Male Students of Color in STEM through the Lens of Intersectionality: A Transformative Mixed-Methods Exploration of Their Science Identities, Relevant Science Learning Experiences, and Decisions to Pursue Science Professions

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MALE STUDENTS OF COLOR IN STEM THROUGH THE LENS OF INTERSECTIONALITY: A TRANSFORMATIVE MIXED-METHODS EXPLORATION OF THEIR SCIENCE IDENTITIES, RELEVANT SCIENCE LEARNING EXPERIENCES, AND DECISIONS TO PURSUE SCIENCE PROFESSIONS

by

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Major Professors: Malcolm B. Butler
Su Gao
ABSTRACT

The purpose of this 3-phase transformative mixed-methods study was to use intersectionality theoretical framework to explore the science identities and relevant science learning experiences of male students of color (MSOCs) in STEM and their decisions to pursue science professions after college. Phase 1 utilized a researcher-developed survey to analyze differences in science identity scores (SIS), science relevancy scores (SRS), and decisions to pursue science professions of 702 diverse college students enrolled in STEM-related courses at a state college in Southeast United States. While there were no statistically significant differences in SIS and SRS scores regarding race/ethnicity or socioeconomic factors, statistical differences in SRS were present regarding gender. Female students had higher SRS than male students. When considering gender and socioeconomic level, a statistically significant interaction occurred across racial/ethnicity groups in SIS and SRS. Black and Hispanic males had higher SIS and SRS when at least one parent had a bachelor’s degree. Phase 2 and 3 utilized interviews of five (MSOCs) from which these themes surfaced as largely shaping their decisions to pursue STEM fields: a) future-focus mindsets, b) connectedness to technology, engineering, and math, and c) science experiences and ideas. Students described the teacher’s personality, the classroom environment, and the foundational characteristics of science as being critical components of relevant formal science learning experiences. Implications regarding what social justice looks like in the science classroom include 1) the need to confirm SIS and SRS construct reliability from this survey instrument with a different population of diverse college students, 2) the important role science teachers and other educational stakeholders play in developing purposeful interactive instruction that adequately connects and prepares male learners for science
professions, and 3) the intentional integration of real-world technology, engineering, and mathematics processes and resources in science curriculum and professional development for teachers of science.
ACKNOWLEDGMENTS

I am first very thankful to God for all of His grace and help. The Lord has been my source of inspiration to get up every day, to read a little more, reflect a little deeper, and write a little longer to successfully get to the end in this process. I hope in some way this dissertation and work that will follow will be a glimpse of His love that others may need to see in the science classrooms and beyond.

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# LIST OF ABBREVIATIONS/NOMENCLATURE/ACRONYMS

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<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>APAN</td>
<td>Asian/Pacific and American Native</td>
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<td>CSC</td>
<td>Creek State College (pseudonym)</td>
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<td>EFA</td>
<td>Exploratory Factor Analysis</td>
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<td>English Language Learners</td>
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<td>ISLDS</td>
<td>Identification of Science Learning Development Survey</td>
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<td>Multivariate Analysis of variance</td>
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<td>Male Students of Color</td>
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<td>Science Relevancy Score</td>
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<tr>
<td>STEM</td>
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CHAPTER ONE: INTRODUCTION

All students are capable of developing science identities regardless of their identification with a specific race/ethnicity, gender, or socioeconomic status (Kim & Sinatra, 2018). However, for many students of color, there appear to be hindrances that inhibit their view of themselves as being a science person, and therefore, pursuing science as a profession. Several reasons exist for the significance of research that can better connect how the intersections of the varied identities of male students of color (MSOCs) relate to one another and can possibly predict future scientific pursuits of these learners.

Background of the Study

First, the social constructs of race/ethnicity, gender, and socioeconomic status often dictate how individuals should interact within society and the expectations for behaviors is hard-wired into the hegemonic systems that largely diminish or ignore the voices of people of color (Lyons et al., 2016; Windsong, 2018). To many MSOCs, success in science is equated with being a White male from a middle-class family background (Archer et al., 2015; Lyons et al., 2016; Fries-Britt, 2017). Often, the multiple intersections of their identities become conflated into an identity that does not mirror their reality leaving them to make a choice: relinquish their identity to that which aligns with the pervasive societal messaging or avoid persisting in science altogether to maintain the identity structure they have known and navigate (Carlone & Johnson, 2007; Crenshaw, 1991; Fries-Britt, 2017; Lyons et al., 2016; McGee, 2015; Strayhorn et al., 2013; Windsong, 2018). Identity-shaping factors such as culture, language, place of birth, and even religious belief can run counter to expectations of what is “normal” for these often-marginalized learners. Using intersectionality as the lens through which to explore MSOCs’
science identities presents a fresh and necessary perspective in science education research (Archer et al., 2015; Avraamidou, 2018; Le et al., 2019; Lyons et al., 2016; Kim & Sinatra, 2018) and one which aspires to reflect the uniquely distinct and complex identities of these students from their viewpoint, shaped not only by their race, gender, or socioeconomic status, but also from the entanglement of these identities as it pertains to positions of power, privilege, and context (Archer, et al., 2010; Harper, 2011; Lyons et al., 2016; Windsong, 2018).

