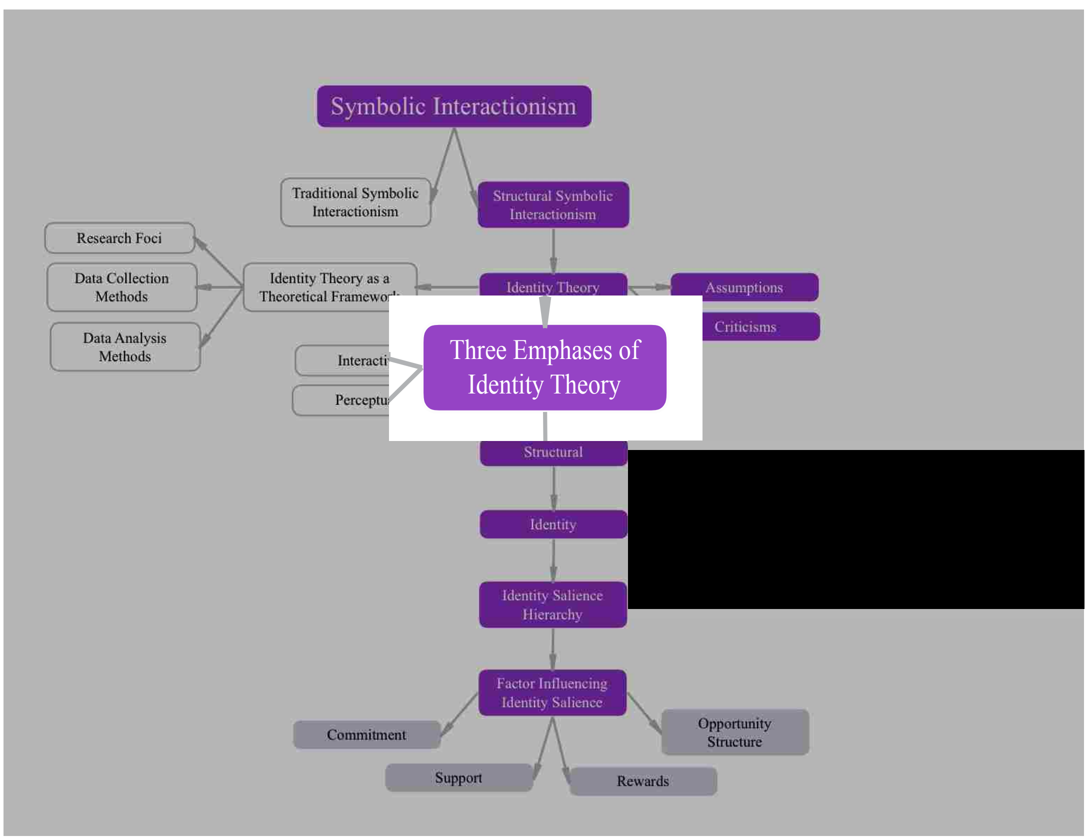

Figure 8. Concept map of the relationship between symbolic interactionism and identity theory- Three Emphases of Identity Theory. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Three Emphases of Identity Theory.

Three Emphases of Identity Theory. Identity theorists focus on different aspects of identity. There are three major emphases of identity theory: interactional, perceptual, and structural (Burke & Stets, 2009). The *interactional* emphasis focuses on understanding how the self influences behavior and on understanding aspects of exchange since interaction brings about behavior. In other words, the interactional emphasis seeks to understand how people communicate with one another, via conversation, physical connections, or otherwise, and how those lines of communication affect the behavior of those who are in communication with each other. McCall and Simmons (1978) indicated that within this emphasis, individuals claim more than one role identity, and place their identities within a salience hierarchy (also known as the ideal self). The aforementioned female chemist will undoubtedly have more than one role in society, which may include homeless shelter volunteer, music artist, and baker, among others. Her most prominent societal role may be that of a chemist because that is the role that she has chosen to exemplify the most when she is interacting with others, and, in so doing, is the identity that is most frequently recognized and validated as her role identity. The salience hierarchy is influenced by support from others for the individual's self-claimed identity, by the commitment the individual has to the role, and by the rewards the individual receives from the identity. This emphasis would be best utilized in research studies that seek to understand how the individual self interacts with others.

Within the *perceptual* emphasis, Burke and Reitzes (1981) argued that an individual's behavior is a function of the relationship between their perceived meanings of self and an identity's standard meanings. For example, a person who has a science identity that contains the meaning of laboratory researcher may perform laboratory experiments regularly. However, a person who has a science identity that contains the meaning of professor may display primary behaviors that are expected to include lecturing, advising, and assessing their students' academic performance regularly. This emphasis would be best used for studies that seek to measure and describe the identity meanings that people claim for themselves.

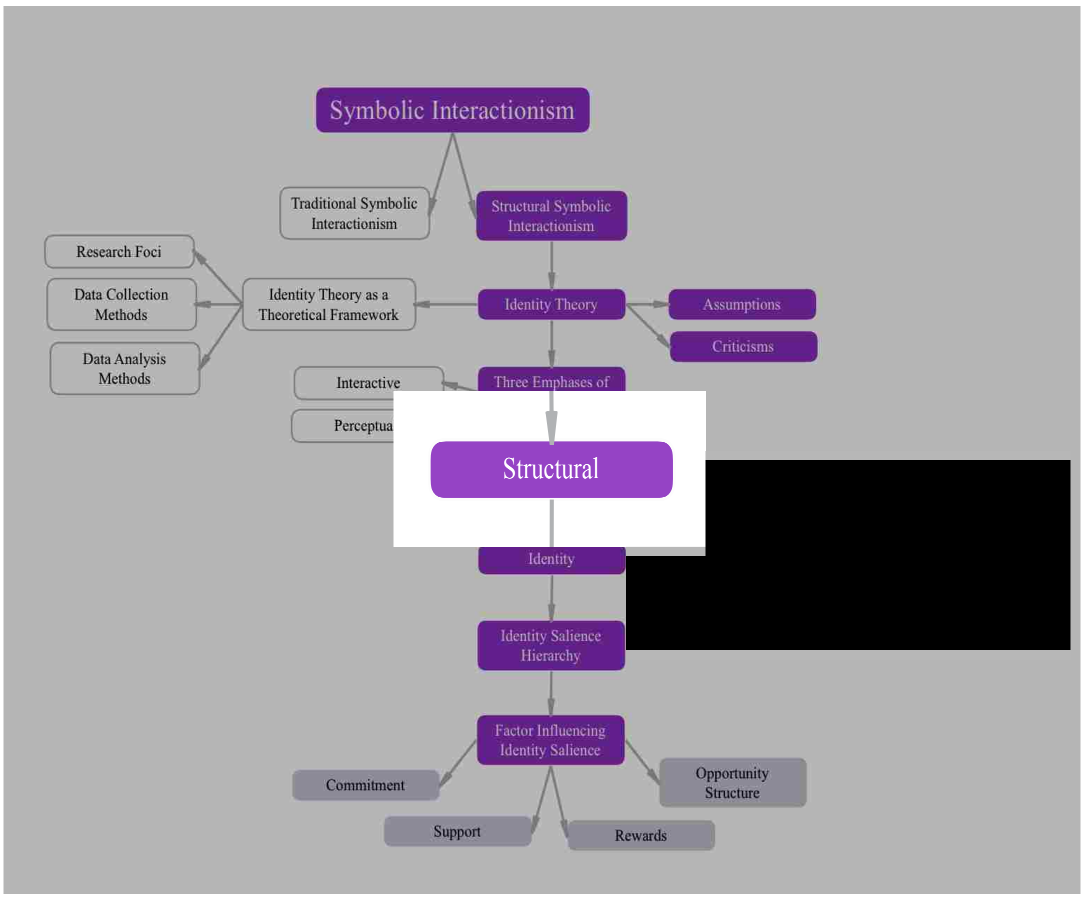

Figure 9. Concept map of the relationship between symbolic interactionism and identity theory-Structural. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Structural.

Structural. The *structural* emphasis of identity theory is concerned with how social structure affects an individual's identity and, therefore, their behavior. As with the interactive emphasis, the structural emphasis follows the belief that individuals claim more than one identity, which can be organized in a salience hierarchy by the individual. This emphasis is best used for studies that would result in an understanding of how an object in society influences the identities of individuals. For example, a person with a science identity may work for an industrial company that offers a mentoring program. The structural emphasis would seek to understand and measure the effect of the industrial company, or the effect of the mentoring program, on the individual's identity development. Of the three emphases of identity theory, the structural perspective was the most appropriate for this study, which is focused on the effect of a particular social structure, URM organizations, on URM STEM students' science identities.

Individual. Before going any further into the description of identity theory, it is important to define the terms of *individual*, *identity, and self* as they are used in identity theory and in this study. An individual is a singular person, a separate human being from all other human beings. A group of individuals make up a society. Individuals have a physical presence and can be seen, heard, and touched. They make their own decisions about what to do when presented with opportunities to exhibit their identity traits. Individuals maintain their own personalities, ideas, and control of their bodies. Individuals also maintain an awareness of their self that guides their identities.

Self. The self is the individual's awareness of competencies, values, and emotions; the individual's confidence to stand alone as well as bond with others; and the individual's ability to move beyond intolerance for openness and self-esteem (Chickering et al., 1993). It is a part of the individual that encompasses who they are. An individual can only possess one self, yet may possess multiple identities within their self (Jackson II & Hogg, 2010). Rosenberg (1979) described self-concept as all that an individual knows, thinks, and feels about themselves and who they are. However, this description is not thorough, as it does not relate the concept of self to the behaviors of self as is done in identity theory. The concept of *identity* provides the link between self and behaviors of self, and will be discussed in the following section.

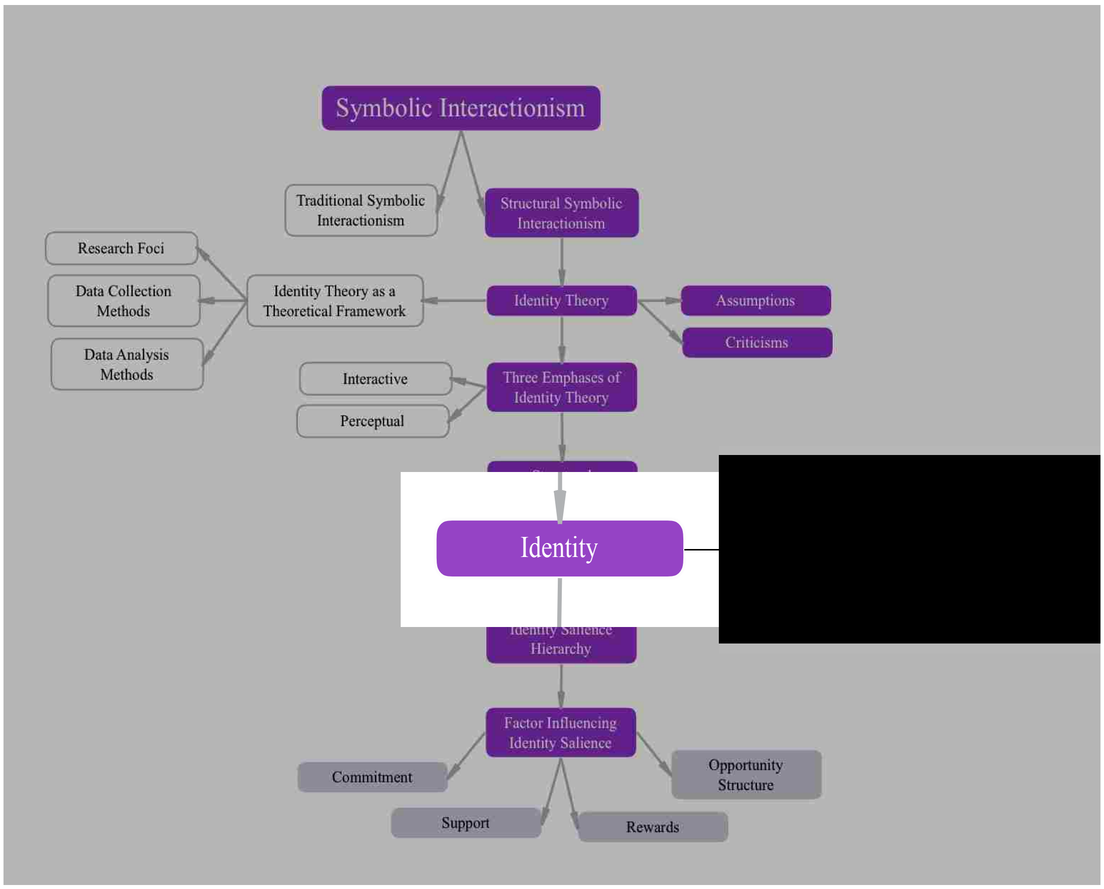

Figure 10. Concept map of the relationship between symbolic interactionism and identity theory-Identity. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Identity.

Identity. There are several definitions for identity in the literature, but Foote (1951) laid out the definition of identity as it is used in identity theory in the present day. He asserted that a person's identity provides the motivation and energy forces for the societal roles with which the individual identifies. McCall and Simmons (1978) later supported Foote's idea of identity in their research on identities and the interactions between identities. In identity theory, an identity consists of the set of meanings that define a person's occupancy of a particular role in society, a member of a particular group, or what particular characteristics the person claims. This description of identity was later supported by Stets & Burke (2000), who highlighted that identity theory maintains that the categorization of the self as an occupant in a role is at the core of an identity. A person claiming a mathematician identity will possess and display characteristics of a set of meanings that are associated with that of a successful mathematician, which may include but are not limited to the ability to solve complex mathematics problems, scholarship and recognition in the field of mathematics, and a career in the field. Identities have cognitive and emotional components, and can operate at the conscious and unconscious levels (Burke & Stets, 2009).

The set of meanings for an identity is unique to each individual: what it means to be who you are. No two individuals have the same set of meanings that make up their self because everyone has unique interactions and interpret shared interactions in their own way using their personal set of shared meanings to make sense of their interactions with societal others. For example, an African-American male student and a Caucasian male student receiving the same lecture in a chemistry class will have a shared experience but may gain different interpretations of the lecture based upon their previous experiences.

The self can be made up of multiple identities. An individual has an identity for each of the roles they play in society (Stryker, 1980). For example, the fictitious female scientist named Ilene who was introduced earlier, has a science identity, an identity as a mother, and yet another identity as a woman. However, she is not limited to just these identities. She may also identify herself as a teacher, a leader, a cook, a wife, a scholar, etc. Each of an individual's identities has a place along the salience hierarchy found within the mind of the individual.

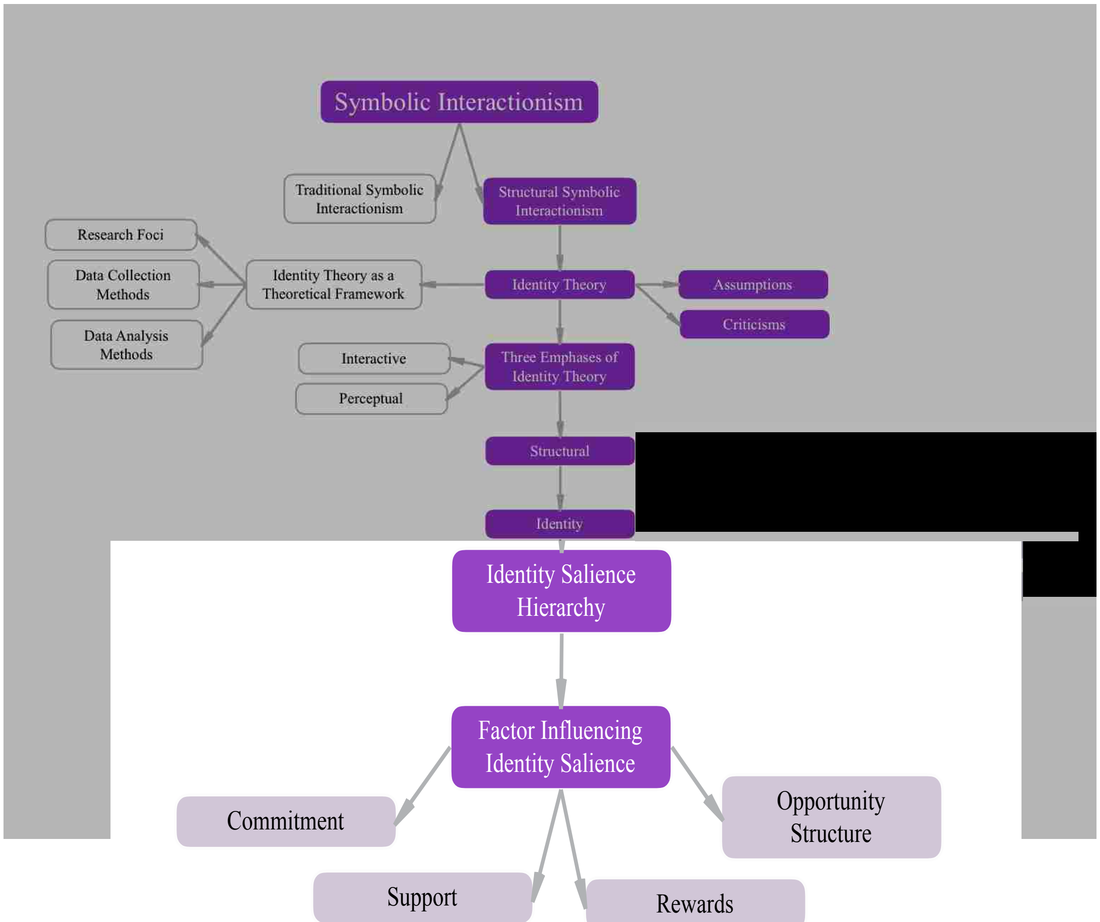

Figure 11. Concept map of the relationship between symbolic interactionism and identity theory-Identity Salience Hierarchy. The text boxes shaded in dark purple denote the line reasoning that were used in this study. The text boxes shaded in light purple denote the components of interest to this study. The highlighted box denotes the next part of the discussion, Identity Salience Hierarchy.

Identity Salience Hierarchy. In the structural emphasis of identity theory, the salience hierarchy within the mind of the individual indicates which of their identities he or she identifies with the most. The higher the identity is in the hierarchy, the more likely it is to be activated in situations. The behaviors of the individual verify the order of their salience hierarchy (Osborn, 2010). The salience hierarchy is influenced by commitment, support, intrinsic and extrinsic rewards, and the perceived opportunity structure to be successful in the identity (Osborn, 2010).

In structural symbolic interactionism, one of the most important influences on the identity salience hierarchy is commitment to the identity (Burke & Stets, 2009). The stronger the commitment to an identity, the higher the identity is on the salience hierarchy, and the more likely that identity will be called upon in any given situation; thus, behaviors for this identity are displayed most frequently. When the female scientist mentioned earlier, Ilene, is presented with an out-of-state job opportunity, she will make her decision based upon the identity that is most important for her. If she identifies most with the identity of a "mom" instead of that of a "scientist," she may decide not to relocate her family if her children do not want to move away from their school, friends, and family. If she identifies more with being a scientist, she may decide to put her career first and accept the job even if her children would be unhappy with the decision for a while.

Another important influence on an individual's identity salience hierarchy is support from others, which validates the identity. An individual develops an identity based upon their perception of being in a group and validation by significant others in the group (Rodriguez, 2000). Stone (1962) points out that an identity is not only defined by the individual, but also must involve identification by others. He proposed that an individual's identity is established when others identify him or her as the social object with which he or she identifies. Culinary mentors and food critics validate a culinary student as a chef each instance they adorn her with the title of chef. The trend is that the more others recognize an identity, the higher the identity is placed on the individual's identity salience hierarchy. In other words, the more an identity is supported, the more the identity is developed, and the individual in possession of that developed identity will display the characteristics of that identity.

Identity Development

Identity development involves discovering the kinds of experiences with which the self resonates, and at what level of intensity (Chickering & Reisser, 1993). The experiences occur at work, play, home, and where identities for the individual self are found. Identity development is influenced by the self's family of origin, ethnic heritage, and religious or cultural traditions (Chickering & Reisser, 1993). Establishing an identity involves a growing awareness of competencies, emotions, and values, and an increased ability to stand alone as well as bond with others.

Use of Shared Symbols. Structural symbolic interactionism (SSI) contends that individuals have a shared view of the world through the use of symbols and language that represent shared meanings and responses. These shared meanings and responses form the basis of behavioral expectations. The symbols are learned via interaction with others within societal structures that often define the behavioral meanings of the symbols, hence Stryker's term *structural symbolic interaction* (Stryker, 1980). Playing a game with a basketball is a symbol that identifies a basketball player. Studying for a final exam symbolizes the actions of a student identity. The symbols represent objects and events that may or may not be physically tangible, such as spoken language. Language is a central concept of SSI and identity theory. Identities tie us to others in society through language and shared definitions of symbols (Burke & Stets, 2009). Language is a symbol with which individuals communicate and interact with one another. Words within the language are symbols that represent objects and events as well. For example, in the English language, the word "scientist" represents a person who studies and possesses an expertise in the natural or physical sciences.

The use of shared symbols by individuals dictates and predicts their behavior in particular situations. The symbols are representations of the shared meanings of an identity. Identities emerge from the named patterns of behaviors and shared meanings of symbols that are cyclically and continuously defined and redefined by the individual and society. The symbols of a science identity include actions such as working in a laboratory, having a career in a scientific field, and publishing articles in scientific research journals, among other things. The symbols of a ballet dancer identity do not include doing any of the aforementioned actions of a scientist, and so no one in society would expect a ballet dancer to complete any of the scientist's actions.

The individual and society use each other to validate the identity of the individual and determine the shared meanings of the identity. In other words, the actions and symbols that make up an identity are not static and can change over time as society redefines the identities through interactions and situations. Scientific grant opportunities have been requiring scientists to collaborate with researchers outside of their field of study to work on a problem with a multidisciplinary approach. This was not always the case. With this new multidisciplinary approach becoming a normal symbol of scientific research, the science identity has evolved to universally include collaboration and the ability to gain an understanding of another, less familiar field of study.

Assumptions of Identity Theory

Identity theory operates under some assumptions about individuals and their behaviors. Burke (2009) pointed out that identity theory assumes that the self originates in the mind of the individual, and that the self is what characterizes the individual's identity. The self is capable of viewing itself as an object; therefore, it is able to evaluate and take account of itself to facilitate manipulation of itself to change its state of being. When an individual begins to treat him or her self as they would treat other people, then they have achieved “selfhood” (McCall & Simmons, 1978). When an individual becomes aware of their self and others, they will begin to notice characteristics of identities that they will adopt as their own, leading them to form their own identities. For example, when a student has achieved selfhood, they are aware of their wants, desires, likes, and dislikes. If that student has recognized a fondness within their self for learning science, they will develop a desire to act more as scientists do, and will begin to exhibit the characteristics of a scientist regularly.

Another assumption of identity theory is that the individual’s behaviors are premised upon a named or classified world (Burke & Stets, 2009). Stryker’s structural emphasis on identity theory is aligned with these assumptions, claiming that symbols used in society designate relatively stable positions, or roles, that make up the social structure that everyone uses. To elaborate, there are preexisting symbols for every identity in society. The identities can include that of a student, a professor, a scientist, a police officer, and a doorman, to name just a few. These symbols were determined by society over the centuries of individuals interacting with one another, designating what each symbol will represent and for whom the symbols will be representative. For example, for the person who has earned the title of President of the United States of America, leadership, government, and respect symbolize their presidential identity. The White House and Air Force One are also symbols of the presidential identity. All of these symbols for the presidential identity designate the relatively stable position of the social structure for the President of the United States of America (USA). The presidential identity symbols were created by presidents, elected officials, and citizens of the USA, all of whom are individuals making up the USA’s society, over the duration of the existence of the presidential identity. These symbols for the presidential identity have not changed much, and will not change for quite some time.

Identity theory also carries the assumption that identities resist change (Osborn, 2010). This is in alignment with the identity theory assumption that identity meanings are fluid, but change at a slow rate. To change an identity means changing the meanings that define who one is. In a study which investigated how identity processes are related to identity change, Osborn (2010) found that changing student identity standards took as long as eight to nine weeks. For example, an individual's student identity can shift from being less studious to more studious. When the individual's meaning of what is necessary to be a student shifts in such a way, identity change has occurred. Eight to nine weeks is considered to be a large amount of time for what may be a small change in only one of an individual's identities.

Limitations of Identity Theory

One limitation of identity theory is that there is not a universally accepted definition for identity because it has crossover definitions with related concepts across different disciplines (Carlone et al., 2011; Korte, 2007). Psychologists describe identity as a set of norms whereas sociologists define identity as a set of societal roles. Anthropology researchers argue that identity is an artifact of culture. This variance can lead to a loss of understanding the concept of identity, especially for those researchers who are new to the field of identity theory research, and a loss of a collaborative understanding of *identity* due to semantics (Korte, 2007). Theorists agree that the concept of identity exists, but they disagree on its construction and development. For this study, I chose to use a definition of identity that considers all of the aforementioned definitions of identity. Identity is defined in this study as a societal role that has an established set of norms to define it and which can be culturally influenced.

Another limitation of identity theory is that an identity is a theoretical concept which can only be found within the mind of the individual; therefore, it is difficult to analyze identities with a high level of accuracy as it is impossible to see an identity, quantify an identity, or physically enter anyone's mind. Also, because identities are unique to each individual, the findings of any study on identities cannot be generalized. Despite this limitation, qualitatively studying identities provides a deeper understanding of the behaviors of individuals and can be used to inform more generalizable research studies.

Identity Theory as a Theoretical Framework

Identity theory is not only a theory, but may also be used as a theoretical framework to explore how identities are constructed. Identity theory as a theoretical framework functions as Bodner and Orgill (2007) suggested: it provides assumptions that guide the research on identity, it assists the researcher when choosing appropriate research questions for a given study on identity, and it directs the researcher toward appropriate data collection methods for their particular study. The assumptions of identity theory outlined earlier in this chapter are the assumptions that guide this research study. Briefly, those assumptions are that the self originates in the mind of the individual, that the self is what characterizes the individual's identity, that the individual's behaviors are premised upon a named or classified world, and that identities resist change.

The way identity theory helps the researcher choose appropriate research questions is by providing multiple directions of focus. Using this study as an example, identity theory allowed me to choose either the traditional or structural symbolic interactionism pathway, and still provided another option to follow one of three emphases of identity theory: interactional, perceptual, and structural. Using identity theory as a theoretical framework does not dictate that any particular types of data collection methods be used, so published research studies using identity theory as a theoretical framework set the example for the appropriate data collection methods to be used with this framework. Some of those data collection methods include open-ended questionnaire surveying and in-depth interviewing, which were the primary sources of data collection for this study. In particular, Gee (2000) described how he used identity theory as an analytical lens for education research. In other words, he described his method of analyzing identity given observation and interview data. Gee's approach was applied in this study, and the following section describes this approach in more detail.

Identity: An analytic lens for education research. Gee (2000) asserts that the notion of identity could be used as an analytic lens for research in education. To do so, the researcher must adopt one or more of Gee's four perspectives on identity: nature-identity, institution-identity, discourse-identity, and affinity-identity. Nature-identities (N-identities) are developed by nature. For example, an individual's N-identities may be identified by their physical characteristics, such as hair color or height, which would be parts of their identity that are controlled by genetics. Institution-identities (I-identities) are determined by institutions with which the individual is associated. A student identity may be considered an I-identity because it is validated by the authorities (the professors, the counselors, the university president, etc.) of the university, an institution, the student attends. Discourse-identities are displayed in individual traits, validated by others' acknowledgement of the traits through dialogue, which contribute to one's individuality. For example, a mother who is told by her husband that she is caring has just had her individual caring trait validated. Finally, affinity-identities (A-identities) are derived from an individual's affinity groups. Gee defines an affinity group as people in a group who all share an allegiance to, access to, and participation in specific practices (Gee, 2000). An individual who identifies with the scientific affinity group would exhibit the practices of a scientist. They would investigate problems with a scientific approach, back up their claims with scientific evidence, and speak such that their knowledge of the natural sciences would be unmistakable. A person who has an affinity for a science group has developed an A-identity for science, which is referred to as a science identity.

For the current study, my analyses focused on Gee's N-, A-, and D-identities. More specifically, the analyses of this study focus on Gee's N-, A-, and D-identities with a science identity perspective. Analyzing the URM STEM organization experiences of URM students included the discovery of experiences that have an effect on the science identity development of the students using a questionnaire instrument. Interviews with some of the questionnaire participants led to a more in-depth student perspective of how they believe the experiences affected their science identity development. Using Gee's identities with a science identity perspective provided a framework for the thematic analysis of the data, which resulted in themes that align with Gee's N-, A-, and D-identities.

Data Collection

The trend in research when using identity theory as a theoretical framework has been to conduct a qualitative research study. The focus of the research studies that use these methods vary from characterizing an identity to understanding identity development to acquiring a deeper understanding of the societal interactions that govern all aspects of identity. When conducting a qualitative research study using identity theory as a theoretical framework, various methods of data collection are available for use. Some identity theory researchers have required their research subjects to write personal reflection journals to document their experiences with identity development (Abell, 2000; Smith & Darfler, 2012). Other researchers conducted surveys to gain a better understanding of identity development and change (Hamman, Gosselin, Romano, & Bunuan, 2010; Osborn, 2010; Stets & Carter, 2011). Another method of data collection utilized was conducting face-to-face, in-depth interviews with members of the target population for a more in-depth understanding of their identities and behaviors (Burke, 2006; Hurtado, Cabrera, Lin, Arellano, & Espinosa, 2009). In addition, combining these methods reinforced and garnered better saturation of the data (Haley, Jaeger, & Levin, 2014; Hurtado et al., 2009). For this study, a combination of an open-ended survey and in-depth interviews were used. The open-ended survey allowed for the opportunity to gather quick, yet descriptive, data regarding the science identities of URM STEM students. It also provided the opportunity to identify the most common features of the URM STEM organizations that affect the science identities of URM STEM students. The in-depth interviews provide deeper descriptive data toward understanding how URM students perceive the development of their science identities is influenced by their interactions with the URM organizations. The data collected was analyzed as described in the following section.

Data Analysis

In the literature, identity theory researchers have used various data analysis methods. For example, thematic coding of open-ended survey responses and interview transcripts using qualitative research software allowed Smith and Darfler (2012) access to teachers' views on adolescent identity development. Open-ended survey data contributed to a better understanding of how teacher identity develops (Hamman et al., 2010). Stets & Carter (2011) utilized a survey to learn more about the moral self through the lens of identity theory. In another study, interpretation, construction, and reconstruction of stories collected via interviews and journal entries were used to create grounded narratives with a focus of shaping the participant's identity as a collaborator (Abell, 2000). In general, when conducting an identity theory research study, qualitative research methods are employed. The qualitative data analysis methods that were used for this study are thematic coding of open-ended survey responses and interview transcripts using qualitative research software to help organize the results.

Conclusion

My interest lies in studying the relationship between the science identities of underrepresented minority (URM) university students and the features of URM STEM organizations that support and encourage the development of URM STEM students' science identities. This relationship has not yet been examined qualitatively through the lens of identity, nor from the perspective of the student; therefore, I chose to use identity theory as the theoretical framework for this study. Using identity theory as a theoretical framework for developing an understanding of URM STEM students' experiences and persistence is becoming more common (Henriksen, Dillon, & Ryder, 2015). The structural emphasis of identity theory was best for this study because it put the focus on the interactions between the individual, the individual's identity, and the social structure, as opposed to the interactive and perceptual emphases, both of which focus more on the individual carrying the identity. Baring the structural emphasis in mind, I developed a study which examines how URM STEM organizations contribute to the science identity development of post-secondary URM STEM students.

CHAPTER 4 METHODS

The purpose of this study was to develop an understanding of the effect of URM STEM organizations on undergraduate and graduate underrepresented minority students' science identities, as viewed from the students' perspective. I drew primarily from the work of Carlone and Johnson (2007) and Gee (2009) as examples for data collection methods and data analysis. Carlone and Johnson (2007) developed a science identity model that informed my data collection. Gee's research (2000) acted as a guide for data analysis.

This study was designed to answer two main research questions. The first main research question is what is the composition of a URM STEM student's science identity? There are two guiding research questions that addressed the first main research question:

1. Which characteristics of a scientist do the students believe that they have?
2. Which characteristics of a scientist do the students believe that they do not have?

This research question was answered to provide an understanding of the composition of the science identity of the post-secondary URM STEM student. To my knowledge, a composite of a post-secondary URM STEM student's science identity has not yet been developed, so a first attempt at that composite will be given in this report. Answering this first main research question will allow for a understanding of the science identity to which the URM STEM students are referring when they speak about how URM STEM organizations affect their science identities when addressing the second research question of this study.

The second main research question for this study is "how do underrepresented minority (URM) science students perceive that their participation in a URM STEM organization at a major university shapes their science identities?" Two guiding research questions addressed the second main research question:

1. Which features of URM STEM organizations do URM STEM students perceive have an effect on shaping their science identities?

2. How do URM STEM students perceive that the features of URM STEM organizations affect their science identities?

This chapter is divided into three main sections: a description of the research setting and participants, an explanation of the methods for data collection, and a discussion of the data analysis procedures. The data collection instruments that were used in this study can be found in Appendices A and B. The university's Institutional Review Board (IRB) approved this study. The informed consent documents that each questionnaire and interview participant received a copy of and signed can be found in Appendices C and D, respectively. All questionnaire and interview participants provided their consent to be part of this study. I used pseudonyms throughout the study for all of the participants.

Research Setting and Participants

Research Setting. In this qualitative study, I sought to learn more about URM STEM organizations at a large, public university located in the southwestern region of the United States of America. The Multicultural Program (MP) at this university is a URM STEM organization with a mission to "encourage and recruit more minority and underrepresented undergraduate and graduate students into the STEM and healthcare related disciplines, foster a positive and caring learning atmosphere that supports classroom instruction and professional development, increase retention and graduation rates, and improve overall student success" (University of Nevada, 2015b). The MP organization anticipates improving student success in STEM by helping URM students:

1. improve their academic motivation and performance
2. enhance their self-esteem and confidence as independent learners
3. engage in related community service activities
4. achieve their educational and career goals (University of Nevada, 2015b)

In addition to sponsoring their own activities and programs, the MP partners with all of the URM STEM student organizations on the university campus location of this study. Students who are members of the MP are often also being serviced by these other URM STEM student organizations on campus, which include the following:

- Society of Women Engineers (SWE)
- National Society of Black Engineers (NSBE)
- American Indian Science and Engineering Society (AISES)
- Society of Hispanic Professional Engineers (SHPE)

The MP is also affiliated with two other student organizations, but because those two organizations are not particularly focused on the advancing the success of URM STEM students, they were not included in this study since their student members are less likely to be from URM groups. It must be noted that the American Indian Science and Engineering Society (AISES) organization could not be included in this study because it was inactive due to low student membership enrollment.

Their mission statements outline the main foci of the URM STEM organizations. According to their mission statements, all of the URM STEM organizations included in this study are focused on advancing the success of URM students in STEM. Tables 2 provides an abridged version of each of the aforementioned URM STEM organizations' mission statements, and the number of members currently registered for each URM STEM organization on the university campus location of this study. According to the director of the MP, the number of registered members listed in Table 2 does not accurately reflect the number of students who participate in and benefit from the features of the URM STEM organizations. The director of the MP also explained that not all students who participate in the URM STEM organization events and activities are willing to pay to become registered members of the URM STEM organizations with which they associate.

Table 2
Abridged mission statements and registered member roster count for each of the URM STEM organizations at this university included in this study (CollegiateLink, 2016a).

URM Organization	Mission	Number of Registered Members
Multicultural Program	"… to significantly increase the recruitment and academic success of the underrepresented population of students in the STEM and health sciences majors." (University of Nevada, 2015b)	~ 300
Society of Women Engineers	"… to stimulate women to achieve full potential in careers as engineers and leaders, expand the image of the engineering profession as a positive force in improving the quality of life, and demonstrate the value of diversity." (CollegiateLink, 2016e)	77
National Society of Black Engineers	"To increase the number of culturally responsible Black engineers who excel academically, succeed professionally and positively impact the community." (CollegiateLink, 2016b)	29
Society of Hispanic Professional Engineers	"SHPE changes lives by empowering the Hispanic community to realize its fullest potential and to impact the world through STEM awareness, access, support and development." (CollegiateLink, 2016c)	32

Table 3 lists the benefits that each of the URM STEM organizations currently offers their students. These URM STEM organizations help URM students succeed in their chosen STEM majors by providing resources that are beneficial to the advancement of the URM STEM student both academically and professionally, such as, but not limited to, career development activities, help with participating in collegiate competitions, and opportunities to interact with guest speakers at special events, as well as other resources. Any of the benefits listed in Table 3 could be a feature of URM STEM organizations that the URM STEM students perceive to affect their science identity development. The goal of this study is to determine which features of the URM STEM organizations the URM STEM students perceive to have an effect on their science identities, and to understand the ways URM STEM students perceive that those features affect their science identities. There is the potential for the URM STEM students to list features of the URM STEM organizations that are not included on Table 3, but still have a perceived effect on their science identities, and this study is also aimed at understanding those features and how the students perceive those features affect their science identities.

Table 3

Benefits offered to the registered members of each of the URM STEM organizations included in this study (CollegiateLink, 2016a-f). An "x" denotes a benefit that is offered, according to the information provided on the organizations' websites.

URM Organization	Multicultural Program (University of Nevada, 2015a)	Society of Women Engineers (CollegiateLink, 2016f)	National Society of Black Engineers (CollegiateLink, 2016b)	Society of Hispanic Professional Engineers (CollegiateLink, 2016d)
Academic Support (Tutoring, study groups, etc.)	X		X	
Access to potential employers	X			
Conference and Events Access	X		X	
Leadership Training	X		X	
Networking Opportunities	X	X	X	X
Outreach Opportunities	X	X	X	X
Personal Counseling	X			
Professional Development (resume building, practice interviews, etc.)	X	X	X	
Scholarships and Grants	X	X	X	
Test Prep	X		X	
Workshops	X			X

Criteria for participation in the current study. In a previous study, purposive sampling was used to capture the experiences of URM students who were successful in navigating the scientific pipeline (Hurtado et al., 2011). Purposive sampling is strategically selecting a sample of participants such that the sample is tied to the objectives of the study (Palys, 2008). I was interested in the effects of URM STEM organizations on the science identity of URM students; therefore, I chose to target a sample group of URM STEM students from within the URM STEM organizations to be studied, as opposed to asking all STEM students on campus to participate.

Undergraduate and graduate students who participate in the MP were eligible for participation in the current study. To become members of the MP, the students must complete an online form that asks for some of their personal demographic information such as name, student identification number, email address, gender, major of study, and more. Also, the potential student members are required to self-select their race with the options of Asian/Pacific Islander, Black (Non-Hispanic), Hispanic, Native-American/Alaskan Native, White (Non-Hispanic), and Other. For the purposes of this study, the races included in the URM category are African-American, Hispanic, Native American/Alaskan Native, and Pacific Islander heritages. The gender included in the URM category is female. As of the fall semester of 2016, when this study began, approximately 300 URM students had completed the form and have become members of the MP.

Methods of Data Collection

In previous studies, various data collection methods have been employed in qualitative research seeking to understand science identity. Focus groups have been used to discover what factors influence the science identity and science aspirations of ten and eleven year old students (Archer et al., 2010). The data gathered from longitudinal interviews and surveys provided narratives about developing science identities; science, engineering and medicine (SEM) participation; and the aspirations of students who were in the SEM pipeline (Aschbacher et al., 2010). Focus groups and individual interviews were utilized in an ethnographic study of science identity formation of African-American graduate students in regard to their research laboratory experiences (Malone & Barabino, 2009). Among the most commonly applied survey methods are questionnaire distribution and interviewing, which were the methods utilized in this study.

Survey

Surveying is used frequently as a data collection method in qualitative research. A survey is defined as a systematic way to gather data from a range of individuals, organizations, or other units of interest (Julien, 2008). Questionnaires and interviews are the two types of surveys that were used in this study. First, I will discuss the questionnaire followed by a discussion of the interview.

Questionnaire. An open-ended questionnaire is a questionnaire that poses open-ended questions to the study participants whose answers will provide text that can be analyzed qualitatively. Open-ended questions, also known as nondirective questions, provide the participants with the opportunity to self-select the terms with which to construct their descriptions and highlight the topics that are most meaningful to them (Roulston, 2008). The literature indicates that an open-ended questionnaire instrument would generate the richest data (Pathare & Pradhan, 2010), so one was used for this study.

An open-ended questionnaire was chosen for this study because it allows the respondents greater freedom in their responses as well as more freedom of self-expression, which generated text for analysis. This is important to achieve in a qualitative research study because it provides more rich and in-depth data than a questionnaire that poses closed questions, as is commonly used in a quantitative study. Rich and in-depth data were needed to fully answer the research question.

Also, an open-ended questionnaire is appropriate for this study because it is an efficient method for gathering data from the large group of students in the MP. There are approximately 300 students participating in the MP. Gathering data using another method, such as conducting individual interviews, with 300 students would require a significant amount of time.

There were a few of goals set for conducting the open-ended questionnaire within this study. Primarily, the questionnaire was used to gather preliminary data that would address the research questions. The open-ended questions asked students to share information about their experiences with and feelings about the URM STEM organizations of which they are members. To my knowledge, there has been little to no research focused on establishing which features of URM STEM organizations affect URM students' science identity, and there is no qualitative research that seeks this information from the students' perspective. Finally, the questionnaire was used to identify students who were willing to be interviewed to further my research as I included a question within the questionnaire which asks if they were willing to be interviewed as part of the current project.

The questionnaire, which can be found in Appendix A, contains three sections: Demographics, Questions about Underrepresented Minority STEM Organizations, and Questions about Science Identity. The first section focuses on the general demographic background information of the participant. The second section asks the participant to discuss the URM STEM organizations of which they are members and to give more information about their interactions with URM STEM organizations with questions such as "What made you decide to become a member of the URM organization(s)?" and "What do you like **most** about the URM organization(s) that you are a part of?" The third section asks the participants questions about their science identity and how their chosen URM STEM organizations support, or do not support, their science identity development. In this third section, the participants are asked directly “Are you a scientist?” and are expected to answer “yes” or “no.” Then they are asked to describe the characteristics of a scientist that they do and do not as well as to describe times when they felt like a scientist. Finally, the participants are asked to write about any ways the URM STEM organizations have made them feel like a scientist. The questionnaire took approximately 15 minutes to complete.

The questionnaire was distributed both electronically and on paper. The electronic version of the questionnaire was constructed using the Qualtrics software (Qualtrics, 2016). These two distribution methods were used because students may be members of the MP independently from the URM STEM organizations affiliated with the MP. In order to reach the students who may be members of the MP, yet not members of any of the URM STEM organizations affiliated with the MP, the electronic version was distributed via email communication.

The electronic version was accessible over the Internet through an electronic link that was distributed via email communication. The MP organization director assisted me in sending out the emails to the students as I did not have access to the students’ contact information. The MP organization director sent out an initial email that introduced me and my study to the MP organization’s student members. Within a week of sending out the initial email, I sent out a personal email, through the MP organization director, to the MP organization student members that reintroduced myself and my study to them, and asked them to participate by filling out the questionnaire electronically (Appendix E). The students were prompted to read and electronically sign an electronic version of the informed consent form before being able to complete the questionnaire. Electronically signing the consent form meant that the student agreed to voluntarily participate in this study when they filled out the questionnaire. The text for the informed consent form to participate in the questionnaire portion of this study is located in Appendix C.