Secondly, science education research needs to incorporate more intentional, rigorous, and accurate investigations and nuanced depictions of MSOCs in the sciences (McGee, 2015). The perspectives of ethnically diverse male learners are limited in U.S. educational research overall (Strayhorn et al., 2013), and, as a result, their identity development is largely left out of science education research as well, which in a way is an issue of inequity. These students are not the same; they have unique lived experiences and aspirations that are particular to who they are as individuals. Intersectionality advances the idea that these young men cannot and should not be gathered into one category or group.

Kimberlé Crenshaw’s (1991) explication of intersectionality has garnered notable and deserved recognition in various education arenas, as her keen observation of the absence of a Black female identity was either being subsumed in what it meant to be Black or what it meant to be a woman, the substance of what she labeled the “single axis analysis” (p. 139). However, for Black women, this left them no space for the uniqueness of their intersectionality to exist. This becomes a critique of existing literature on science identity research over the last 10 years as this field of intersectionality primarily focuses on female students. Understandably, STEM professions are overwhelmingly dominated by males. There needed to be a strong pendulum swing in a different direction to unearth the ways in which girls and women have been
overlooked, slighted, ignored, and hidden in science as publicly presented in the 2016 film *Hidden Figures* and the minimization of Rosalind Franklin’s substantial contribution to the discovery of DNA’s structure. This momentum for female students in science needs to continue, however, doing our due diligence in science education also means questioning what groups in the margins continue to be overlooked: in this case MSOCs. For example, the phrase *students of color and girls* (or females or women) subsumes other identities into one broad category, essentially running counter to Crenshaw’s (1991) criticism of single axis analysis framework (p. 139) and bypassing male students of color altogether. This type of phrasing that is common in science education research literature does to these male students what it aims to dismantle: systemic power dynamics toward marginalized learners.

This research study, therefore, not only answers the call presented by Kim and Sinatra (2018) and Avraamidou (2020) for science education researchers to use the lens of intersectionality in their examination of students’ science identity development, but it also challenges the existing science identity literature to critically reflect upon its mission to attend to the diverse voices represented by *all* the students in the science classroom. The individual and collective voices of MSOCs in STEM can challenge science education researchers, practitioners, and policy makers to reframe what social justice and equity looks like in science learning classrooms across contexts and grade levels.

If MSOCs are to pursue science professions, they need to know that there is an interest in making science and the development of their science identity accessible and relevant to them, which leads to a third and equally important need for this research relevance of science learning. Within this discussion of intersectionality and science identity is the relevancy of science learning (not to be confused with culturally relevant pedagogy and other related culturally
relevant education frameworks) to and for MSOCs, particularly Black and Hispanic male learners. Science learning that is embedded in traditional Western Modern Science (WMS) often lacks relevance to students that come from different cultural backgrounds (Jegede & Aikenhead, 1999; Lyons et al., 2016; Russell, 2014). "It is important that students have access to science ideas that are local and relevant if they are to appreciate how science impacts on their lives and to begin to conceive what science research identities might be available to them in the future." (Cowie et al., 2010; p. 362). Research draws a direct relationship between the relevance of science learning experiences to students and their interest and motivation in science learning so that the more relevant science instruction, lessons, curriculum is to students’ lived experiences, the more motivation they will have to continue in science (Iwuanyanwu, 2019; Kang et al., 2019; Russell, 2014; Strayhorn et al., 2013; Stuckey, 2013). Contrastingly, when science is presented in a way that does not emphasize the interconnection between science and students’ lives—for example, cooking healthy meals or playing video games—further marginalization can occur which may lead to negative views of science (Russell, 2014). Few science identity research mentions relevance of science learning (Carlone & Johnson, 2007; Kim & Sinatra, 2018; Strayhorn et al., 2013) and literature on relevance of science learning minimally addresses students’ science identities (Stuckey, 2013), yet there appears to be a stronger connection between these two constructs than is explicitly and thoroughly presented in the science education literature. While there is research detailing the importance of relevance in science learning experiences for MSOCs and other students of color (Bidwell, 2015; Price et al., 2013; Strayhorn et al., 2013) and characteristics of the relevance of science education (Kang, 2018; Stuckey, 2013; Williams & Williams, 2011), this research study hopes to quantitatively and qualitatively
draw a more direct relationship between aspects of MSOCs’ science identity development and the relevance of their formal science learning they have experienced throughout their lives.