The paper version of the questionnaire was distributed at meetings of the individual URM STEM organizations with the hope that a personal interaction with myself as the researcher would encourage more students to participate in filling out the questionnaire. Before I visited the URM STEM organization meetings, the students and organization leaders were notified via email of my intent for attending their meetings and were introduced to my study. I attended at least one meeting for each of the three URM STEM organizations (NSBE, SHPE, and SWE) that has an active membership and are associated with the MP organization, presented myself and my study to the student members in attendance using the script found in Appendix D, and asked the student members to participate by filling out the questionnaire while at the meeting. Prior to receiving the questionnaire, the students were asked to read and sign an informed consent form indicating their voluntary participation in the study. The MP does not host regular organizational meetings, so I was not able to attend a meeting for that URM STEM organization. It was for this reason that questionnaires were distributed electronically to the members of the MP.

An incentive to participate was offered to all of the students that were approached. That incentive was an opportunity to win a fifty-dollar Amazon.com gift card via a raffle. For those who completed the questionnaire on paper, the students were given a raffle ticket to fill out when they handed in their completed questionnaire. The raffle ticket was given to them after they handed in their questionnaire to ensure that their identities remained unaffiliated from their questionnaire answers. For those who completed the questionnaire electronically, a raffle ticket was filled out for them by me. To ensure that those students' responses remained unaffiliated from their questionnaire answers, they were prompted to provide their first and last names, email address, and telephone number in a second form that was accessible via a hyperlink provided at the close of the questionnaire. Each student who participated by filling out the questionnaire received one raffle entry. The raffle was held at the close of the questionnaire distribution period. I notified the winning participant through email. There was only one winning participant. The chances of them winning were one out of 42 because 42 participants completed the questionnaire.

Interview. An interview is defined as a conversational practice between an interviewer and an interviewee or a group of interviewees which produces knowledge (Brinkmann, 2008). Interviewing for data collection has become mainstream and is an essential means to most qualitative researchers' ends. In this study, I used the interview method to gain a better understanding of the URM students' interpretations of how their experiences with the URM STEM organizations have shaped their science identities.

All of the interviews were approached as in-depth interviews. In-depth interviews, also referred to as semi-structured interviews, are interviews that encourage the interviewees to talk in-depth about the topic being investigated without the researcher having to use focused, short-answer questions (Ayres, 2008; Cook, 2008). The questions used in this study were pre-determined, yet allowed for a more in-depth exploration of the topics being discussed. The questions can be found in the interview guide provided in Appendix B.

The interview guide for this study consists of four sections: (1) informed consent, (2) demographics, (3) science identity and URM STEM organization questions, and (4) closing questions. The first section confirms that the participant has received, understands, and has signed the informed consent document. The second section asks the participant about their declared major, and what made them choose that major of study. They are also asked to disclose all URM STEM organizations of which they are a member, and to discuss what it means to "feel like a scientist" by describing times when they have felt like a scientist. The third section of the interview guide concentrates on the students' interactions with the URM STEM organization(s) of which they are members, and how the student perceives the URM STEM organization(s) has/have impacted their science identity. In this section, the participants are asked questions such as "In what ways has (have) the underrepresented minority STEM organization(s) that you are a member of impacted the way you think of yourself as a scientist?" and "How has (have) the underrepresented minority STEM organization(s) that you are a member of helped you succeed as a scientist?" These questions were included to gain the URM STEM students' perspectives of how the URM STEM organizations affect their science identities.

The final section focuses on providing the interviewee the opportunity to share any thoughts that they may have regarding the study, and reiterating to the interviewees that their participation is appreciated. The goal of the interview guide was not to establish the science identity of the URM STEM student, as the participants had already provided this information in their responses to the questionnaire, but to gain a more in depth understanding of how URM STEM organizations affect the science identities of the URM students that they serve. Therefore, questions regarding the characteristics of a scientist that the students believe that they have and do not have were not included in the interview guide.

My criteria for selecting interviewees included the following, in order of importance:

- questionnaire participants who volunteered to be interviewed;
- questionnaire participants who declared their race/ethnicity to be African-American, Latino, Native American, or Pacific Islander; and
- questionnaire participants who declared their gender to be female.

The participants who were interviewed in this study are URM STEM students who had completed the questionnaire and indicated in the questionnaire that they would volunteer as interview participants in this study. After they agreed to volunteer to be interviewed, each of the interviewees was recruited for an interview session via email communication. The script used in the recruitment email can be found in Appendix F. Before attending an interview, the interviewees received an electronic copy of the informed consent form to read and understand. That informed consent form can be found in Appendix G. At the interview, before any interview questions had been asked, the interviewee was given a chance to ask questions regarding the informed consent form and then was asked to sign the form in order to proceed with the rest of the interview. Had the interviewee chosen not to sign the informed consent form, the interview would have been immediately terminated.

The interviews were conducted in-person. Each interview lasted between 15 and 60 minutes. All of the interviews were audio-recorded to ensure an accurate account of what was said during the interview (Morgan & Guevara, 2008). The audio recordings from each interview were transcribed verbatim by me to maintain consistency in the analysis and interpretation of all of the data, as well as to maintain the confidentiality of my research participants. The transcribed data was evaluated using analytic methods of grounded theory.

Participants. Multiple STEM disciplines were represented in this study. The questionnaire and interview participants all self-declared their ethnicities, majors, and genders. The ethnicity groups are listed using the students' actual questionnaire responses. Tables 4, 5, and 6 provide the demographics for the questionnaire participants.

Table 4
Questionnaire Participants' Ethnicities

Number of Participants	Ethnicity
3	African-American
1	Armenian
8	Asian
6	Caucasian (White)
17	Hispanic (Latino)
1	Indian (Asian)
1	Middle Eastern
1	Mixed (British/Filipino)
1	Mixed (Caucasian/Filipino)
2	Mixed (Latino/White)
1	Mixed (Vietnamese/Chinese)

Table 5
Questionnaire Participants' STEM Majors

Number of Participants	Major
11	Civil & Environmental Engineering
3	Computer Engineering
11	Computer Science
5	Electrical Engineering
2	Entertainment Engineering
1	Health Physics
1	Kinesiology
8	Mechanical Engineering

Table 6
Questionnaire Participants' Genders

Number of Participants	Gender
27	Female
15	Male

Table 7 provides the demographics for the interview participants. The interview participants are a subset of the questionnaire participants. In order to keep the anonymity of my research participants, I will be using pseudonyms throughout this report.

In this study, eleven participants were interviewed. Only eleven interviews were conducted in this study because I focused my study on a small, specific group of students. Considering that the study participants are from groups that are underrepresented in STEM, the having a small group of participants was expected. Despite this expectation, I tried to recruit as many interview participants as possible to ensure reaching the point of saturation of my data. I attended URM STEM organization meetings for each of the organizations represented in this study, hoping that my personal plea for their participation would grant me more volunteers for interviews. I emailed all of the MP organization members multiple times. I asked for the director of the MP organization to put me in contact with any students who she thought would be more likely to participate in my interview. I encouraged those who did participate in an interview to ask their friends and fellow organization members to grant me an interview. I emailed, called, and texted each student directly that provided their contact information on my questionnaire, which they were asked to do if they would be willing to be interviewed in the future. In the end, with the eleven interviews that I did complete, saturation of my data was met.

Table 7
Interview Participants' Demographic Information

Participant	Gender	Ethnicity	Major	Considers self a scientist? (Y/N)
Adowa	Female	African (Ethiopian)	Civil Engineering	N
Alaijah	Female	Caucasian	Mechanical Engineering	Y
Jacel	Female	Caucasian/ Asian (Filipino)	Electrical Engineering	Y
Kema	Female	Hispanic	Computer Science	N
Khari	Male	African-American	Mechanical Engineering	N
Martin	Male	African-American	Computer Science	N
Michael	Male	African-American	Mechanical Engineering	Y
Monticello	Male	Asian (Indian)	Electrical Engineering	Y
Nayan	Female	Asian (Chinese)	Civil & Environmental Engineering	Y
Uriah	Male	African-American	Computer Science	Y
Zynia	Female	Caucasian	Computer Science	N/A

Data Analysis

Data were organized in computer files. The questionnaire data collected on paper in this study were converted to computer files using an electronic document scanner. The in-depth interview data was transcribed verbatim into Microsoft Word computer files. All of the questionnaire and in-depth interview transcript data collected for this research study was thematically coded with the assistance of the Atlas.ti Qualitative Data Analysis & Research software (Muhr, 2015). Following the grounded theory approach of thematic analysis, all of the data was analyzed systematically and iteratively through several coding processes until categories, then themes, emerged (Charmaz & Bryant, 2008; Glesne, 2011). The thematic coding process began with two rounds of coding, followed by a round of categorizing the codes. Finally, an application of Gee's (2000) identity perspectives was used to pinpoint the themes which address the research questions. The next section includes a more in-depth account of the thematic analysis process used to analyze the questionnaire data, followed by that which was done to analyze the interview data.

Analysis of the questionnaire data. The thematic coding process consisted of assigning an initial code, in the form of a word or short phrase, to all subject matter of interest to this study. In other words, I read through each response to all questions in the questionnaire for each participant and assigned initial codes to everything that the participants wrote that may have any significance. For example, in response to the question "What characteristics of a scientist do you have?," some of the participants' answers included "ambitious," "determination," and "persistence." Each of these responses was assigned the initial codes of "ambitious," "determination," and "persistence," respectively. Once each interesting point in the questionnaire data was assigned initial codes, the initial codes were grouped together based on their similarities and assigned secondary codes. Continuing with the example given to describe the initial round of coding, the initial codes of "ambitious," "determination," and "persistence" were then grouped together, and that group was assigned the secondary code of "persistence."

After all of the secondary codes were assigned, categories of the codes were formed. The secondary code of "persistence" was placed under the category of "work ethics/personality traits." From the categories, overarching themes began to emerge. Ultimately, with the application of Gee's identity perspectives, three major themes were drawn from the analysis of the questionnaire data that would answer the main research questions. The application of identity as an analytic lens using Gee's identity perspectives consisted of analyzing the alignment of the categories found within the data with the definitions of Gee's identity perspectives. When the definitions of Gee's identity perspectives were analyzed with the data of this study, I discovered a need to modify the perspectives and their definitions to reflect that of science identity, as will be described in the paragraphs that follow.

Gee suggests that adopting one or more of four identity perspectives is necessary to use identity as an analytic lens. Those four identity perspectives are nature-identity, institution-identity, discourse-identity, and affinity-identity. More information about Gee's identity perspectives has been given in Chapter 3, but here are brief descriptions of the identity perspectives as defined by Gee. Nature-identities (N-identities) are developed by nature. Institution-identities (I-identities) are determined by institutions with which the individual is associated. Discourse-identities are displayed in individual traits, validated by others' acknowledgement of the traits through dialogue, which contribute to one's individuality. Finally, affinity-identities (A-identities) are derived from an individual's affinity groups. The institution-identity perspective was not found to be useful for analyzing the data of this study, so it was not used to define a theme. However, the other three identity perspectives inspired the three themes established from the data in this study.

For the purposes of this study, the definitions for Gee's identity perspectives were modified such that they would reflect science identity perspectives, as opposed to general identity perspectives. The modified definitions correlate with the themes that emerged from the data. The original identity perspectives and their definitions are listed in Table 8 alongside the corresponding themes and modified definitions. When a category from the data was found to be in alignment with a modified version of Gee's identity perspective, it was considered to be a contributor to and support for that theme. The major themes that emerged from the data are natural science identity traits, science affinity practices, and discursive science identity products.

The theme of natural science identity traits encompasses the personality traits that are associated with the identity of a scientist. For example, scientists are often thought of as being intelligent and curious. “Intelligent” and “curious” would be personality characteristics that would fall under the theme of natural science identity traits.

Science affinity practices are actions that are associated with the identity of a scientist. Any action that a scientist is known to do would fall under this theme. For example, scientists are known to solve problems with experimentation. In this example, solving problems and experimentation are considered the science affinity practices.

Finally, discursive science identity products are professional qualities or products associated with the identity of a scientist. Discursive science identity products are intangible, and are the result of verbal interactions between someone who identifies themselves as a scientist (someone who has a science identity) and another individual who is capable of recognizing that someone as a scientist. For example, networking is a discursive science identity product because a scientist gains their network of science professionals through their abilities to verbally interact with scientific others.

Table 8
Gee's Identity Perspectives With Their Corresponding Modified Definitions and Themes of This Study

Gee's Identity Perspective	Definition for Original Identity Perspectives	Themes	Definition for Themes
Nature-identity	developed by nature	Natural Science Identity Traits	characteristics that are part of an individual's natural personality which are accepted by others as characteristic to those who possess a science identity
Affinity-identity	derived from an individual's affinity groups	Science Affinity Practices	practices that are associated with science
Discourse-identity	displayed in individual traits, validated by others' acknowledgement of the traits through dialogue, which contribute to one's individuality	Discursive Science Identity Products	professional qualities or products determined by discourse or dialogue with other scientific people

Analysis of the interview data. The interview data was analyzed in the same manner as the questionnaire data. The interview data analysis began with 2 rounds of coding. The secondary codes that were used in the questionnaire data analysis were also used in the interview data analysis. Those secondary codes were then categorized based upon their similarities, and using the categories that were established in the questionnaire data analysis. These categories were also checked for their alignment with the themes that were established from the questionnaire data. No new themes evolved from the interview data analysis.

Data Triangulation

According to Brickhouse and Potter (2001), data triangulation is essential for identity research. Data triangulation is a multi-method approach to data collection and analysis that is meant to provide a more complete understanding of the research topic while reducing biases or deficiencies that would be caused by using only one research method (Rothbauer, 2008). Triangulation occurs in data collection and data analysis techniques, as well as sources of data. In this study, the sources of data were triangulated. The three sources of data was the questionnaire survey of URM organization student members, the interview surveys of URM organization student members, and member checking. For this study, the in-depth interviews combined with the questionnaire makes the research data more rich, but was not sufficient to provide a complete account of the phenomenon being investigated. Therefore, data triangulation was necessary.

Member checking assists in validating the interpretation of interview data. Member checking involves using the research participants to evaluate whether the researcher has accurately portrayed their experiences, whether the researcher has fully captured the meaning those experiences had for them, and/or whether or not the researcher's final interpretation of those experiences does them justice (Sandelowski, 2008). In this study, member checking was executed as a separate event upon completion of data analysis. Five of the eleven interviewees were asked to evaluate my interpretation of their experiences and their responses. They all agreed that my interpretations of their statements were correct.

Researcher. To provide full disclosure, I am sharing some information about my background. I, the primary researcher for this study, am an African-American female graduate student in chemistry with expertise in chemistry education. I have had personal experiences with URM STEM organizations as an active member, but not with the NSBE, SWE, SHPE, or AISES organization chapters on the campus where this study takes place. I am a member of the MP organization. I am solely responsible for collecting all of the questionnaire data and conducting all of the interviews. I am disclosing this information to show that I am aware of biases that I may bring to this study. One of those biases may include a sense of support for the URM STEM organizations. This bias can influence my results in that I could subconsciously focus on presenting the best parts of the URM STEM organizations as I am a supporter for the organizations and have benefited from organization such as these in the past. To combat this bias, I am making a conscious effort to present the URM STEM organizations from the perspectives of my participants in order to develop an understanding of areas in which the URM STEM organizations can better their efforts toward the development of their student members' science identities.

CHAPTER 5 RESULTS AND DISCUSSION: RESEARCH QUESTION 1

The results of this study are organized into two chapters, one chapter for each of the main research questions. The first chapter, Chapter 5, relays the data and findings that contributed to the development of the composite of the URM STEM student's science identity. The second chapter, Chapter 6, will discuss the features of URM STEM organizations that this study's participants have revealed to have an effect on their science identities.

The results from the analysis of both the questionnaires and interviews are presented concurrently because the study was designed such that the interview data would provide a deeper understanding of what was discovered in the questionnaire data. The students' perceptions of their science identities and how the URM STEM organizations affect their science identities are better understood when the findings from the questionnaire data are presented directly with the students' quotations and explanations of the questionnaire findings.

Both Chapter 5 and Chapter 6 will discuss the themes that have been derived from the data and their significance for answering the main research questions. The first of the three themes derived from the data of this study is natural science identity traits. The second is scientific affinity practices. Finally, the third theme is discursive science identity products. These three themes are reflective of Gee's (2000) nature-identity, affinity-identity, and discursive-identity perspectives, respectively. A description of each of these identity perspectives can be found in chapter 3 of this report in the literature review of this study. Just as the themes are reflective of Gee's identity perspectives, the definition for the themes are reflective of the definitions of Gee's identity perspectives. The themes found in this study are defined as follows:

1. Natural science identity traits - characteristics that are part of an individual's natural personality which are accepted by others as characteristic to those who possess a science identity
2. Scientific affinity practices - practices that are associated with science
3. Discursive science identity products - professional qualities or products determined by discourse or dialogue with other scientific people.

The following sections will provide a broader description of each of the themes derived from the data of this study and a more in-depth account of the data which support each of these themes. The sections will focus on (1) the characteristics of a scientist that URM STEM students say they possess and (2) the characteristics of a scientist that URM STEM students say they do not possess. In this study, the characteristics that URM STEM students believe they possess will be considered as characteristics that make up their science identities, which means they are characteristics that are part of the composition of the URM STEM student's science identity. Conversely, the characteristics that URM STEM students believe they do not possess will be considered as characteristics that are not a part of their science identities, which means they are characteristics that are not part of the composition of URM STEM students' science identities.

Composite of the URM STEM Student's Science Identity

As noted in chapter 3 of this report, the set of meanings for an identity, what it means to be who you are, is unique to each individual. No two individuals have the same set of meanings that make up their self because everyone has unique interactions and interprets shared interactions in their own way. Although URM STEM students do not have the exact same science identities or concepts of science identities, it is likely that their concepts of science identities have some similarities because the students share some similarities in terms of their ethnic and cultural backgrounds, as well as in their experiences as URM STEM students.

This chapter focuses on URM STEM students' perceptions of their science identities. Trujillo and Tanner (2014) suggest that an inventory of students' science identities must be completed in order to encourage students to persist and commit to science. In other words, the general make up of students' science identities must be understood in order to assist in the students' persistence in the STEM fields. To inform the assistance in persistence efforts of URM STEM organizations, a composite of URM STEM students' science identities has been developed in this study, and will be presented in this chapter, which is a composite of the way the URM STEM students in this study have described their science identities. The development of the composite science identity of the URM STEM student has been derived from the results of the analysis of the data which answers the first main research question of this study: what is the composition of the URM STEM student's science identity? There are two guiding research questions that were asked to help answer the first main research question are:

1. Which characteristics of a scientist do the students believe that they have?
2. Which characteristics of a scientist do the students believe that they do not have?

The data which answers the first main research question primarily arose from the questionnaire, though any supporting data from the in-person interviews will be presented along with the data from the questionnaire.

Natural Science Identity Traits

As part of their responses to the questionnaire items, the URM STEM students identified several characteristics that they associate with the science identity, some of which they feel they possess and some that they do not feel that they possess. Many of the characteristics that they named are often considered natural traits that individuals possess as part of their personalities. Gee (2000) defines the natural-identity perspective as identities developed by nature. An individual's natural identity can be thought of as that person's disposition, which is characterized by the individual's personality traits. In this study, natural personality traits are assumed to be obtained intrinsically or extrinsically. In other words, natural identity traits can be personality traits that are part of what makes up that individual naturally or they can be personality traits that are learned and taken up by an individual at that individual's discretion. The theme of natural science identity traits refers to natural personality traits that tend to be associated with the science identity.

Natural science identity traits associated with the URM STEM student's science identity are discussed next. It should be noted that no natural science identity traits came up in conversation during the interviews for this study. The lack of interview data in this area can be contributed, at least in part, to an artifact of the interview guide design, as was discussed earlier in the methods chapter. Ultimately, questions that were likely to elicit responses that refer to natural science identity traits were not included in the interview guide.

Natural science identity traits: Characteristics of a scientist URM STEM students believe they do possess. The questionnaire participants were asked "What characteristics of a scientist do you have?" URM STEM students recognize several characteristics of a scientist that they themselves possess. Some of those characteristics fall under the theme of natural science identity traits. The most common natural science identity traits the participants listed were curiosity, persistence, and the desire for change.

Curiosity. The participants' responses regarding curiosity alluded to seeking knowledge. That is to say that the participants equate curiosity with the urge to seek out knowledge, and they perceive scientists to be curious in nature. For example, students said they are "curious of finding things and knowing the truth" and that they have a "natural curiosity about the world around [them]." One student remarked "I am curious, innovative, and constantly question why things work and what can be done to make it better." Other students chose to express their curiosity by labeling it as a "thirst for knowledge" and a "pursuit of the truth." From these responses, the interpretation that URM STEM students feel that they share the natural science identity trait of curiosity with scientists has been drawn.

Persistence. URM STEM students also believe that they share the natural identity trait of persistence with scientists. Whether or not their curiosity fuels their persistence, or vice versa, the participants did not say. However, they did list curiosity and persistence as two separate characteristics of a scientist that they do possess. The URM STEM student participants' idea of persistence is continuing on a difficult path despite the challenges along the way. The participants' definition of persistence is interpreted from their responses that listed "determination" and "ambition" as characteristics of a scientist that they do have, in addition to the many instances when they simply listed "persistence."

Because of the large numbers of URM students who leave STEM fields for other non-STEM related fields of study, there is an increased amount of research that suggests that the persistence of these students in STEM must be considered in retention efforts at the university level (Graham et al., 2013). Research shows that having persistence is essential for the retention of URM students majoring in STEM (White et al., 2006). While the increased interest in research on persistence could give the impression that URM STEM students in general do not have the trait of persistence within their science identities, URM STEM students in this study believe that they do have the persistence trait. Knowing that URM STEM students believe that they have the persistence required to be a scientist informs educators that they can assist in maintaining their students' persistence in STEM by focusing on factors that promote the persistence of students in STEM, such as providing an active learning environment and scientific research opportunities (Hurtado, Newman, Tran, & Chang, 2010; Palmer, Maramba, & Dancy, 2011).

Desire for change. The last characteristic of a scientist that was prevalent in the students' questionnaire responses is the desire for change. Often, the students note their desire for change through scientific endeavors. "The desire to create a better world" is how one student recognized their alignment with the identity of a scientist. One student revealed in their questionnaire that they chose to major in mechanical engineering because "I wanted to help create and change the world, and utilize my skills to help those in need." Their desire for change in the world is expected based upon the pre-existing literature that describes how URM STEM students are often driven to pursue STEM in order to better their communities (Jackson et al., 2016).

Natural science identity traits: Characteristics of a scientist URM STEM students believe they do not possess. The questionnaire participants were also asked to list the characteristics of a scientist do that they do not have. The two natural science identity traits that came up most often to answer this question were intelligence and motivation.

Intelligence. When asked which characteristics of a scientist they do not have, the responses from the students were all straight-forward and unpretentious. For example, a student felt that they are "not overly intelligent." Another student simply replied "intelligence" in response to the question asking them to list what characteristics of a scientist they do not have. Believing that they need to be more intelligent in order to be more like a scientist can have a degrading effect on the students' motivation to succeed in STEM, which results in diminishing their science identity.

Motivation. The questionnaire participants also said that they do not have the motivation that they believe it takes to be as a scientist. This conclusion was drawn from student responses including "I'm lazy so I'm not as motivated as a scientist would be," and "Sometimes I think I slack off too much!" Having the motivation to be a scientist has been proven to be an important factor for the success of URM students in STEM (Johnson, 2007; Russell & Atwater, 2005), so students who feel that they are deficient in motivation for science may be less likely to have a positive science identity for themselves.

Natural science identity traits: Conclusions. In a previous research study, scientific faculty noted that important parts of the science identity include, but are not limited to, curiosity, a passion for the work, persistence and resilience in the face of challenges (Beals, 2016). Yet, to my knowledge, there is not any other research literature that can corroborate my findings regarding the natural science identity traits of curiosity and the desire for change as being important for the URM STEM student's science identity specifically. There are no research studies available that focus directly on the natural science identity traits of curiosity and the desire for change in the context of understanding the post-secondary URM STEM student's science identity. Therefore, this study contributes to the literature with the discovery of URM STEM students' perception of these traits being a part of their science identity and by starting the conversation about these natural science identity traits and their connection to the science identity of the URM STEM student.

Although "persistence" has been recognized as an important characteristic for successful URM STEM students, existing research tends to recognize persistence as an action rather than a personality trait that describes part of the student's science identity (Ghee et al., 2016; Trujillo & Tanner, 2014). In other words, the currently available research on URM students' persistence in STEM uses the term "persistence" as a measurable entity that can describe the attrition rate of

URM STEM students, often saying that an understanding of URM STEM students' science identities can lead to an increase in their persistence, meaning their retention, in STEM. However, from this research study, the students have revealed that they perceive persistence as a part of their science identities, making persistence a natural science identity trait rather than a performance indicator.

Science Affinity Practices

Gee (2000) defines an affinity-identity as an identity which an individual possesses because of their affiliation with a particular group, an affinity group. Members of the affinity group participate in distinct practices, practices that uniquely define the affinity group. For example, a science affinity group would be distinguished by the scientific practices in which scientists tend to engage, such as experimentation in a laboratory and attending science classes. Many of the URM STEM students' questionnaire and interview responses included characteristics of a scientist that are included in the theme of science affinity practices. The most common science affinity practices that the students mentioned fell into two categories: physical scientific activities and knowledge acquisition activities.

Science affinity practices: Characteristics of a scientist URM STEM students believe they do possess. Carlone and Johnson's (2007) model of a science identity includes three dimensions: performance, recognition, and competence. The performance dimension is defined as "social performances of relevant scientific practices," such as talking and using scientific tools (Carlone & Johnson, 2007, p.1191). The theme of science affinity practices is similar to Carlone and Johnson's (2007) performance dimension of a science identity. Science affinity practices are actions that are recognized by scientific and non-scientific others as scientific actions and are demonstrable of how a scientist acts. The theme of science affinity practices includes two categories: physical scientific activities and knowledge acquisition activities.

Physical scientific activities. The science affinity practices involving physical scientific activities are actions that result in the use of tools that scientists typically use, such as during experimentation in a laboratory, or the use of one's brain to engage in other activities that support experimentation, such as the gathering of information to design studies or the writing up of study results. Consider a workday of a graduate student in a laboratory. On any given workday, this graduate student may handle common laboratory equipment, such as glassware, chemicals, a computer, and specialized machines to conduct an experiment. When conducting their experiment in the laboratory, the graduate student is engaging in scientific activities that are commonly associated with the science identity. As another example, a student working on a prosthetic hand at her desk may be crafting and testing the new circuit she designed for the prosthetic hand. In this example, using her hands to build and test the circuit is an example of scientific activities associated with the science identity. Additionally, she will use her test results, her scientific knowledge, and her scientific training to design her next experiments. URM STEM student participants in this study often use physical scientific activities to describe characteristics of a scientist that they do have, with the most common characteristics mentioned by participants being experimentation and other science related work.

Experimentation. Many of the URM STEM students' responses include the science affinity practice of experimentation as a characteristic that they share with scientists. When prompted by questionnaire items, students recount feeling like a scientist "during chemistry laboratories in high school," "during middle school in chemistry, mixing the chemicals and using the Bunsen burner," and while "conducting an experiment during my fluid dynamics lab." They also list “looking through a microscope,” “[growing] crystals on paper from a science kit,” as well as “[making] a smoke bomb in 9th grade chemistry class” as things that they were doing when they felt like scientists. Engaging in scientific activities such as these that are typically associated with scientific experimentation made the students identify themselves as scientists. The students’ identification as scientists in the above scenarios is to be expected when considering Carlone et al.’s (2011) five normative scientific practices mentioned earlier in the literature review section of this study (Chapter 2). In the students’ examples, they designate physically manipulating scientific equipment and conducting experiments in association with feeling like a scientist.

Science related work. Palmer et al. (2011) found that URM STEM students value participation in STEM-related activities, which agrees with what was found in this study. “I feel most like a scientist when I'm actually engaging in work related to it.” This was one of Martin’s remarks in his interview, and it sums up the point of this part of the discussion of the results of this study. The study participants often referred to science-related work, which is defined in this study as work that scientists do that is not necessarily associated with physical experimentation. For example, reading through articles to find information and learn about other scientists’ discoveries is an activity that is part of scientific research, but is not considered an act of experimentation in this study. Essentially, science related work is all scientific activities that are not commonly associated with the physical act of carrying out experiments.

Some of the science related work the questionnaire participants list as science affinity activities that make them feel like scientists include “research experience,” “mathematics,” “creating models,” “improving data capture and analysis,” “[writing] pre and post lab reports” and “creating approaches.” Another activity on the list is computer programming. One questionnaire participant views computer programming as a science-related activity that makes them feel like a scientist, which is presented in their quotation “writing [computer] programs and testing them.” In this example, writing computer programs and testing them is the science related activity that is not typically associated with experimentation in the minds of the URM STEM student participants, even though this activity is probably a regular activity in many science laboratories.

Two of the interview participants commented about theorizing as a science-related, non-experimentation-based activity that makes them feel like scientists. Khari, an African-American male student majoring in mechanical engineering, talked about when he feels like a scientist:

> I feel like the research or theoretical aspect of being a scientist, […], I would say that's where I find it, personally. It’s like doing projects on my own that require me to go outside of the classroom and pull from other sources of information, people, experiences, and things like that.

Alaijah, a Caucasian female majoring in mechanical engineering, recalls how theorizing makes her feel like a scientist as she says

> When I'm just by myself, and I start thinking of random theories in my head, I'm like, “Maybe I can test that out. Maybe that'll work.” Then once I actually tried to put realistic aspects to it, that's when I start feeling like, wow, it's actually starting to make this possible.

Engaging in all science activities, experimentation and otherwise, makes URM STEM students feel like scientists, with experimentation being the primary type of science activity that the participants note.

Similar results were seen in a recent study involving high school students. Chapman et al. (2015) sought to understand how participation in an authentic science experience affected the science identities of urban high school students, as well as how it affected their perceptions of who can do science and what an authentic science experience means to them. The authors define an authentic science experience as that which includes the use of authentic science practices (such as the science affinity practices of creating research questions, designing research experiments, making observations, explaining the results, developing theories, and reading and interpreting research reports), yet is student-focused in its approach. In other words, an authentic science experience is meant to empower the student while giving them the opportunity to use authentic science practices.

The authentic science experience used in Chapman et al.'s (2015) study consisted of the high school students collaborating with a local environmental engineering professor, engaging in research on algal growth in relation to biofuels at a local research-intensive university. The majority of the high school participants in this study (nine out of twelve) were from URM groups. This mixed methods study used data from interviews, journals, and survey responses to draw their conclusions. The authors learned that authentic research experiences in which the students are expected to participate in authentic science practices positively affected their science identities and altered their perceptions of who can do science. The students developed a less stereotypical and more diverse perception of who can do science, which led to them being able to see themselves as capable of working in authentic science experiences, which is evidence for their science identities being enhanced. Chapman et al.'s study is an example of how physical science activities can enhance the science identities of URM STEM students as well as those of non-URM STEM students.

Knowledge acquisition activities. URM STEM students also associated knowledge acquisition activities with their science identities, such as when one student said "discovering how something works and which [factors] yield which results and why makes me feel like a scientist." This student is describing a time when they were gaining new knowledge from their scientific activities and, thereby, participating in knowledge acquisition activities. Knowledge acquisition activities, the second category derived from the data that falls under the theme of science affinity practices, are science related activities in which an individual engages to obtain scientific knowledge. Some examples of knowledge acquisition activities include attending a science course, completing science homework, and applying and testing scientific theories. Knowledge acquisition activities always involve cognitive processes, such as critical thinking and problem solving processes. The participants of this study noticeably referred to performing knowledge acquisition activities as characteristic of being a scientist, and as activities which made them feel like scientists.

Critical thinking. In their questionnaire responses, URM STEM students frequently articulated that thinking critically is a part of their identity that they share with scientists. One student made it unmistakably clear that thinking critically is a part of their science identity when they said "I think critically like a scientist." Another student was more specific in their recall of thinking critically like a scientist when they stated that they "use critical thinking to come up with solutions."

Thinking critically was not elaborately discussed in the interviews, but one student indirectly spoke about thinking critically when he talked about his opinion of what it means to be a scientist. Michael, an African-American male majoring in mechanical engineering, said

> To me, to feel like a scientist, I'd say that having my opinion matter in the topic that we're talking about, and being able to do research and not just, kind of, having that shallow engineering look into things, but actually taking in the depths of doing the equations itself, and things like that.

"Taking in the depths of doing the equation" is Michael's description of thinking critically. A second student, Uriah, chose to speak about using the critical thinking process in a more pragmatic scenario. Uriah, a male undergraduate student majoring in computer science, said

> Well applying the underlying principles behind it…knowing if we just put an egg in a container, we know before we actually test our hypothesis that it's just going to crack…That's what I would say, the thought process, the critical thinking aspect behind it.

Attending and participating in science classes. As mentioned before, attending and participating in science classes are considered by the URM STEM students who participated in the current study to be knowledge acquisition activities. Attending and participating in science classes are knowledge acquisition activities because doing so results in the act of learning. In science classes, students gain scientific knowledge that they did not have before. "I take a lot of science classes" is one way a student relates to the science identity. Another questionnaire participant recalled "I think the first time that I ever felt like a scientist was when I joined engineering and taking the classes and actually thinking about the world in a different way."

Knowledge acquisition activities were also discussed with the participants during their interviews. The knowledge acquisition activity of learning through science coursework was brought up by Jacel in her interview. Jacel, a female undergraduate electrical engineering major, told me

> I feel like I'm a scientist even when I'm just learning. Like if we're reading a textbook about electricity, or if I'm reading a textbook about physics, or anything, I feel like if you're learning and you're putting in that effort, that's steps to becoming a scientist. You need the knowledge before you actually make something out of it. No one's really a scientist unless

> ... You can't just [say], 'I'm a scientist now', you have to go through the process of learning everything.

Jacel is right, one must go through the process of learning in a scientific way if they want to possess a science identity. One popular avenue for learning in a scientific way is by attending science classes.

During the semi-structured interviews, the participants were asked to describe the last time they felt like a scientist. The question continued to prompt the participants to describe actions that would fall under the category of knowledge acquisition activities. For instance, the fact that participating in scientific classes had an effect on the science identities of URM STEM students was apparent in the URM STEM students' responses. An example is here in one student's response. Kema, a female undergraduate student majoring in computer science, said

> So, in my computer science classes, when I'm doing the assignments they give to us, when I'm trying to figure out how to do it, that's ... I feel like I have the mentality as a scientist at that point.

Kema also stated that "pretty much anytime I'm a scientist, I feel like one, is during class, or when I'm doing work."

Problem solving. A third science affinity practice in the knowledge acquisition activities category that the students identified is the act of problem solving. Based upon the URM STEM student participants' responses, the act of problem solving is interpreted as testing and applying new ideas and concepts to solve a problem. The students explain that problem solving made them feel like scientists when "doing my homework for chemistry," when "I go through the problem solving method," and when "making a bridge on my software program and thinking about the steps and problem solving", to relay a few examples. In his interview, Monticello, a male graduate student who is near the completion of his Master's degree in electrical engineering, talked about how problem solving makes him feel like a scientist when he says

> I feel the most like a scientist when I'm solving engineering problems, since I am an engineer. That could be either in the course of in my career, or it could be while I'm doing some academic work, because I do that as well, or it could be when I'm doing an interesting project as a hobbyist, which is just engineering for fun.

Maton and Hrabowski III (2004) have stated that development of "analytic problem solving capacity" and other critical skills are essential for student confidence and success (p. 549). Possession of the critical skill of problem solving gives the participants of this study confidence in STEM, which positively contributes to the development of their science identities.

Science affinity practices: Characteristics of a scientist URM STEM students believe they do not possess. Knowing how students feel about their science identities will lead to a greater understanding of the effect that URM STEM organizations can have on their student member's science identities through science affinity practices. In this section, I discuss the science affinity practices in which students do not feel they participate, and so feel that they do not possess as part of their science identities. Again, the theme of science affinity practices refers to practices that are associated with science. Those practices are learned by science students from scientific others such that the science students gain skills that make them capable of performing as scientists do. The science affinity practices the students believe scientists participate in, but in which they themselves do not participate, include training and the wearing of a science "uniform."

Training. The definition of training for this study is the action of teaching and learning a particular skill, a science skill. For the purposes of this study, I consider training to be a science affinity practice in that "training" refers to the actions associated with a student's learning of the practices of a scientist.

Although students said that they feel like scientists when they are participating in experimentation, they recognized that they do not always have the necessary hands-on training to participate in those activities. They expressed this in their questionnaire responses, such as by saying "[I do not have] the training or background, certification" and "I do not work in a traditional lab." "[I do not know] methods of approaching problems, research skills" is how one student described the science affinity practices that they do not have. The "methods of approaching problems" that the student may be referring to are "the scientific method" or the "problem solving method" which other students relayed in their survey responses as characteristics of a scientist that they do not have. The overall feeling of the URM STEM student that was conveyed in these responses is a lack of science related skills that would result from hands-on training.

The URM STEM student participants in this study have varying levels of science-related training, and those who may be in their first couple of years of their undergraduate degree program are understandably more likely to feel a lack of training in science. One student describes this idea well when they said "I have not gone far enough in my education to research and develop things that interest me." These student accounts show that having more hands-on scientific training would benefit URM STEM students' science identities by developing their expertise, training, and experience with science activities. In the literature, researchers have shown that URM STEM students benefit from participating in research experiences that give them the hands-on training that is critical to their science identity development (Carlone & Johnson, 2007; Chapman et al., 2015; Lane, 2016). However, none of the current research portrays scientific training as part of URM STEM students' science identities. In other words, the authors of previous research discuss scientific training as consisting of actions that students carry out while learning to act as scientists do when growing their science identities, whereas the URM STEM participants in the current study have identified scientific training as being a part of their science identities, a part that they are currently lacking.

Uniform. Wearing a uniform is considered to be a science affinity practice in this study because it refers to the action of wearing the uniform, and not the uniform itself. The students mentioned that they do not own or wear a lab coat and googles, as they expect a scientist would. This is an indication that the stereotype of a scientist still lingers among post-secondary URM STEM students. Many people associate the science identity with the act of wearing a white laboratory coat and goggles. The white laboratory coat and goggles are perceived as a "uniform" for scientists, as one URM STEM student participant labeled it. The persistence of the stereotypical scientist's outward appearance has been proven to have a negative effect on the science identity of URM students because it makes the science identity less relatable to the URM student (Carlone & Johnson, 2007; Malone, 2009; May, 2003; Ryder, 2011). One way to combat the persistence of a URM STEM student's perceived image of stereotypical scientist for the URM student is to challenge their perceptions with images of, and interactions with, scientists from who are from underrepresented groups (Brooks, 2016; Hughes, Nzekwe, Molyneaux, 2013). Additionally, based on these studies, URM STEM organizations could support the development of their students' science identities by engaging the students in activities that give them interactions with scientists from underrepresented groups. Designing and implementing interventions that cultivate URM STEM students' perceptions that their skills, abilities, qualities, and attributes are aligned with what it takes to be a scientist will positively contribute to the development of their science identities (Ryder, 2011).

Science Affinity Practices: Conclusions. The science affinity practices that are characteristics of a scientist, and in which URM STEM students perceive they participate include experimentation and other science related work, as well as critical thinking, problem solving and participation in science coursework. The science affinity practices that URM STEM students perceive that they do not have in common with scientists are scientific training and the wearing of a uniform. These characteristics will be addressed in the composite science identity of the URM STEM student later in this report.

The fact that the science affinity practices theme came out of the data analysis in this study suggests that URM STEM students associate physical scientific activities and knowledge acquisition activities with their science identities. This finding is unique to this study, and would not have been discovered had the perspective of the URM STEM student not been part of the research design. Normally, those who research science identity in relation to URM STEM students view science affinity practices only as a way to make students' science identities accessible and visible, as Carlone and Johnson (2007) have done in regard to the performance dimension of their science identity model. However, the current study suggests that URM STEM students themselves view science affinity practices as part of their science identities, not just as an outward manifestation of their science identities. This result underscores the importance of including URM STEM students' perceptions in studies of their science identities.

Discursive Science Identity Products

In addition to natural science identity traits and science affinity practices, the URM student participants of this research study identified certain discursive identity products that they associate with scientists. The theme of discursive science identity products is similar to Carlone and Johnson's (2007) competence dimension of the science identity, which defines competence as knowledge and understanding of science content which is "less publicly visible" (p. 1191). Thus, discursive science identity products are professional qualities or products determined by discourse or dialogue with other scientific people. For example, when a chemistry student is receiving homework assistance from their chemistry professor, the student and the professor are engaged in a scientific discussion. Once the discussion is over, the student has gained new knowledge on how to solve the homework problem. The knowledge that the student has gained is an intangible characteristic which evolved from the discourse between the student and the professor. When a student gains scientific knowledge and becomes more confident in their academic performance in their STEM coursework, their science identity becomes further developed. Therefore, in this example, knowledge is the discursive science identity product.

Discursive Science Identity Products: Characteristics of a scientist URM STEM students believe they do possess. In identity theory, a set of shared symbols and artifacts, such as the alphabet and words, determine the attributes of any particular identity (Burke & Stets, 2009). The shared symbols and artifacts are communicated between individuals in society through various means, one of which is discourse. Discourse is verbal communication between two or more people in a group (Merriam-Webster, 2018b). Written communication is also a form of discourse, but will not be addressed here because the student participants did not mention it. Scientific discourse in a group setting is a powerful tool for developing a URM STEM student's science identity as it is a main way that a science identity is communicated and recognized by others (Carlone and Johnson, 2007; Kendricks et al., 2013; Merolla & Serpe, 2013). It is during a scientific discursive exchange in a group setting that the URM STEM student gains valuable information about how they are viewed as scientists in the eyes of scientific others.

The importance of scientific discourse in a group setting for the science identity development of URM STEM students has been made evident in the literature, as well as in the in-depth interviews of this study (Merolla & Serpe, 2013). From the scientific discursive exchanges between the URM STEM student and at least one scientific other come discursive science identity products that the study participants believe make them feel like scientists. The discursive science identity product that the students most identified as being characteristic of their science identities is knowledge.

Knowledge. Knowledge was a recurring characteristic of scientists that the students listed as one that they share in common with scientists. I interpreted many students' single word responses of "knowledge" to mean that scientists have a lot of knowledge, referring to scientific and general knowledge. Note that knowledge is not the same as knowledge acquisition, which was listed as a science affinity practice earlier. Knowledge acquisition is considered to be a science affinity practice because the term represents the act of gaining knowledge. In comparison, the term "knowledge" represents a product that a person gains from others in their environment, and which they gain from the act of knowledge acquisition. In other words, the knowledge that scientists possess is acquired through actions considered to be science affinity practices, but the entity of knowledge itself is the result of those actions, making knowledge a discursive science identity product.

Discursive Science Identity Products: Characteristics of a scientist URM STEM students believe they do not possess.

Expertise. The discursive science identity product that URM STEM students believe they do not possess is expertise. "Expertise in a subject" is a characteristic URM STEM students think they need if they are to identify themselves as scientists. Scientific expertise is considered a discursive science identity product because being recognized as a science expert by scientific others is achieved through discourse and/or dialogue (Carlone & Johnson, 2007). In this study, I define a science expert as one who possesses a significant bank of scientific knowledge in at least one STEM field and knows when and how to use that knowledge. Expertise in a subject comes from experience over time. There is an implied message that by virtue of being a student, a student must inexperienced, and has more to learn before graduating to the level of expert. The URM STEM student participants have expressed their awareness of their lack of experience in statements such as "I have not gone far enough in my education to research and develop things that interest me" and "I have not been doing this long enough to consider myself [a scientist]."

Expertise has not been recognized in the literature as a characteristic of a student's science identity—one that URM STEM students do not believe that they possess. As mentioned previously, this study is the first to generate a composite of a post-secondary URM STEM student's science identity, and the first to inquire about post-secondary URM STEM students' perceptions of the components of their science identities. The only other study to examine science identities from the perspective of URM students focused on the science identities of female URM STEM high school students (Parsons, 1997).

Using a survey and semi-structured interviews as data collection methods, Parsons (1997) asked academically competent African-American female high school students to describe the attributes of scientists of difference races and genders. They were asked to describe the white male scientist, the white female scientist, the African-American male scientist, and the African-American female scientist. The participants in that study assigned different characteristics to the four scientists based on their ethnicities. For example, their descriptions of the African-American female scientist listed characteristics of knowledge, intelligence, and looking "like a nerd" (p. 760) alongside the altruistic scientific work that she does as part of her job. Suggesting that images portrayed by the participants are a reflection of their own self images, Parsons concluded that the African-American female participants' assigning of these characteristics to the African-American female scientist suggests that the participants see those same characteristics as part of own science identities. Similarly, in the current study, I have concluded that the statements the URM STEM student participants make about the characteristics of scientists are a reflection of their perceptions of their own science identities.

Discursive Science Identity Products: Conclusions. The discursive science identity products of knowledge and expertise have been identified as the characteristics of a scientist that URM STEM students believe they do have and do not have, respectively. Knowledge will be represented in the composite of the URM STEM student's science identity as a characteristic that they do possess, and expertise will be represented as a characteristic that they do not possess. Knowledge has not been acknowledged as a component of URM STEM students' science identity in previous research.

While it is impossible to determine which specific type of "knowledge" the participants in the current study were referring to when they responded that they have "knowledge" like scientists do, I assume that scientific knowledge is at least a part of the knowledge that the participants believe they have in common with scientists. If URM STEM students believe that they possess the knowledge it takes to be considered a scientist, then why do they not feel that they have the expertise of a scientist? I postulate that the disconnect between possessing the scientific knowledge and the scientific expertise, for the URM STEM student, lies in the students' lack of confidence in their ability to apply their knowledge when faced with scientific challenges. This point reiterates the importance for URM STEM students to participate in research experiences that are hands-on and holistic in which they have the opportunities to apply their knowledge to all stages of research, from coming up with a research question to designing the methods to drawing conclusions and reporting the findings (Beals, 2016).

Conclusion: Post-secondary URM STEM Students' Science Identities

This chapter outlined the URM STEM students' perceptions of their science identities. To understand what makes URM STEM students feel like scientists, we must first know how they characterize themselves as scientists. In other words, to understand what affects the science identity of a URM STEM student, one must first understand the composition of the URM STEM student's science identity. In the questionnaire survey (Appendix A), the URM STEM student participants were asked to name characteristics of scientists which they feel they possess and those which they feel they do not possess. They were also asked to describe experiences from their past that made them feel like scientists. Their responses to these questionnaire items were interpreted as descriptions of their science identities so that a composite of a URM STEM student's science identity could be determined.

A composite of the post-secondary URM STEM students' science identity characteristics has been theorized based upon the students' perceptions of their science identities, and a model of that composite science identity is shown in Figure 5. In the model, the natural science identity traits of a scientist that the URM STEM student believes they have are within the silhouetted head figure, which is meant to represent the mind of the URM STEM student. Outside of that student's mind, which is purposely depicted outside of the representation of that student's head, are the characteristics of a scientist that the URM STEM student believes they do not have. To my knowledge, a composite of the post-secondary URM STEM student's science identity has not been completed in past qualitative research. I have found one study in which a composite of both male and female African-American scientists has been proposed based upon the perceptions of secondary African-American female students (Parsons, 1997). However, that study did not provide a composite of the URM students' own science identity. The composite is presented as a way to understand URM STEM students' science identities and how the URM STEM students perceive themselves as scientists.

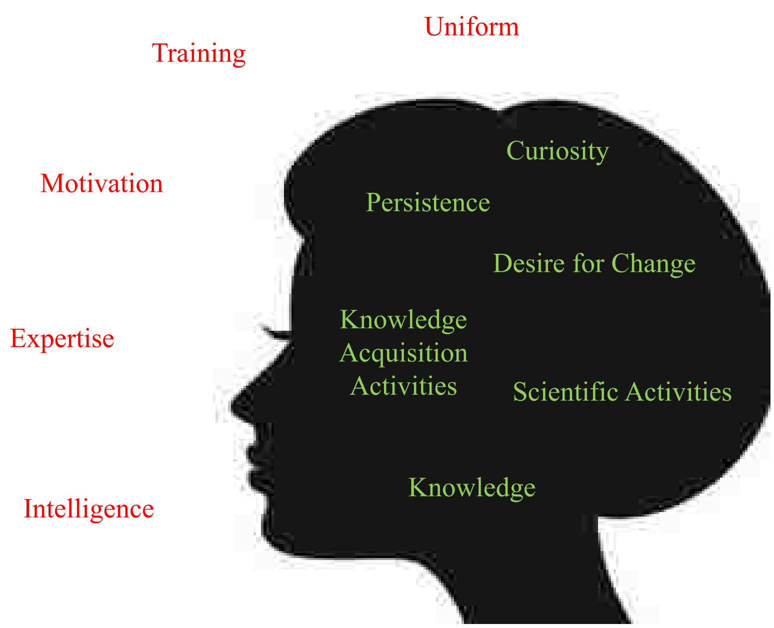

Figure 12. Composite science identity of the URM STEM student.

CHAPTER 6 RESULTS AND DISCUSSION: RESEARCH QUESTION 2

Features of URM STEM Organizations that URM STEM Students Believe Have an Effect on Their Science Identities

This chapter will address the results related to the second main research question: how do underrepresented minority (URM) science students perceive that their participation in a URM STEM organization at a major university shapes their science identities? The two guiding research questions are:

1. Which features of URM STEM organizations do URM STEM students perceive have an effect on shaping their science identities?
2. How do URM STEM students perceive that the features of URM STEM organizations affect their science identities?

Knowing what is already helping URM STEM post-secondary students build their science identities is important so that those efforts can continue. It is just as important to understand how the effort toward building URM STEM students' science identities can be improved upon so as to further develop the students' science identities which will lead to the persistence of URM students in STEM. Therefore, this chapter focuses on the features of URM STEM organizations that have a positive effect on the URM STEM students' science identities. In this study, a positive effect on a science identity is an effect which supports further development of a science identity.

The participants identified several features of the URM STEM organizations that have a positive effect on their science identities. Each of these fell under the themes of science affinity practices and discursive science identity products. The study participants did not list any features of URM STEM organizations that have an effect on their natural science identity traits. The lack of data in this area can be explained in a couple of ways. For example, the students may not recognize any efforts that the URM STEM organization may be offering that would enhance their natural science identity traits. Alternately, perhaps the design of the questionnaire and interview guide was such that they did not elicit the information needed to obtain the students' perceptions of how features of the URM STEM organizations affect their natural science identity traits. The latter explanation is more plausible; however, the uncertainty is evidence for the need for future research.

Science Affinity Practices

If URM STEM students equate science affinity practices with being a scientist, do they also think that features of the URM STEM organizations include opportunities to engage in science affinity practices that support their science identity development? The answer is yes. The students have identified times when URM STEM organizations have provided opportunities to engage in science affinity practices that positively affected their science identities. The students' questionnaire and interview responses concentrated on particular features of URM STEM organizations that fall into two categories: (1) activities and events, and (2) academic support.

Activities and Events. The URM STEM students' questionnaire and interview responses express that URM STEM organizations make them feel like scientists through an array of activities and events that give them opportunities to participate in science affinity practices. The students have attributed organization meetings as well as outreach, internship, scholarship, and workshop opportunities provided by the URM STEM organizations with having a positive effect on their science identities. All of these opportunities fall under the category of activities and events, with outreach events being the most frequently mentioned by this study's URM STEM student participants.

Outreach Events. Coordinating outreach opportunities for their student members is one of the services that URM STEM organizations provide. The outreach opportunities tend to put URM STEM students directly in contact with elementary, middle, and high school students for the purpose of encouraging younger generations of students to pursue STEM degrees when they attend college. The URM STEM organizations encourage URM STEM students to participate in outreach events, allowing them to be mentors and be examples of successful STEM college students for younger generations of URM STEM students. The undergraduate and graduate student members of URM STEM organizations are expected to share their experiences in STEM and higher education with the younger students so that they can help to inspire the success of the younger students that they encounter at the outreach events.

The URM STEM student participants in this study show a great appreciation for the outreach opportunities in which they were able to serve as examples of scientists for younger students. An example of when a student feels their URM STEM organization has made them feel like a scientist is during an outreach opportunity which "allowed me to be a part of teaching kids what it means to be an engineer and just being involved." The URM STEM students' accounts of their experiences with outreach events included how the events made them feel like a scientist. Zynia, a female undergraduate URM STEM student majoring in computer science, told a story about how one of the URM STEM organization's outreach events positively affected her science identity. Zynia's face got a little brighter and she sat up a little taller in her chair as she recalled

> They've helped me with my confidence, that I can say that I am a computer scientist and they have helped me realize how much I have to contribute. I wouldn't…doing outreach the first time it can be a little nerve wracking, that I'm suddenly the professional talking to these girls and I am maybe the first time they're getting an introduction to STEM and I

> don't want to ruin it. So getting the practice with other gals to do outreach and I think that's so important that now I feel confident that I can have one on one conversations or if I needed to go visit a group by myself I could. I would rather not, because the more opinions the better. But that's been really great, to be able to build that up.

Zynia's story of her outreach experience, or a version similar to hers, was repeated by other URM STEM students in their questionnaire responses. One questionnaire participant wrote about how the outreach opportunity contributed to their success as a scientist, and I considered the participant's reference to "success as a scientist" to be a sign of positive development of the participant's science identity. That student wrote "The group exposed me to outreach opportunities. From mentoring young kids at the boys and girls club, I am able to grow as a communicator, which strengthens my ability to be a successful scientist." In this quotation, it is apparent that the student is aware of how they are growing as a communicator of science, which is evidence of the positive development of their science identity.

The outreach events appear to have an impact on the URM STEM students' science identities because they immerse the students into the role of the expert scientist. In the expert scientist role, the student is engaged in hands-on activity while also being the science teacher, which further develops the student's scientific training and gives them the opportunity to use their knowledge of the basic principles and concepts in their STEM field of study. A student's science identity grows in strength as they gain more training and use their science knowledge.

The student participants' descriptions of their outreach event experiences included stories of how they were able to perform as scientists with hands-on activities. A student's questionnaire response was "For the outreach, it made me feel more like a scientist because I'd be demonstrating to them. Just the hands-on aspect on that part." Another student's experience during an outreach event inspired them to write "[The URM STEM organization] has given me the opportunity to volunteer at a local elementary school and teach fundamental scientific concepts to young minds to inspire them to pursue STEM."

When describing what they most liked about being a member of a URM STEM organization, one student replied that the organization "Allowed me to be a part of teaching kids what it means to be an engineer and just being involved." During an outreach event, URM STEM students get to see their science education come to life at their own fingertips all while they are making an impact on their community, which appeals to URM STEM students' motivation for pursuing a STEM degree (Jackson et al., 2016).

Conferences. While outreach events are impactful on the development of URM STEM students' science identities, outreach events cannot give students all of the experiences of a typical scientist. The URM STEM student participants in this study also testify to the influence that URM STEM organization conferences have on their science identity development.

In this study, URM STEM students confirm that conferences are an important feature of URM STEM organizations that the students believe have an effect on their science identities. The conferences that the students were mainly referring to are the national conferences hosted by the URM STEM organizations of which they are members. The URM STEM organizations' national conferences are not unlike other mainstream organizations' national conferences in the sense that they offer a variety of professional development opportunities for the attendees. At the conferences, the attendees can present their research to their peers and other scientific professionals, attend seminars to learn about other research efforts in relation to their own, participate in workshops for career and professional development, and meet with potential future employers. What makes the URM STEM conferences unique is that they give URM STEM students the chance to meet other URM STEM students, academics, and professionals who share similar backgrounds and experiences to their own. It also gives URM STEM students who feel that they are at a disadvantage due to their URM status a place to be noticed by future employers, which is a chance that they are less likely to have elsewhere. Michael recognized the power in the employment potential at conferences, and articulated that here in his statement:

> What I really like about the organization is the conferences and conventions that they have, because it allows students who aren't necessarily in the top highest school, a chance to get into their dream jobs, like they have Boeing and things like that. I actually got interviewed with Boeing as well.

Monticello's appreciation for the potential for employment opportunities at URM STEM organization conferences agrees with Michael, as is evidenced by his statement that

> …most of those underrepresented engineering organizations, they have really good conferences, which tend to have a lot of companies that are looking to hire. A lot of students have gotten really good employment opportunities through just simply being a member of these organizations, and then also going to the conferences.

All of the student participants of this study who spoke about URM STEM organization conferences in their interviews said that the conferences are a feature of URM STEM organizations that helps them develop their science identities. Uriah talked about how the conferences made him feel like a scientist:

> I would say being introduced to all the different conferences. Because with that, I was able to meet a lot of different professionals, and with that, the professionals would tell me what we need to kind of learn on our own, if not offered in our coursework, to kind of prepare for a specific position or that specific field. And they would speak out from their experience

> to actually help guide us, so I felt like a lot of times, it was up to us to still be studious and do our own research, and try to do our own self learning outside of class. And then to start preparing us for the employment opportunities, and be more prepared for the field versus what's given to us in a standard degree, and what's going to be something that everybody going through the degree is going to have.

Uriah went on to say "The conferences made me feel like a scientist, because you could see we could all be together, and then see the bigger picture in improving the world, and all that stuff." From Michael, Monticello, and Uriah's accounts, attending the URM STEM organization conferences positively affects their science identities by giving them the chance to have their science prowess rewarded with encouragement and opportunities to continue their science careers, by building their network of science professionals, and by learning more information about how they can best prepare for future employment in STEM.

URM STEM Organization Meetings. Based upon the responses from the participants of this study, URM STEM organization conferences are a feature of URM STEM organizations that the students view as an asset and benefit for their careers as well as the development of their science identities. Considering that the URM STEM organization chapter meetings offer many of the same opportunities and benefits that the conferences offer, it was expected that URM STEM students would also consider the meetings to be a feature of URM STEM organizations that affects their science identities. The URM STEM students' comments suggest that the organization meetings and conferences affect their science identities in very similar ways. Therefore, this section will only focus on the ways that the participants revealed the meetings affect their science identities differently from the conferences.

"Going to meetings and listening to talks, guest speakers, it felt I was going to conference." The student who gave this quotation was referring to URM STEM organization meetings. What this student means is that they feel they are getting a lot of the same benefits from their organization's chapter meetings at their university that they would get from the organization's national conferences. The students listed several benefits that they get from the meetings, such as hands-on science project experiences that test creativity and ingenuity," the support and "motivation" to succeed in their field, academic support in the forms of help with coursework and academic counseling from their peers, and a "flow" of information resulting in a "knowledge base" about career opportunities and events related to their field. One student, Zynia, highlighted how she gets to enhance the teamwork characteristic of her science identity during the ice breaker activities at her URM STEM organization's meetings. Zynia's story of how a typical URM STEM organization meeting will start paints the picture of how and why she feels like she gains the benefit of a better understanding of teamwork from the meetings:

> I feel like I should also mention teamwork, because something, especially for SWE, a lot of times in the beginning of their meetings they try to do an icebreaker project and sometimes it's a competitive where you have to build with straws and cups and strings to see how high you can get a tower … so you put together a team and of course we're coming from all different parts of the engineering school, mechanical, electrical, computer science. What do we know about physical stuff? We know a little bit. So we all come together and apply our logic and that's the great experience of teamwork that is crucial out in the real world.

Feeling like she is part of the team does more for Zynia's science identity than just enhance her science identity's teamwork characteristic. Working in a team gives Zynia and the other URM

STEM organization members a sense of belonging in a community of scientists, and feeling a sense of community has been shown to have a positive effect on the science identity of URM STEM students (Lewis, 2003). Zynia's fellow URM STEM organization member Alaijah verifies the sense of belonging that is achieved from going to the organization meetings when she says "I would say just SWE [Society of Women Engineers] helped me a lot with feeling like a scientist, mainly for the acceptance in the group." In the team atmosphere of the organization meetings, URM STEM organization members have a space in which they can display their scientific knowledge and scientific skills amongst her STEM peers. In the space of the organization meetings, while working in a team, they also receive extra opportunities to apply and solidify their scientific knowledge and practice using their scientific skills. All of these benefits positively contribute to the science identity of the URM student.

Academic Support. The academic support students can access through their URM STEM organizations was also mentioned as having a positive effect on the students' science identities. Academic support is defined in this study as that which encourages and assists in the success of students in their STEM coursework. Academic support can take the form of tutoring, study groups, or even access to class notes and previous exams, to name a few examples. This theme of academic support is considered to be a form of science affinity practices because it refers to the actions scientists often take to learn difficult scientific material and pass their scientific coursework. Having a high level of success in STEM coursework is required to obtain a STEM degree and gain access to a successful STEM career. It is also a factor that plays a considerable role in the persistence of URM STEM students toward their STEM degrees (Chang et al., 2011; Lane, 2016). In their interviews, URM STEM students brought up the ways in which they receive academic support from URM STEM organizations, and those ways will be described here.

URM STEM students named two specific types of academic support that they receive as members of URM STEM organizations. Those two types of academic support are "study tables" and a peer support system. Study tables are a regularly occurring studying session hosted by one of the URM STEM organizations. The study table sessions are an example of a peer support system, which is a network of student members that come together for the purpose of helping one another succeed in their scientific coursework. First, the study table sessions will be discussed next followed by a discussion of the peer support system within URM STEM organizations that is used to support the students' academic success.

Study tables. Study tables are specific to the National Society of Black Engineers (NSBE) URM STEM organization, though they are open for anyone to participate. According to the NSBE student members who participated in this research study, a study table is a study session which meets regularly on Sundays in the university's main library and is run by the NSBE student members. At a study table session, all students are encouraged to come and work on their homework. Khari describes the study tables in this way:

> So, we have study tables every weekend, and that's basically, just anyone's free to come, for tutoring, or whatever you need. And we have just about everybody. We have biology, chemistry, mechanical, electrical, and computer science covered, as far as STEM.

To elaborate on Khari's description, during the study table session, the students assist each other on their assignments and offer each other advice for their coursework.

Attending the study table sessions helps the URM STEM students build their science identities by increasing their success in their coursework. Michael told me his thoughts about what he gains from attending study table sessions:

> I think ... the study tables, those were really beneficial to me to. I would go every Sunday and work on my math homework and that really helped me in the class, to get a good grade. I think that's about the main thing, we just did it so often that, that's what really helped me through my coursework.

Martin adds that the study table sessions help him stay disciplined and motivated to succeed in his coursework:

> I feel like it really disciplines myself to take what I'm doing I would say more serious. I know since I've joined I've been a lot more serious about my STEM classes. In my math I'm more focused. I want to do better in the class. I don't want to just struggle and give up, I want to do better simply because I know people who went through the same thing who's trying to end at the same thing as I am.

Snyder et al. (2016) reported that peer-led team learning can drastically reduce the failure rate of URM STEM students in undergraduate STEM coursework. In addition, previous research has already proven that success in STEM coursework positively affects the science identity development of the URM student and contributes to their persistence in STEM (Chang et al., 2011). Without the URM STEM organization bringing URM STEM students together, study sessions such as study tables are unlikely to occur because it is difficult for URM STEM students to find each other outside of their classes, especially on a large university campus such as the one which is the location of this research study (Wade, 2012). It would be especially difficult to bring together students who are at varying points in their degree programs such that the upperclassmen can help the lowerclassmen. There are not many URM STEM students to find on a typical university campus due to the fact that they come from ethnic groups that are largely underrepresented in STEM. Therefore, having a place for them to come together and get to know each other is essential for those URM STEM students who thrive academically with peer support and a sense of community, which URM STEM organizations provide.

Peer support system. URM STEM students also identify a peer support system as a feature of URM STEM organizations that positively affects their science identities. Peer support groups that are established within the setting of the URM STEM organizations were presented in different contexts in the participants' interviews in this research study, but one context that stood out is that of academic support. The positive effect on URM STEM students' science identities from peer support in the form of academic support has been noted previously in research (Palmer et al., 2011). As can be deduced from the above description of study tables that the NSBE students host, the URM STEM organization student members rely on their peers for academic support. The academic support between members not only occurs in the NSBE URM STEM organization, but is evident in interview statements of members from other URM STEM organizations as well without the context of a regularly occurring study session.

Some quotations that depict how peer support groups help the URM STEM participants are relayed here. Jacel talks about how the SWE URM STEM organization has made her feel like a scientist when she says

> It has motivated me to do my coursework, because we all go there and we go say, "These courses are hard, but we need to prove that we can do it. And we especially need to prove that we can do it, because if all of us start to fail it will just raise the whole standard that girls can't do this." And I feel like that's not the case, I feel like there's lots of other girls doing other programs that are just as hard. I recognize biology and pre-med and fields where more girls are present, I do recognize those to be just as hard as engineering. And so I feel like that's not the case, I feel like people just don't want to do it. So I feel like the

> less women there are the harder it looks, when it's not harder than maybe anything else that is in the STEM field.

Alaijah corroborates Jacel's statement with her own that tells of how the SWE URM STEM organization has helped her to succeed in her science coursework:

> A lot of motivation from the other group members, a lot of help from them too. Whenever I'd have a problem or anything I might be stuck up on, and I don't feel comfortable going to a tutor or anything, I can just ask them and they'd help me out. That's one of the ways.

Zynia also speaks about how the Society of Hispanic Professional Engineers (SHPE) and SWE URM STEM organizations have helped her in her science coursework through peer support in the following statement:

> Overall, maybe just a little bit more of the teamwork being able to talk to others who have been through the program ahead of me, to we talked about which professors to take, which not to take. I'm a motivated student, so I want to take the good professor, not the easy A professor.

Peer support groups positively affect the URM STEM student's science identity by making them feel like they are a part of a scientific community with continuous validation of their science identities from scientific others, their peers (A. Johnson, 2007; J. Johnson, 2016). This point is made by Martin who said "If anything, our study tables would probably be the closest [to making me feel like a scientist] because you're surrounded by people who have similar majors to you and similar interests." Involvement with peers who are also aspiring scientists strengthens science identity (Graham et al., 2013). Also, identifying and socializing with others who share similar ethnic and racial backgrounds positively affects academic achievement and motivation (Syed, Azmitia, & Cooper, 2011). In fact, what makes the peer support groups formed within the URM

STEM organizations particularly helpful for the URM STEM students' science identity development is that those peer support groups are comprised of other URM STEM students. The URM STEM students in the current study really appreciate being able to see and interact with other URM students and professionals who look and act like them due to their racial and ethnic backgrounds, a point which will be discussed further in the next section of this chapter which focuses on discursive science identity products.

I conclude this section with a discussion of an observation made during the data analysis process of this study. When the students described characteristics of scientists with science affinity practices, they talked about the actual actions and practices that scientists will physically do, usually actions and practices that would be performed in a laboratory setting or scientific learning environment. Yet, when the students described the features of URM STEM organizations that are related to science affinity practices, they listed activities that could be considered as more broad events where science affinity practices are typically carried out, not specific science affinity practices. The differences in the ways the students report science affinity activities may be an artifact of the way the questions were asked in the questionnaire surveys versus in the interviews. However, there is another possible explanation, which is that the goal of URM STEM organizations is not to provide the STEM education, but to support the student as they gain their STEM education from their college or university.

URM STEM organizations tend to provide their students with opportunities that are more broadly related to building the students' careers and less on strengthening their prowess with specific science affinity practices because the students are expected to build their scientific knowledge base in the classrooms of their higher education institutions. Instead of using their resources toward providing services that the students are already getting from their institution and their STEM professors, the administrators of URM STEM organizations have provided the students with services that complement their learning in STEM and that prepare them for the trajectory of their STEM careers. The URM STEM organizations provide services and resources which the URM STEM students are unlikely to get from their STEM classroom experiences, such as a network of URM STEM peers and increased opportunities for scientific discourse.

Discursive Science Identity Products

Another of the services that URM STEM organizations provide to their students is opportunities for scientific discourse. These opportunities can lead to the development of discursive science identity products, the third and final theme found in the data of this study. As a reminder, the theme of discursive science identity products is defined as professional qualities or products determined by discourse or dialogue with other scientific people.

URM STEM students need opportunities to use scientific vocabulary often and regularly, as does any science student. Martin let it be known that he feels most like a scientist when engaged in scientific discourse with this statement:

> I feel more like a scientist when I'm in conversations in regards to the matter. I would say, for example, if we were talking about programming, I feel like that's when my scientist side would come out, because I have a legit passion for programming, so I can talk to somebody about it, even if I don't know as much as they do, I can still talk about it and have my input on things and that's when I feel most like this.

Part of being a scientist is being able to communicate scientific knowledge (Carlone & Johnson, 2007). Events hosted by URM STEM organizations can give the URM STEM students opportunities to speak scientifically using what they have learned in a setting where they feel more comfortable and supported, which is amongst a community of their URM STEM scientific peers.

Scientific discourse that occurs as a result of opportunities provided by URM STEM organizations results in products that have been determined to have an effect on the URM STEM students' science identity development, and those products will now be discussed.

Recognition. Recognition refers to being recognized and acknowledged by societal others as scientists. Recognition is a discursive identity product because recognition is communicated through discourse and dialogue. In other words, in order to know that you are being recognized as a scientist, you must be told by someone outside of yourself that they recognize you as a scientist. Being recognized as a scientist is necessary in the development of a science identity, and may be especially important for a URM STEM student's development of a science identity as previous studies have reported URM STEM students are less likely to be recognized as "scientists" by their STEM peers and professors in comparison to non-URM STEM students (Beals, 2016; Carlone & Johnson, 2007; May, 2003; Remich, Naffziger-Hirsch, Gazley, & McGee, 2016; Wade, 2012; Wenger, 1998). This lack of recognition of being scientists can have serious consequences for URM STEM students' futures. As Wade (2012) explained, "Lack of recognition is a barrier to STEM identity production and therefore science degree attainment" (p. 20).

The person recognizing an individual's science identity does not need to have a scientific background. They only need to be able to appreciate the efforts the individual makes at being a scientist. However, an individual's possession of a science identity needs to be supported and recognized by others from the scientific community in order to validate, and not only recognize, that individual's science identity. Scientific "others" from the scientific community may refer to scientists, scientific peers, and science professors, to name a few. It may also refer to caring, kind science teachers. For example, one URM STEM student recounted that they first felt their science identity was verified when "I switched over to engineering and my professors expected more from me." Another student, Zynia, attested to feeling most like a scientist when she is with her professors and peers who tell her that she is a computer scientist:

> I think without the encouragement of my professors and peers telling us that when you go through the degree program, you are a computer scientist, it feels like we're just learning and learning and then it doesn't necessarily apply to us until we've got tons of experience, but along the way, it's like I'm about to graduate, I am a computer scientist. It's been for me encouragement from my professors and peers that I felt like a scientist.

Being recognized by others as scientists is vital to extend the possession of a science identity for anyone, and particularly important for URM students (Aschbacher et al., 2010; Carlone & Johnson, 2007; Malone et al., 2009).

URM STEM student participants of this study appreciated being recognized as scientific professionals, and declared so in statements during their interviews. The participants' statements all credit URM STEM organizations as places to get the recognition that they desire as scientists. In particular, they gave credit to the conferences that are hosted by the URM STEM organizations of which they are members. Conferences have already been discussed in this paper as a feature of URM STEM organizations that students perceive to have a positive effect their science identity development under the theme of science affinity practices. Interview participant Michael's comments are more telling of how the conferences give him and his fellow URM STEM organization members the opportunity to be recognized by potential employers. In essence, Michael speaks to feeling like a scientist when he is recognized as a scientist by potential employers at the conferences that are put on by the URM STEM organizations of which he is a member. Michael's comments regarding conferences can be found in the science affinity practices section of this chapter, but is repeated here for reference:

> What I really like about the organization is the conferences and conventions that they have, because it allows students who aren't necessarily in the top highest school, a chance to get into their dream jobs, like they have Boeing and things like that. I actually got interviewed with Boeing as well.

Although being recognized as a scientist is important for the positive development of a science identity, the URM STEM student participants' ideas about being recognized as a scientist are implied and were not directly relayed in their responses. In other words, there are not many quotations from the study participants that speak directly to recognition and how it affects their science identities.

Professional development. Students also stated that they feel recognized as scientists when they participate in professional development activities. For the purposes of this study, professional development qualifies as a discursive science identity product because professional development occurs within the individual, is not visible, and is the product of discourse. Professional development is defined as professional learning intended to improve professional knowledge, competence, skill, and effectiveness (Glossary of Education Reform, 2018). Professional development stems from multiple sources, each of which presents an opportunity for professional discourse, such as internships, networking, and opportunities for personal growth. In order for a URM STEM student to improve upon their professional development, they will need to have discursive interactions with other STEM professionals who will verbally recognize and acknowledge their growth in that area. The URM STEM student participants of this study credit URM STEM organizations for making them feel like scientists when they provided opportunities resulting in personal professional development, such as "workshops to test my skills in my field," "doing small projects to test creativity and ingenuity," and "meetings and listening to talks/guest speakers, it felt I was going to conference." Other professional development opportunities the students highlighted as making them feel like scientists include outreach events. The quote that exemplifies how outreach events made the students feel like scientists is "The group exposed me to outreach opportunities. From mentoring young kids at the boys and girls club, I am able to grow as a communicator, which strengthens my ability to be a successful scientist."

Networking. Building a network of friends, acquaintances, and professionals is important for any field of work, and the field of science is no different (Lane, 2016). Networking is interacting with others to make connections, connections that are usually made to further one's career (Merriam-Webster, 2018c). One of the ways STEM enrichment programs and URM STEM organizations help URM STEM students expand their science identities is through networking for academic and professional success (Eagen et al, 2013; Lane, 2016). Networking is considered to be a discursive science identity product because a network of science professionals is only made through discourse between individuals who have science careers and who have interacted with each other on at least one occasion during which their science identity was acknowledged by another. In other words, to establish a connection with a scientific professional that they have not met before, a dialogue between the URM STEM student and the scientific professional must be had so that they reach a point of exchanging contact information so that the connection can be reinforced later. The next sections describe how the URM STEM student participants of this study view networking as a feature of URM STEM organizations that affects their science identities.

Employment opportunities. Having a network of scientific professionals is beneficial when a URM STEM student with a science identity is seeking personal professional development and employment opportunities in science (National Academies, 2011). Professionals in the science individual's network will have a cache of information regarding professional development and employment in their field that the science individual may be unaware of, or may find it challenging to access. For example, while looking for participants for this study, I met an individual who was seeking an internship opportunity at a particular company which had escaped him for some years. This individual is an African-American male undergraduate student who is a high achiever and is focused on earning a STEM degree. This individual also holds an official position on the executive board of one of the URM STEM organizations that is a part of this study, and has earned multiple achievements in STEM and beyond. When the individual heard that I had previously received an internship similar to the one for which he had been searching, he reached out to me. After meeting for a short time, I realized he should be connected with a member of my own network of science professionals, who then connected this individual with others who may be of help to him. Before long, the individual informed me that he had finally received an internship offer that he had been unable to obtain on his own previously, and that he was excited to accept. He thanked me for helping him find a way. Without a connection to a URM STEM organization and networking, this student may not have ever had the opportunity for this internship.

Just as the male URM STEM student benefited professionally from his network in the internship example just presented, the study participants pointed out that networking benefits them professionally. Michael’s response to being asked how the URM STEM organization that he is a member of has helped him develop his science identity is

> I'd say to not only helping me with getting through school academically and also providing chances for scholarships, financially, but giving me the chance to go out into the world and experience how companies, that I might apply towards one day, interview, and also giving me the chance to network with those companies…I would say when I went to the conventions, and was able to find companies that were actually interested in me and what

I had to say, that made me feel more like a scientist. To know that professionals thought that, they saw something in me.

URM STEM students can benefit professionally from networking in various ways, including being granted access to professional networks that they would not have been able to access on their own due to perceived barriers such as race, prejudice, and inaccurately perceived education level. Access to professional networks can also lead to employment and academic opportunities that students would not have been privy to otherwise (Lane, 2016; Merolla & Serpe, 2013; Remich et al., 2016). When networking proves to benefit the URM STEM student in a professional sense, the student will further their science identity because they are continuing to receive validation of their science identity from other scientific professionals.

According to the students' responses, networking appears to have a positive effect on their science identity development. One way that the students felt that networking supported their science identity development is by connecting them with "like-minded" individuals. In their questionnaire response, one student talked about how being a member of a URM STEM organization made them feel more like a scientist because their membership "allowed me to network with other individuals who share my interests and exchange ideas and knowledge." Being connected with people who are like them professionally and like them culturally contributes to URM STEM students' science identity development by increasing their confidence in themselves as scientists because their claims to their science identities are being validated with every connection they establish in their personal professional networks.

Interacting with other underrepresented minorities. Being connected with others who think like them is just as important as being connected with others who look like them, according to the participants of this study. Simply seeing and interacting with a scientific person who has an ethnic background and physical appearance similar to their own has had positive effects on the science identity development of URM students (Chang et al., 2011). Exposure to a diverse community of STEM professionals lets URM STEM students that they are not alone and that they belong in an environment of smart and capable scientific individuals, regardless of skin color or gender (Beals, 2016). The URM STEM student participants of this study also attest to the positive effect that interacting with "like-minded" individuals has on their own confidence levels. Zynia pointed out that interacting with other women in her field is crucial for building her confidence in the following statement:

> I really like the networking that it provides, not only with fellow students, that we're all in the same boat, not only struggling through the program but trying to make the best way out into the world for our careers, but also the networking that it provides with professionals. That's been crucial to hear from women that are already out in the field, the experiences they've had, some intimidations that we have aren't really a problem, some are. It can be addressed to let us know how to enter the world as best as possible, and build our confidence. That was huge.

Zynia then went on to point out that networking in the setting of the URM STEM organization events is different from networking in events meant for the general population of students. She explains that she learns more about challenges that she may face as a minority from other minorities as she builds her network in URM STEM organization events in the following statement:

> The career services and College of Engineering career services offers a lot of networking opportunities with people in the field; but they're not necessarily from underrepresented minorities, and it makes a big difference when I can talk to someone who knows what

challenges I might be facing as opposed to just an employer out there that the situation isn't set up for necessarily bringing us up from the imbalance but just helping us in general.

Martin echoes Zynia's sentiment as he explains how URM STEM organizations have impacted the way he thinks of himself as a scientist when he states

> I would say it's impacted the way of how I think of [myself as] a scientist simply because I'm looking at people who look like me. You know, [in the] National Society of Black Engineers (NSBE), you know being a black STEM major, I see other black STEM majors. Some that look like me doing the same thing that I'm trying to do has helped me…And that's why I'm saying that me being around people who are computer science majors as well as I am, and they're succeeding at it, they're doing well, they're about to graduate, they have internships coming shows me that there's something that I can do, and that helps me within NSBE and helps me want to succeed and do better as well.

URM STEM students use the success of others like them as a source of inspiration toward their own persistence in their STEM fields. URM students are less likely to enter and remain in STEM fields if they lack mentors and role models who are from STEM fields (Nelson, Brammer, & Rhoads, 2007). In their statements above, Martin and Zynia are crediting URM STEM organizations for enhancing their science identities by allowing them to participate in networking events that connect them with other minorities in STEM. The need for role models in STEM that are from URM groups has been documented in the literature (A. Johnson, 2007; J. Johnson, 2016; May, 2003; Towns, 2010). Having more role models in STEM will positively affect the self-esteem and persistence of the URM student in STEM (Nelson et al., 2007; Towns, 2010). On the other hand, Nelson (2007) declares that without URM STEM faculty professors who are hired, treated fairly, and retained, URM STEM students will perceive that their experience will be the same, making them less likely to pursue a STEM career. Having an effective mentor-mentee relationship with someone who is of the same STEM discipline and who has a similar cultural background is critical for creating academic and career support systems (Beals, 2016; Ghee et al., 2016). The student responses in this study suggest that seeing someone who looks like them be successful in the scientist role positively impacts URM STEM students' science identities by giving the students another way to identify with scientists that do not have the stereotypical physical image of a scientist.

Academic support. In addition to providing opportunities for professional development and interactions with other minority scientists, networking has been a positive influence on URM STEM students' science identities through academic support, which is a finding from this study that aligns with what has been found in other research (Lane, 2016; Wade, 2012). The discussion of academic support given here in this section of discursive science identity products is different from the one given earlier in the section of science affinity practices. In the science affinity practices section, the URM STEM students' perspectives of what is available to them that will help them directly with completing their course work is the focus, such as study tables and informal study sessions. Here in the discursive science identity products section, the students' perceptions of networking focus on networking as an intangible result of attending URM STEM events. In turn, that networking helps them find out about the science affinity practices that will directly assist them with completing their coursework. In other words, the discursive science identity product of networking leads to the science affinity practice of studying in groups for the academic support that URM STEM students need for completing their rigorous STEM coursework.

While networking can be a way to make students aware of their tutoring options as a form of academic support, networking within URM STEM organization events has the added benefit of providing the opportunity to learn from and with peers who share similar social and cultural backgrounds with them, making their learning environment more comfortable and familiar. Two interview participants, Kema and Alaijah, talked about how being a participant in the URM STEM organization has made it easier to establish a network connection to other female students in their class, and how that connection lead to increased academic support in science. Kema says

> I've seen just a few people that are in my classes and also in the clubs, so I'm starting to meet them, and I have been able to study with one of them. And right now, in one of my summer classes, I saw another girl that was in the SWE program too, so it gives me, it's like we have one similarity, so we, like, were able to become partners in the class for some of it, so yeah. I think it ... the more I'm in the clubs, the more I feel like I'll see people in the classes and in the clubs that will help me relate to them.

Zynia agrees with Kema:

> The reason I like SWE a lot is because it helps take the small amount of women in my major, and put us together. It just makes us feel like we have a safe place. It helps us connect, 'cause all the boys will only partner up with all the other boys in classes. There's no other girls in the room. There's nothing wrong with girl and boy partners, but it'd be nice to have other girls in there sometimes, 'cause it's kind of hard to relate to other men, basically, in certain aspects. It's nice to have that connection with the same sex, and that stuff.

Zynia gave a more detailed response that helps to understand how networking within the URM STEM organization helps her gain academic support:

> I meet the students in my class, that we're on the same level, but then I've got the students that are like one class ahead of me, one class behind, and so then we can help each other

> that way. Also the people that are in different majors all together, I've really bonded with some in entertainment engineering, mechanical engineering, electrical, and then we can talk about not only our class experiences but what career options are out there. It comes into play for senior design where a lot of us really need each other for the big projects we're going to work on, and it's a glimpse into our future that I'm going to need a mechanical and an electrical in my future. I can't do it all with computer science, we need each other. So there's that communication as well that I wouldn't get without the organization.

Zynia feels that networking creates a team, and that teamwork makes college better for everyone on the team. Here, she describes how networking that leads to teamwork is helpful for her academic success:

> So there's some of that that also it's networking. I'm a big fan of teamwork, and college is the best way to get through it. Teamwork as much as you can, you have to do your own assignments and your own tests, of course, but you can talk about the concepts and it's made the whole journey so much better for a lot of us that are also top students.

In summary, the URM STEM students in this study revealed some discursive science identity products that they perceive to affect their science identities. From their perspectives, being members of URM STEM organizations gives them the benefits of the discursive science identity products of professional development, interactions with other minorities, and academic support from networking. Overall, all of these benefits of networking contribute to the development of URM STEM students' science identities by increasing their confidence in science. Next, I will present a closer look at how URM STEM students perceive that confidence, which they receive from interactions with URM STEM organizations, positively affects their science identities.

Confidence.

Schetema: Okay. How have these [URM STEM organization] activities made you feel more like a scientist?

Zynia: I would say primarily in the confidence. Without confidence, it's hard to place a fabulous title on yourself.

This excerpt from one of the interviews conducted in this study is an example of how URM STEM students see the benefit of one of the features that URM STEM organizations have which positively affects their science identity: confidence boosting. Confidence is generally defined as one's feeling of self-assurance in one's own abilities or qualities (Merriam-Webster, 2018a). In the context of this study, confidence is defined as a feeling of self-assurance stemming from one's belief in their own abilities or qualities in science. An individual's confidence in their abilities and qualities in science is a sign of that individual having a positive science identity (Lane, 2016). An increase in an individual's confidence in relation to science will have a positive effect on that individual's science identity (Lane, 2016). Confidence is a discursive science identity product because it can be the result of any of the URM STEM students' verbal interactions that are science focused. Whether the conversation is with a professor, a colleague, or an elementary school student, any scientific conversation can result in building the URM STEM student's confidence in their STEM field because the student is learning more about their own science knowledge and their ability to communicate their science knowledge during the discursive encounter.

As declared earlier, outreach events have a positive effect on the science identity development of URM STEM students. According to the participants of this study, one of the ways outreach events positively affect the science identities of URM STEM students is by building their confidence in their chosen STEM fields. As URM STEM student participant Zynia put it,

> They've helped me with my confidence that I can say that I am a computer scientist, and they have helped me realize how much I have to contribute. I wouldn't…doing outreach the first time it can be a little nerve wracking, that I'm suddenly the professional talking to these girls and I am maybe the first time they're getting an introduction to STEM and I don't want to ruin it. So getting the practice with other girls to do outreach and I think that's so important that now I feel confident that I can have one on one conversations or if I needed to go visit a group by myself I could. I would rather not, because the more opinions the better. But that's been really great, to be able to build that up.

Participating in outreach events provides URM STEM students with opportunities to hold conversations with different people of all ages and with varying levels of scientific knowledge.

One advantage that URM STEM organizations have when it comes to supporting their students' science identity development is their ability to bring URM STEM students together at the same time. Bringing URM STEM students together will lead to the students feeling a sense of community on their college campus, and gives them an increased number of interactions with scientific others who have similar ethnic and racial backgrounds to themselves, which URM STEM students tend to have a hard time finding on almost every college and university campus due to a gross underrepresentation of minority individuals in STEM (A. Johnson, 2007; J. Johnson, 2016; Lane, 2016; Lewis, 2003). With the increased number of interactions with URM scientific others comes an increase in the likelihood that URM STEM students will find scientific others with whom they can relate, which then translates into increasing the URM STEM student's self-esteem and confidence in STEM because they can now see themselves in the position of the more senior and more successful scientific other (Nelson, 2007). In other words, being a member of a URM STEM organization has the advantage of significantly increasing the number of interactions that the URM STEM student has with URM STEM peers and professionals who look and act like them. The impact of seeing and interacting with other URM STEM peers and professionals is profound for the URM STEM student, and they made that known when talking about their confidence in science. Kema said

> It makes me feel like I am more capable of becoming a scientist, and that it's not about, you know, their appearance or what I am, but, you know, my intelligence, pretty much that, it like, takes away the fear that I have that just because I'm a woman and because I'm Hispanic that I might not be able to. And seeing that all these other girls are really confident about their fields and about their classes, that, I'm like, "Okay, well, that has nothing to do with this, so I shouldn't think about it." So it does make me feel like ... it does make me more confident, pretty much.

To reiterate the message in Kema's statement, the rise in Kema's confidence level in regard to her classes, her abilities in her STEM field, and being a Hispanic woman in STEM is due, in part, to seeing and interacting with other female URM peers and professionals in STEM.

Uriah gives another example of how a URM STEM student's level of confidence is positively affected by seeing and interacting with other URM STEM peers and professionals. Uriah talks about his appreciation for not feeling like he has to push through his STEM degree program by himself in the following statement:

> Definitely I have more confidence now because before, I'm pretty sure you've been there before too, where it's like you go to a classroom and there's no familiar faces…It's like you go in to them and you stand out like a sore thumb. I've been there before, and so coming together with the MP, the multicultural program orgs, it gives me that extra confidence that

> I'm not here doing it alone, and it's like as I stayed in the program I would see more and more faces where it's like it would consistently grow. And that's what I would like to see.

Fortunately for the URM STEM student participants of this study, they have had interactions with other URM STEM organization members, and they recognize that their confidence is positively affected by these interactions, as is demonstrated in the following responses.

The effect of simply knowing there are others whose race is the same as hers and who are on the same or similar scientific journey that she is on is enough to keep Kema motivated and more confident in her science classes even when none of those particular others are in her class:

> I feel like, apart from...I feel more confident, you know, going into classes that is mostly guys, and that mostly not people of my race. It does...it makes me feel like I don't belong there, and just being in these organizations, knowing that there's others, it makes me feel more confident, and more motivated in my classes.

Gaining more confidence in STEM is a feature of URM STEM organizations that is likely unknown to the URM STEM student before they become an active member of the organization and participate in the activities. However, the URM STEM students who were interviewed for this study definitely identified that their level of confidence in science was elevated by their experiences with URM STEM organizations. As another example, in response to being asked how URM STEM organizations have helped her succeed as a scientist, Zynia expressed

> I think it comes down to building my confidence, the advice I got from individuals already in the field […] I think it all comes down to confidence and knowing to always share my opinions, to not stay on the sidelines, another thing that we sometimes do as women.

Michael's statement below agrees with Zynia's experience, and shows that the impact that the URM STEM organization has made on his science identity will last beyond his time as an undergraduate student. He said

> Oh, I'd say that it has brought up my self-esteem, kind of, in the science world. It's made me feel like I'm important, and that I should continue to search for my career and follow my path I'm taking.

Michael's sentiment was echoed by Alaijah when she spoke about one of her experiences with the Society of Women Engineers:

> More confidence, because I can see some of the ones that have graduated already. I think our past president works for JPL (NASA's Jet Propulsion Laboratory) now. That's like, wow! That's a big confidence boost. I was part of this organization. [...] Seeing someone being able to do it makes me feel more confident. I can go and pursue whatever I think it is I want to, regardless of what field it may be.

Alaijah went on to show her confidence in being a woman in science by saying being a member of the URM STEM organization has taught her "Just not to mind that I'm a woman in a men dominated field. That's about it." Both Michael and Alaijah have gained confidence from their experiences in URM STEM organizations that will assist in their persistence in STEM, as is substantiated by their talk of being able to see future STEM careers of their own.

Conclusion: Post-secondary URM STEM Students' Perceptions of How Their Participation in URM STEM Organizations Shapes Their Science Identities

This chapter presented the findings of this study which describe how URM STEM students perceive that their participation in a URM STEM organization at a major university affects their science identities. The students' responses to the questionnaire and interview questions led to an understanding of what URM STEM organizations are doing to support the development of their URM STEM student members' science identity development. From the URM STEM students' perspectives, URM STEM organizations positively affect their science identities by providing opportunities for engagement in science affinity practices that strengthen their scientific academic abilities and enhance their scientific professional development. Outreach events that the students access through the URM STEM organization meetings enhance the URM STEM students' science identities by allowing them opportunities to perform science affinity practices as expert scientists would, which, in turn, develops their science identities through building the students' expertise in their STEM fields and helping them remain motivated in STEM as they help their communities and inspire younger generations of URM STEM students.

From the URM STEM students' perspectives, URM STEM organizations also bring URM STEM students together at conferences, and organization meetings such that they are able to obtain discursive science identity products of recognition, professional development, and a scientific network of peers and other scientific professionals. The network of scientific peers and professionals gives the students recognition as scientists by scientists, which then increases the development of their science identities. In addition, opportunities for professional development arise from the URM STEM students' participation in events and activities provided by the URM STEM organizations as they build their network of potential future employers and learn to interact with more with scientific others. Obtaining these discursive science identity products will positively affect the URM STEM students' science identities by building their confidence in the abilities in STEM.

The fact that URM STEM students feel a boosted sense of confidence from an amplified amount of interactions between themselves and other URM STEM student peers and professionals has been established in the discussion above and in the literature (Ovink & Veazey, 2011). However, confidence is only one of the benefits that the students gain from an increased amount of interactions with their scientific peers and professionals. From this study alone, the URM STEM student participants have articulated that from their interactions with scientific others at URM STEM organization events they gain opportunities in professional development, information about career and employment opportunities, academic support, and scientific networks in addition to confidence in their abilities to succeed in their STEM fields, all of which positively affects their science identities.

The students have also pointed out that they would like to see an increase in membership within the URM STEM organizations. When asked what they liked least about the URM STEM organizations, some of the participants' said "I wish the organization had more members," and "Not enough members!" The more members there are in the organization, the more interactions the URM STEM student members will have with scientific others, which leads to greater student benefits from discursive science identity products. In other words, low organization memberships, in essence, limits some of the benefits that students could gain from their participation in the URM STEM organizations, which then limits their science identity development.

CHAPTER 7 PROJECT SUMMARY, LIMITATIONS, BROADER IMPLICATIONS, AND FUTURE WORK

Project Summary

Research Question 1: The URM STEM student's science identity. In summary, this study sought to understand the effects of URM STEM organizations on the science identity development of post-secondary URM STEM students. To accomplish this goal, I collected data using the survey methods of an open-ended questionnaire and in-depth interviewing. To answer the first research question, "what is the composition of the URM STEM student's science identity?," I began by surveying URM STEM students who are members of URM STEM organizations with a questionnaire. The questionnaire was distributed to all of the URM organization student members, resulting in 42 questionnaire participants. Interviews were conducted with eleven of those student members who completed the questionnaire. The data generated was then analyzed using identity theory as an analytical lens following the analytical methods highlighted in the works of Carlone and Johnson (2007) and Gee (2000).

Three themes emerged from the analysis of the data collected in this study: (1) natural science identity traits; (2) science affinity practices; and (3) discursive science identity products. The first theme, natural science identity traits, encompasses characteristics of a scientist that URM STEM students believe they have and do not have. Curiosity, persistence, and the desire for change are the natural science identity traits that URM STEM students recognized as part of their science identities. Intelligence and motivation are the natural science identity traits that URM STEM students perceive to not be parts of their science identities. The second theme, science affinity practices, represents discernable actions that are associated with the identity of a scientist. Experimentation, other science related work, critical thinking, problem solving, and participation in science coursework are all science affinity practices that URM STEM students listed in this study as being characteristic of their science identities. The participants also said that scientific training and wearing a uniform, which are scientific affinity practices, are not part of their science identities. The final theme, discursive science identity products, includes professional qualities and products that are not visible, but result from verbal discourse or dialogue. Knowledge and expertise are discursive science identity products, with both being perceived by URM STEM students as parts of a science identity, although knowledge was given by the URM STEM students as a product that is part of their science identities while expertise as not a part of their science identities.

The questionnaire generated data which informed the development of a composite of a post-secondary URM STEM student's science identity based on the natural science identity traits, science affinity practices, and discursive science identity products that the students listed as characteristics that they share, and do not share, with scientists. A model of a URM STEM student's science identity is shown in Figure 6.

Post-secondary URM STEM students' perceptions of themselves as scientists. Interestingly, although students identified a number of characteristics that they share with scientists, about half of the students surveyed in this study said that they do not think that they are scientists. This would indicate that approximately half of the URM STEM student participants do not have a science identity. In fact, some of the students surveyed could not list any characteristics that they have in common with scientists. The idea that so many URM STEM students don't identify themselves as scientists should be of concern for URM organizations because a URM student is less likely to succeed in STEM without a positive science identity (Chang et al., 2011).

Why is it that students recognize that they have some characteristics in common with scientists but do not believe that they, themselves, are scientists? Is there a particular characteristic, or combination of characteristics, that distinguishes a scientist from a non-scientist from the perspectives of these URM STEM students? In order to answer these questions completely, additional data must be collected. However, there may be other reasons that the students surveyed in the current study did not identify themselves as scientists. Considering one of the characteristics of identity, which is identity is contextual, nonessential, and temporally developed, there is the understanding that not everyone who demonstrates the actions of a scientist actually possesses a science identity. Hazari et al. (2013) have pointed out that many students who are planning STEM careers in college have low self-perceptions of themselves as scientists. It stands to reason that the URM STEM students in this study may follow this trend of being able to exhibit the actions of a scientist while still not being able to identify with being a scientist.

Additionally, the population available for this study consisted primarily of URM STEM students from URM STEM organizations that focus on supporting engineering students, not necessarily science or all STEM students. While, technically, the organizations are open to all STEM students, they focus on supporting engineering students. Therefore, the students may not identify with being a scientist because they prefer to identify themselves as engineers, even though engineers are required to exhibit characteristics of a scientist as part of their profession. For example, the survey question "What is the most recent thing you did that made you feel like a scientist?" prompted one student to respond "I am an engineer." I interpreted this as this student declaring that they are an engineer, not a scientist. Based on this comment, I believe that it may also be useful to examine, in the future, the ways in which students who belong to URM STEM organizations make the distinction between scientists and engineers and if they believe that different types of support would be useful for engineering students than would be useful for science students.

For the purposes of this study, all of the students were considered to be scientists, regardless of their chosen STEM major because all of the STEM fields require that the students acquire scientific skills and knowledge to be successful. Although I assumed that students in all STEM fields would have science identities, it may be that the students do not see themselves that way. For example, perhaps the engineers believe they have an engineering identity instead of a science identity. This perception may have influenced the students' responses. Nevertheless, most of the URM STEM students were able to articulate times when the URM STEM organizations that they are members of made them feel like a scientist. As a consequence, their accounts were analyzed together to determine which features of the URM STEM organizations affected their science identities.

Research Question 2: The data generated from the questionnaire and in-depth interviews were also analyzed with the ultimate goal of generating a theory that will answer the second main research question, how do underrepresented minority (URM) STEM students perceive their participation in a URM STEM organization at a major university shapes their science identities? The answer to this question is that URM STEM students perceive that their participation in a URM STEM organization positively shapes their science identities. In other words, URM STEM students perceive that their participation in a URM STEM organization enhances and develops their science identities. The URM STEM students reported that the science affinity practices under the category of academic support, in the forms of study tables and a peer support system, contribute to their science identity development by improving their abilities, and thereby building their confidence, in their STEM coursework. Having a high level of success in STEM coursework is a significant factor in the persistence of URM students in STEM (Chang et al., 2011; Lane, 2016). Also, a peer support system, especially one in which the peers share similar ethnic and racial backgrounds, positively affects the URM STEM students' science identities by including them in a scientific community which continuously validates their science identities as they interact with their scientific peers (A. Johnson, 2007; J. Johnson, 2016; Syed et al., 2011). Each of these features is provided by the URM STEM organizations.

The URM STEM students also report that their participation in the science affinity practices under the category of activities and events offered by URM STEM organizations, which are outreach events, conferences, and URM STEM organization meetings, further develops their science identities by giving them opportunities to act as expert scientists do. The URM students' science identities grow as they gain more training and use their science knowledge while acting as expert scientists. Attending the URM STEM organization conferences positively affects URM STEM students' science identities by giving them an opportunity to display their science prowess and have their display rewarded with encouragement and opportunities to continue their science careers through professional development and networking.

Part of being a scientist is being able to communicate scientific knowledge (Carlone & Johnson, 2007). Events hosted by URM STEM organizations give URM STEM students increased opportunities for scientific discourse in a comfortable setting amongst a community of their URM STEM peers. URM STEM students in this study talked about gaining the discursive science identity products of recognition, professional development, and networking from scientific discourse within the URM STEM organization setting. Gaining these discursive science identity products positively affects the URM STEM students' science identities by building their confidence as they display their claims on their science identities and having those claims validated by others through scientific discourse. As mentioned before, being recognized by others as scientists is vital to extend the possession of a science identity for anyone, and is particularly important for URM students (Aschbacher et al., 2010; Carlone & Johnson, 2007; Malone et al., 2009).

Features of URM STEM organizations that positively affect URM STEM students' science identities. One of the main research questions for this study was "how do underrepresented minority (URM) science students perceive that their participation in a URM STEM organization at a major university shapes their science identities?" The answer to this research question is that URM STEM students perceive that their access to particular features of a URM STEM organization at a major university has resulted in a positive shaping of their science identities in multiple ways. Figure 6 shows a model of the features of URM STEM organizations that the students have declared to have an effect on their science identities. The features of URM STEM organizations which provide support for the URM STEM students' science identities are on the bottom of the pyramid, leading up to the themes derived from the data, which, in turn, influence the URM STEM student's science identity. The section missing from the supportive foundation of the pyramid below the natural science identity traits theme is empty. That section is empty because the students did not provide any information about the features of URM STEM organizations that affect the natural science identity traits that would be characteristic of their science identities. The omission on the students' part may be an artifact of the design of the questionnaire and interview guide. However, to be sure that the omission is not due to a lapse in the efforts of the URM STEM organizations, further research would need to be conducted with a focus on the students' perceptions of how URM STEM organizations affect their natural science identity traits. In essence, this model of the features of URM STEM organizations that support the URM STEM student's science identity (Figure 6) and its generalizability needs to be tested and completed with larger groups of URM STEM students. To test and complete this model, a study which includes questions about natural science identity products in the interview guide will need to be designed and implemented.

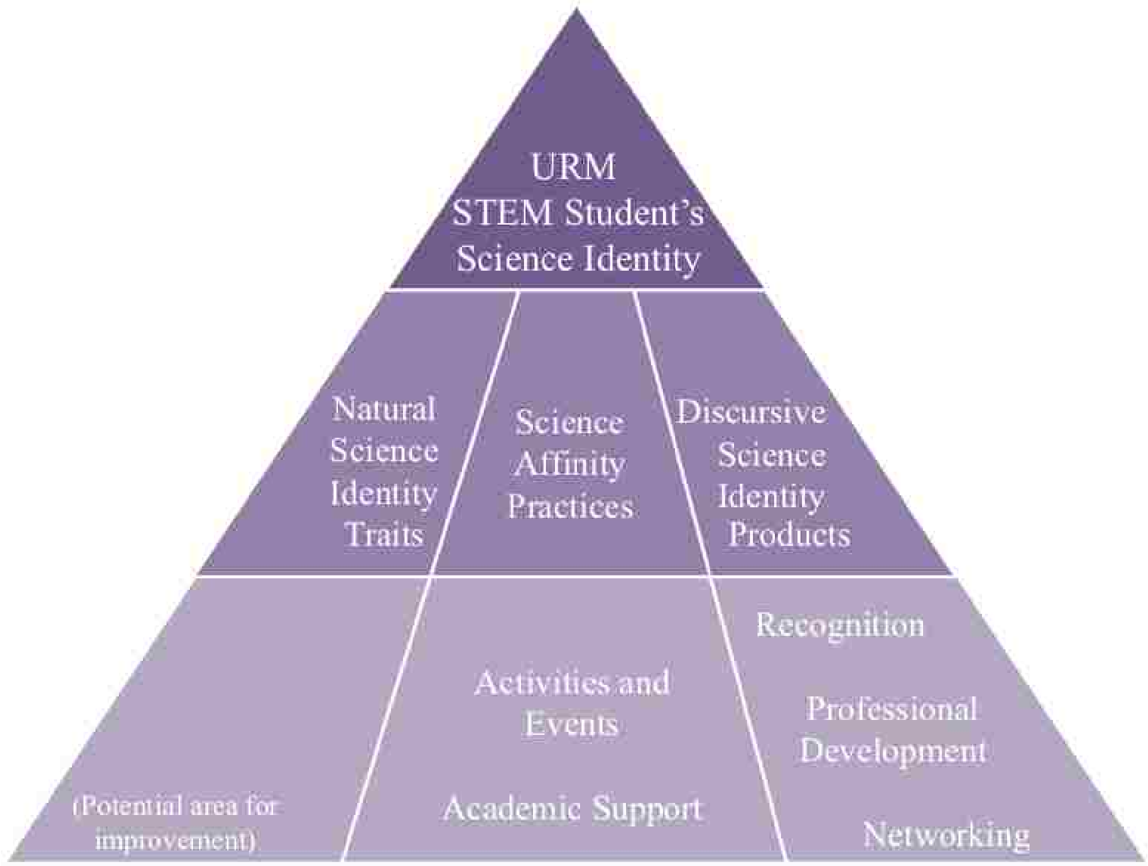

Figure 13. Model of the features of URM STEM organizations that support the URM STEM student's science identity.

The students have described how their science identities have been enhanced by their participation in the science affinity practices of academic support and activities and events. The academic support that positively affected their science identities are study tables and a peer support system, both of which helped them succeed in their academic coursework. Previous research revealed that performing well in one's STEM coursework leads to further development of one's science identity (Brown, 2002; Jackson & Suizzo, 2015; Johnson, 2007). The activities and events introduced to the URM STEM students by the organization which the students perceive to affect their science identities are the science affinity practices of outreach events, conferences, and organization meetings.

Participation in the science affinity practices of the URM STEM organization resulted in the students' perception of having gained some discursive science identity products, which stood out as features of the URM STEM organization that have shaped their science identities. Based on the students' perceptions, the discursive science identity products that they gained are recognition, professional development, and networking, which are perceived by the URM STEM students as the most influential discursive science identity products on the URM STEM students' science identities. As the students acquired their discursive science identity products, they secured more confidence in their scientific knowledge and abilities, which is an indication of further development of their science identities. Overall, according to the students' perceptions, the URM STEM organizations are providing them with multiple opportunities to shape and develop their science identities.

Features that URM STEM organizations can improve upon. Though most of what the students told me were their perceptions of the features of URM STEM organization which positively shape their science identities, there was one organization feature many students pointed out that could help to negatively affect the students' science identities: low membership. Without additional URM STEM organization student membership, the current members will have a smaller network of STEM peers and professionals, and a lower amount if interactions with STEM peers that could have led to greater academic support and professional development. The URM STEM student participants gave a suggestion for increasing the number of student members in their URM STEM organizations. When asked what they liked least about the URM STEM organizations that they are members of, they relayed that the organizations could advertise their existence more. The lack of marketing done by the URM STEM organizations leads to low membership, the effects of which have already been mentioned.

There were also some characteristics of a scientist that the URM STEM students perceive that they do not have. Those characteristics are intelligence, motivation, the uniform, training, and expertise. Now that these characteristics have been identified by the URM STEM students themselves, URM STEM organizations can use this information to focus more of their efforts and resources toward improving the students' perceptions of themselves as scientists via enhancement of their perceptions of their level of intelligence and motivation for STEM.

The interpretation of the participants' claim to not have the uniform that they associate with the science identity is that they do not look like a scientist. The students' view of what a scientist looks like will be challenged and altered with every encounter they have with scientists at the activities and events (conferences, outreach events, organization meetings) that the URM STEM organizations bring to the URM STEM students over time.

Limitations

There are some limitations to the design of this study that should be noted. A limitation is that this study took place at one university, and it excluded students who did not participate in the Multicultural Program or any of its affiliated URM STEM organizations on that university campus. Therefore, the findings of this research study may not reflect the experiences of nonparticipants. In fact, this brings me to the second limitation of this study, which is that the results are not generalizable due to the small sample size of participants. For the findings from a survey study to be generalizable, the sample size should be approximately 350 individuals (Creswell, 2012). Having a small sample size for this study was expected considering the sample population for this study are members from racial and ethnic groups that are vastly underrepresented in the STEM fields. Although the results of this study closely align with those of previously published studies, the findings of this research study will need to be verified with additional research studies. Therefore, the composite of the URM STEM student's science identity presented in this study is meant to inform future research in science identity of URM STEM students, but cannot be generalized. Future research focused on developing a complete composite and full understanding of the URM STEM student's science identity could be set up such that data is collected from a larger sample group, with data collection from multiple sites, giving that study the possibility of being generalizable.

Broader Implications

The findings from this study add to the body of literature that is focused on understanding how to best support the persistence of URM students majoring in STEM fields. It also adds to the literature which seeks to inform universities on the impact that URM STEM organizations have on the persistence of the students that they serve. Part of the knowledge gained from this study is that URM STEM organizations positively impact their student members' science identities through academic support and activities and events, such as outreach events, conferences, and organization meetings. The students receive networking, professional development, recognition and confidence from participating in the activities and events that are offered by the URM STEM organizations. All of these findings are aligned with the benefits that the URM STEM organizations advertise on their websites (See Table 3), so the URM STEM organizations are meeting those needs based on their student members' perspectives.

This study also revealed that URM STEM organizations could improve upon building their student members' natural science identity traits. If URM STEM organizations better understand how they can make a greater impact on their students' science identities, they would be more effective in their efforts to retain URM students in STEM. To increase URM STEM students' confidence in their intelligence, URM STEM organizations can continue to recognize their students as intelligent people. One student participant appreciated that their science identity is affected by the URM STEM organization when "We are all treated equally like intelligent people." Although the students never revealed how the organizations explicitly recognized their intelligence, knowing the students need their intelligence to be acknowledged is enough to inform ways that URM STEM organizations can bolster their students' perception of their intelligence.

URM STEM organizations can further support their URM STEM students' science identity development in ways that specifically target strengthening their students' natural science identity traits, such as developing a structured mentoring program in which the students are being recognized as scientists through their natural science identity traits (Kendricks et al., 2013). URM STEM organizations may also consider an intervention which targets the specific natural science identity traits that the URM STEM students feel that they are lacking: intelligence and motivation. Essentially, the URM STEM organization can choose to be responsible for bringing their URM STEM students together with their perceptions of themselves as scientists in a more explicit and direct way. The more a student can identify themselves as a scientist, the more they persist in their scientific endeavors, which makes them more likely to graduate with a STEM degree (Chang et al., 2011; Maton et al., 2016). Figure 7 depicts a proposed role of the URM STEM organizations in furthering the development of their students' science identities. One way that has been shown to positively affect URM STEM students' perceived intelligence and motivation levels is the use of growth mindset interventions suggested by Dweck, Walton, and Cohen (2014). Yeager and Dweck (2012) suggest that students' motivation for learning is increased when they are taught that intelligence is a quality which can be developed, and is not a fixed quality. In studies that are focused on using growth mindset intervention, students are taught in a workshop setting that their mental qualities, such as intelligence, can be positively developed with focus and more effort over time. When students complete these workshops, they show a marked improvement in their academic performance, which leads to a heightened motivation for learning and their motivation for success in their challenging courses.

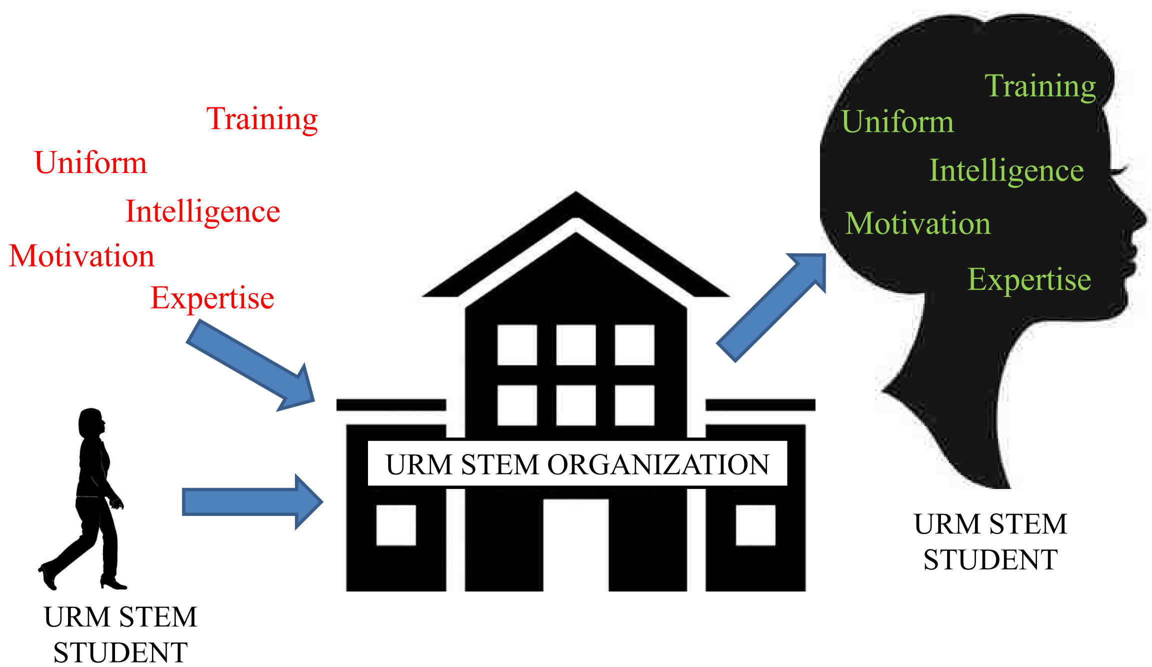

Figure 14. The role that URM STEM organizations can fill toward developing URM STEM students' science identities.

URM STEM students could also use assistance with increasing their motivation for science, which can lead to further development of their science identities. A student exclaimed that they "feel motivated by my peers around me" when asked how the URM STEM organizations make them feel like a scientist. This is evidence to what the organizations are already doing to increase their students' motivation for science, which is bringing URM STEM students together at the same time and getting them to build their network of support with their URM STEM peers.

Whenever the organization hosts an event, conducts an organizational meeting, or provides an opportunity for students to interact with one another, they are increasing their students' motivation for science. However, the findings in this research study indicate that students still lack motivation to be a scientist, more efforts must be made to increase their motivation to help them persist in STEM.

Future Work

Future work for this study should focus on repeating this project—with the modifications mentioned in this dissertation—with a larger sample of participants to verify the design of the study while determining if the findings of the current study are generalizable to a larger group of URM STEM students. The sample group for these future studies should be purposively selected to include students who major in STEM fields other than engineering. The majority of the participants in this study from the engineering field; and some sciences were not represented at all, such as biology and mathematics. It is understandable that the sample group of participants obtained for this study was over representative of engineering students because the university where this study takes place does not have other URM STEM organizations that focus on the retention of URM STEM students in other fields. However, these URM STEM organizations do exist elsewhere. For example, there is a nationally recognized organization that exists for the support and advancement of African-American chemists. It would be interesting to repeat the current study at an institution where URM STEM organizations focused on other STEM fields exist.

APPENDIX A

Survey Instrument – Science Identity and Underrepresented Minority STEM Organizations Questionnaire

Instructions: Thank you for participating in this survey. Your responses will help us understand how underrepresented minority (URM) organizations affect the science identities of the student members that they serve. You will be asked a series of questions about your experiences with URM organizations that serve underrepresented minority students in the science, technology, engineering, and mathematics fields of study. We expect that it will take you approximately 15 minutes to complete the questionnaire. Please respond with your best complete answers.

Demographics

1. Are you an undergraduate or graduate student?
2. What year of study are you in?
3. What is your major of study? What made you decide to choose that major?
4. Do you have a second major of study? If so, what is that major? What made you choose that major?
5. Do you have a minor of study? If so, what is that minor?
6. What is your ethnicity/race?
7. What is your gender?
8. This study will continue beyond this survey and will require some survey participants to be voluntarily interviewed. May we contact you in the future for an interview? If so, please answer the following 3 questions. If not, please skip to question 9.
    - 8a. What is your name?
    - 8b. What is your email address?
    - 8c. What is your telephone number (the best number to reach you at)?

Questions about Underrepresented Minority (URM) Organizations

9. Are you a member of the Multicultural Program?
10. Are you a member of any of the following URM organizations or groups related to science on campus? (Please circle all that you are a member of.)

    a. Society of Women Engineers (SWE)
    b. National Society of Black Engineers (NSBE)
    c. National Society of Hispanic Professional Engineers (SHPE)
    d. Society of Asian Scientists and Engineers (SASE)
    e. Other:

11. How long have you been a member of the URM organization(s)? Please write the number of years next to each URM organization that you are a member of.
12. What made you decide to become a member of the URM organization(s)?
13. What do you like most about the URM organization(s)?

14. What do you like least about the URM organization(s)?

Questions about Science Identity

15. Are you a scientist?
    a. What characteristics of a scientist do you have?
    b. What characteristics of a scientist do you not have?
    c. Please describe the first time that you ever felt like a scientist.
    d. Please describe the most recent thing that you did that made you feel like a scientist.
16. What has (have) the URM organization(s) that you are a member of done to make you feel more like a scientist?

APPENDIX B

Survey Instrument - Science Identity and Underrepresented Minority STEM

Organizations - Interview Guide

INTERVIEW GUIDE FOR THE STUDENT MEMBERS (Goal: to identify underrepresented minority university students' perspective on how underrepresented minority programs at their university affect their personal science identity.)

I. **Informed Consent**
   a. Hello. My name is _________. I want to thank you for meeting with me today. I think your insights will really help us with our project. Before we start, I wanted to ask if you received the Informed Consent document that I emailed you earlier.
      i. Did you have a chance to read it?
      ii. Do you have any questions for me about it?
      iii. Do you agree to participate in this interview? Do you agree to be audio-taped during the interview? If so, could you please sign this copy of the Informed Consent document for me? Thank you.

II. **Demographics**
   a. OK. Let's begin. Tell me a little about your major.
      i. What is your declared major?
      ii. What made you choose _______ as your major?
   b. Please tell me about some of the organizations that you are a member of on campus.
   c. Tell me what it means to you to "feel like a scientist."
      i. When do you feel the most like a scientist?
      ii. What are you doing when you feel like a scientist?
      iii. Who are you with when you feel like a scientist?
      iv. Where are you when you feel most like a scientist?

[If they say that they do not feel like a scientist:
1. What makes you say that you do not feel like a scientist?
2. What would make you feel more like a scientist?]

   d. Would you please tell me about the last time you felt like a scientist?
      i. Who were you with the last time you felt like a scientist?
      ii. Where were you the last time you felt like a scientist?
      iii. What were you doing the last time you felt like a scientist?

For students in college, there are resources on campus that are put in place to help them succeed and graduate in their chosen fields of study. Underrepresented minority students who have chosen to major in STEM fields have how underrepresented minority science, technology, engineering, and mathematics (also known as STEM) organizations as resources. My goal for this study is to better understand how underrepresented minority STEM organizations affect the science identity of underrepresented minority students who are majoring in STEM fields of study. For that reason, I'm going to ask you a series of questions about different things that may or may not happen in the underrepresented minority STEM organizations of which you are a member.

III. **Science Identity and Underrepresented Minority STEM Organization Questions**

a. What do you like about the underrepresented minority STEM organization(s) that you are a member of?
b. What do you not like about the underrepresented minority STEM organization(s) that you are a member of?
c. Please describe any activities that you have participated in with the underrepresented minority STEM organization(s) that you are a member of. (Presentations, internships, networking, speakers, scholarships, etc.)
    i. In what ways have these activities made you feel more like a scientist?

[If they say that these activities have not made them feel like a scientist:
        1. How could these activities have made you feel more like a scientist?]

d. How has (have) the underrepresented minority STEM organization(s) that you are a member of helped you succeed with your science coursework?
    i. Would you please give examples of what the underrepresented minority STEM organization did to help you succeed with your science coursework?

[If they say that the organizations have not helped:
        1. How could the STEM organizations help you succeed with your science coursework?]

e. How has (have) the underrepresented minority STEM organization(s) that you are a member of helped you succeed as a scientist?
    i. Would you please give examples of what the underrepresented minority STEM organization did to help you succeed as a scientist?

[If they say that the organizations have not helped:
        1. Would you please give examples of what the underrepresented minority STEM organization could do to help you succeed as a scientist?
        2. How would that help you succeed as a scientist?]

f. In what ways has (have) the underrepresented minority STEM organization(s) that you are a member of impacted the way you think of yourself as a scientist?

IV. **Closing**

a. Thank you for sharing your time and insights with us. They will help us develop a better understanding of the ways the MP and other underrepresented minority programs help students build their science identities.
b. Do you have any final comments about how the practices of the underrepresented minority STEM organizations help or could help you to feel more like a scientist that you would like to share with us?
c. Thank you again!

APPENDIX C

Informed Consent Form for Questionnaire Participants

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Science Identity and Underrepresented Minority STEM Organizations - Informed Consent Form for Questionnaire Participants

INFORMED CONSENT

Department of Chemistry and Biochemistry

TITLE OF STUDY: Science Identity and Underrepresented Minority STEM Organizations
INVESTIGATOR(S): Dr. MaryKay Orgill (UNLV Professor), and Schetema Nealy (UNLV Doctoral Student)
For questions or concerns about the study, you may contact Dr. Orgill at **702 895-3580.**

For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted, contact **the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794 or via email at IRB@unlv.edu.**

Purpose of the Study
You are invited to participate in a research study. The purpose of this study is to understand how the activities of underrepresented minority organizations have helped or not helped their underrepresented minority student members feel more like scientists, as viewed from the students' perspective. For the purposes of this study, underrepresented minority students include students whose race includes African-American, Hispanic, Native-American/Alaskan Native, and Pacific Islander. Female students are also included in the category of underrepresented minority students.

Participants
You are being asked to participate in the study because you fit this criterion: you are a student from an underrepresented minority group and are currently a member of the Multicultural Program, or at least one of their student organization partners.

Procedures
If you volunteer to participate in this study, you will be asked to do the following: fill out a 15 minute survey about your experiences with underrepresented minority organizations that serve underrepresented minority students in the science, technology, engineering, and mathematics fields of study.

Benefits of Participation
An incentive to participate will be offered to all of the participants. That incentive will be the opportunity to win a fifty-dollar Amazon.com gift card via a raffle. Also, we hope to understand how underrepresented minority organizations have helped or not helped their student members feel more like scientists.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks which may include embarrassment, emotional distress, and psychological trauma associated with the discussion of unfamiliar topics.

Cost /Compensation
There will not be financial cost to you to participate in this study. The study will take approximately 15 minutes of your time. You will not be compensated for your time.

Confidentiality
All information gathered in this study will be kept as confidential as possible. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for three years after completion of the study. After the storage time the information gathered will be destroyed.

Voluntary Participation
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with UNLV. You are encouraged to ask questions about this study at the beginning or any time during the research study.

Participant Consent:
I have read the above information and agree to participate in this study. I have been able to ask questions about the research study. I am at least 18 years of age. A copy of this form has been given to me.

______________________________________ ________________
Signature of Participant Date

____
Participant Name (Please Print)

APPENDIX D

Informed Consent Form for Interview Participants

<u>Science Identity and Underrepresented Minority STEM Organizations - Informed Consent Form for Interview Participants</u>

INFORMED CONSENT

Department of <u>Chemistry and Biochemistry</u>

TITLE OF STUDY: <u>Science Identity and Underrepresented Minority STEM Organizations</u>
INVESTIGATOR(S): <u>Dr. MaryKay Orgill (UNLV Professor), and Schetema Nealy (UNLV Doctoral Student)</u>
For questions or concerns about the study, you may contact Dr. Orgill at **702 895-3580.**

For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted, contact **the UNLV Office of Research Integrity – Human Subjects at 702-895-2794, toll free at 877-895-2794 or via email at IRB@unlv.edu.**

<u>Purpose of the Study</u>
You are invited to participate in a research study. The purpose of this study is to understand how the activities of underrepresented minority organizations have helped or not helped their underrepresented minority student members feel more like scientists, as viewed from the students' perspective. For the purposes of this study, underrepresented minority students include students whose race includes African-American, Hispanic, Native-American/Alaskan Native, and Pacific Islander. Female students are also included in the category of underrepresented minority students.

<u>Participants</u>
You are being asked to participate in the study because you fit this criterion: you are a student from an underrepresented minority group and are currently a member of the Multicultural Program, or at least one of their student organization affiliates.

<u>Procedures</u>
If you volunteer to participate in this study, you will be asked to do the following: participate in a one-hour interview about how your experiences with the Multicultural Program, or at least one of their student organization partners, have helped or not helped you feel more like a scientist.

<u>Benefits of Participation</u>
There may not be direct benefits to you as a participant in this study. However, we hope to understand how underrepresented minority organizations have helped or not helped their student

members feel more like scientists.

Risks of Participation
There are risks involved in all research studies. This study may include only minimal risks which may include embarrassment, emotional distress, and psychological trauma associated with the discussion of unfamiliar topics.

Cost /Compensation
There will not be financial cost to you to participate in this study. The study will take approximately 60 minutes of your time. You will not be compensated for your time.

Confidentiality
All information gathered in this study will be kept as confidential as possible. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for three years after completion of the study. After the storage time the information gathered will be destroyed.

Voluntary Participation
Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with UNLV. You are encouraged to ask questions about this study at the beginning or any time during the research study.

Participant Consent:
I have read the above information and agree to participate in this study. I have been able to ask questions about the research study. I am at least 18 years of age. A copy of this form has been given to me.

____ __________________
Signature of Participant Date

____
Participant Name (Please Print)

Audio Taping:

I agree to be audio taped for the purpose of this research study.

____ __________________
Signature of Participant Date

____
Participant Name (Please Print)

APPENDIX E

Science Identity and Underrepresented Minority STEM Organizations - Recruitment

Email for Student Participation in the Questionnaire Survey

SCIENCE IDENTITY AND STEM UNDERREPRESENTED MINORITY ORGANIZATIONS: Study Questionnaire Survey Email

Dear UNLV Student,
Greetings!

You are receiving this email because you are a member of the Multicultural Program, or one of its partner student organizations. I am a doctoral student co-researcher, working with Principal Investigator Dr. MaryKay Orgill as an advisor, on a dissertation study regarding the impact that underrepresented minority organizations have on the science identity of underrepresented minority students majoring in science, technology, engineering, and mathematics (STEM). I would like to invite you to participate in this research study. Your participation would be via an online questionnaire, possibly followed up with a face-to-face interview.

The questionnaire portion of the study is designed to generate student responses about their experiences with, and feelings about, the URM organizations of which they are members.

The survey will take approximately 15 minutes.

Your participation is voluntary, you may choose not to respond to any question on the survey, and you may stop the survey and decline to participate in the study at any time. If you have any additional questions about this study, please feel free to contact me at nealys@unlv.nevada.edu (or Dr. Orgill at marykay.orgill@unlv.edu).

As an incentive for your participation, you will be given the opportunity to be entered into a raffle for a $50.00 Amazon.com gift card. If you would like to be entered into the drawing for the $50.00 Amazon.com gift card, please click on the link provided at the close of the questionnaire and fill out the entry form.

Your completion of the survey will help me to complete my dissertation and add to current research in the field of chemistry education. If you complete the questionnaire, you may be subsequently invited to participate in a face-to-face interview.

Thank you for your time and consideration of this invitation. The link to the questionnaire is posted below.

Sincerely,
Schetema Nealy, PhD Student.
University of Nevada, Las Vegas.
Follow this Link to the Questionnaire:
(Note: the link to the survey was inserted here but is now inactive.)
Or copy and paste the URL below into your Internet browser:
(Note: the link to the survey was inserted here but is now inactive.)

APPENDIX F

Science Identity and Underrepresented Minority STEM Organizations - In Person Questionnaire Recruitment Script

Good (morning/afternoon/evening),

I would like to thank ____________________ for letting me come in and speak with you today.

My name is Schetema Nealy, and I am a doctoral student in the chemistry department here at UNLV. I am working on my dissertation research and am looking for underrepresented minority students majoring in science, technology, engineering, and mathematics, also known as STEM, to complete a short questionnaire.

I am very interested in helping students like you succeed in their pursuit of a STEM degree. Underrepresented minority STEM organizations such as ______________________ (insert name of the organization whose meeting I am at), share my interest. One way for me to help students like you is to gain a better understanding of how underrepresented minority (URM) organizations affect the science identities of the student members that they serve. In other words, I'm trying to figure out how these organizations help or don't help you feel more like a scientist.

The questionnaire should take about 15 minutes. I'm not looking for right or wrong answers. I'm only interested in your personal experiences with the Multicultural Program and any of its partner student organizations and how they have affected your science identity. If you complete the questionnaire, you may be subsequently invited to participate in a face-to-face interview. If you would like to volunteer to be interviewed, please leave your name, email address, and telephone number on the questionnaire where it asks.

If you are interested in participating, please read and sign this consent form and bring it back to me. Once I have your signed consent form, I ask that you take a questionnaire from me and complete it. When you are done with your questionnaire, please hand it back to me.

As an incentive for your participation, you will be given the opportunity to be entered into a raffle for a $50.00 Amazon.com gift card. If you would like to be entered into the drawing for the $50.00 Amazon.com gift card, please fill out a raffle ticket, which I will hand to you when you hand in your completed questionnaire.

Thank you all for your time, and a special thank you to anyone who volunteers.

APPENDIX G

Science Identity and Underrepresented Minority STEM Organizations - Recruitment

Email for Student Participation in the Interview

SCIENCE IDENTITY AND STEM UNDERREPRESENTED MINORITY ORGANIZATIONS: Study Interview Email

Dear UNLV Student,
Greetings!

You are receiving this email because you are a member of the Multicultural Program, or one of its partner student organizations, and you consented to being contacted when you completed a questionnaire for this study. I am a doctoral student co-researcher, working with Principal Investigator Dr. MaryKay Orgill as an advisor, on a dissertation study regarding the impact that underrepresented minority organizations have on the science identity of underrepresented minority students majoring in science, technology, engineering, and mathematics (STEM). I would like to invite you to participate in an interview for this research study. Your participation would be in a face-to-face interview.

The interview portion of this study is designed to get more information about students' experiences with, and feelings about, the URM organizations of which they are members.

The interview will take approximately 1 hour.

Your participation is voluntary, you may choose not to respond to any question during the interview, and you may stop the interview and decline to participate in the study at any time. If you have any additional questions about this study, please feel free to contact me at nealys@unlv.nevada.edu (or Dr. Orgill at marykay.orgill@unlv.edu).

Your completion of the survey will help me to complete my dissertation and add to current research in the field of chemistry education. Thank you for your time and consideration of this invitation. If you are able to participate in an interview, please say so in a reply to this email so that we can set up a time.

Sincerely,
Schetema Nealy, PhD Student.
University of Nevada, Las Vegas.

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CURRICULUM VITAE

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EDUCATION

Ph.D. Chemistry Education, University of Nevada, Las Vegas — August 2018
M.S. Environmental Organic Chemistry, California Institute of Technology — June 2012
M.S. Chemistry (Analytical) California State University, Los Angeles — August 2008
B.S. Chemistry, University of California, Los Angeles — June 2004
A.S. Chemistry, San Bernardino Valley College — May 2001

RESEARCH EXPERIENCE

Graduate Research Assistant in K-12 STEM Outreach, UNLV — 2017-Present

Project management for the Student Interactions with STEM (SISTEM) project and the Work Force Development (WFD) Project. Responsibilities include event planning for the SISTEM event which exposes local high school students to various careers in STEM, supervision of undergraduate students, and data collection and analysis for future publications. The Center for Energy Research. University of Nevada, Las Vegas, NV.

Graduate Research Assistant in Chemistry Education, UNLV — 2012-2017

1. Discovering the best techniques for teaching middle and high school students the fundamentals of chemistry in such a way that they understand the complex chemical concepts and gain confidence in learning them.
2. Designing, developing, and delivering professional development workshops for K-12 STEM teachers for Nevada State GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) and the Tengchong PIRE (Partnerships in International Research and Education) Project.
3. Collecting and analyzing data to co-author a research article. Department of Chemistry. University of Nevada, Las Vegas, NV.

TEACHING EXPERIENCE

Guest Lecturer, University of Nevada, Las Vegas — October 2017

Taught on the topics of ionic and molecular compounds as well as bonding and properties of solids and liquids in an introductory chemistry course. Chemistry & Biochemistry Department.

Adjunct Faculty, Nevada State College — May 2015-August 2016

Taught Introduction to Chemistry for Non-majors. Provided materials (quizzes, homework, etc.) via a learning management system. (Webcampus/CANVAS). Physical & Life Sciences Department.

PRESENTATIONS

2. Nealy, S., & Orgill, M. (2018, March). Science Identity and Underrepresented Minority STEM Organizations Oral presentation at the 255th American Chemical Society National Meeting & Expo. New Orleans, LA.

1. Nealy, S., & Orgill, M. (2018, March). Science Identity and Underrepresented Minority STEM Organizations. Poster session presented at the Annual International National Association for Research in Science Teaching Conference. Atlanta, GA.