_The Researcher’s Positionality: My Voice and My Identity_

Traditionally, quantitative research is written and presented from the third-person voice to provide a sense of objectivity, whereas many qualitative studies utilize first-person writing as a way to incorporate a more personal or meaningful dialogue between the author (or researcher) and the audience or participants. Mixed-method writings often utilize the objective third-person voice. However, as Zhou and Hall (2018) keenly note that even when objectivity and generalizability are the intentions, “one cannot escape from the personal dimensions of his or her thoughts, thoughts birthed from the brows of the countless before it, swayed by the incessant pull of new, personal, individualized experiences” (p. 346). In the effort to give voice to male students of color, whose societal placement often marginalizes their experiences and perspective, it seems fitting to demonstrate this first-person voicing throughout the description, explanation, and reasoning behind this necessary work. Nevertheless, centering these students’ voices is of utmost importance in the theoretical framing and research design of this study, so at times, I will use first-person to emphasize an interaction, idea, or process where my identity orients the study in a particular way. At other times, I will regress my voice to highlight nuances that are better presented and explained in the third-person. My expectation is that this interweaving of first- and third-person may in some way construct a metaphorical model and how, in the science classroom and learning contexts, it matters which narrative or vantage point is predominant and whose identities are being voiced.

Lastly, the issue of identity and how male students of color identify with science holds significance for me professionally, as a science teacher to black and brown middle and high
school boys and personally, as a sister to six Black brothers and as a mother of an elementary-aged Black boy. Both my brothers and students exhibited intelligence, curiosity, and creativity, and yet, many of them showed an inability or hesitancy to identify as capable science learners. Undoubtedly, there were other unknown or hidden factors that contributed toward the decisions these young men made regarding their participation in and an identity associated to school and the science classroom. It is these unknowns that should motivate science education researchers to utilize an intersectionality lens to reveal these hidden yet powerful obstacles preventing many male students of color from flourishing in science inside and outside the classroom. Therefore, supporting the multi-faceted identities of male students of color particularly in relation to their science identity that lies at the heart of this research study.

**Defining Key Terms**

Intersectionality – describes the idea and theoretical framework that acknowledges the existence of socially constructed identities such as race, gender, sexual orientation, and socioeconomic status (SES) and how these identities interact within systemic structures to either privilege or oppress groups of people depending upon certain identities (Harris & Leonardo, 2018)

Intersecting identities (or Intersection of Identities) – the point at which (or phenomenon that occurs when) two or more of an individual’s socially constructed identities cross or meet developing the formation of unique and different identity group that is distinct from any one of the single identities (Atewologun et al., 2016).

Lived experiences – a the recollective reflection on an experience or experiences one has already had or lived through (Sloan & Bowe, 2014); incorporates “life as people experience it in a certain context, a certain culture” (Østergaard et al., 2008).
**Gender** – operationalized as an attribute of individuals’ biological sex and their sexual orientation such that the self-identified “male” or “female” designation given at birth also corresponds to the established societal ideas of being male or female (It is noted that gender identity construct is fluid; the need for science education research regarding gender is necessary and is also a matter of equity, social justice, and inclusion.)

**Race / Ethnicity** – socially-developed constructs that are largely based upon physical appearances and features that hierarchically categorize individuals based upon their geographic region of origin, language, and other cultural components

**Black vs. African American** – typically refers to individuals who simultaneously have ancestors who originated from Africa, are citizens of the United States by birth, and who society has identified as such based upon their physical features, culture, and history; Except when appearing in cited or quoted descriptions or participant responses, the term “Black” will be used as an operationalization of those who identify as being a member of this racial group

**Hispanic** – references individuals that ancestry or origins from predominantly Spanish-speaking countries, and unless specifically addressed differently by a direct quote or excerpt, will include Latino/a/x

**Science Identity** – a construct that represents how individuals view themselves or are viewed by others to be a “science person” or a “scientist” and the degree to which they feel they belong in science and science learning environments.

**Science Identity Development**- the ongoing production, construction, or shaping of a person’s science identity that takes place over time, across contexts, through varied experiences and formative social interactions
Science Relevancy – a construct that represents how individuals perceive the meaningfulness of the various characteristics and features of their science learning in a classroom/instructional setting (also referred to as relevance of science learning)
Purpose Statement

The purpose of this 3-phase transformative mixed-methods study was to use intersectionality theoretical framework to explore the science identities and relevant science learning experiences of male students of color in STEM and their decisions to pursue science professions after college. The development of male students of color’ science identities does not occur in a vacuum; the shaping of how they view science, how they view themselves in relation to science, and how they view the relevance of their science learning occurs as and in relationship with the intersections of their socially constructed identities such as race/ethnicity, gender, and socioeconomic status. The intermingling of these factors, without properly framing the hegemonic context within which these constructs communicate, can continue to lead to bright capable male students of color who choose to avoid science in the classroom and professionally as well. Intersectionality theory provides a unique platform that calls out inequities associated with the conflation of MSOCs’ place in a society that often diminish their status and voice.

Given the context and background of this problem, this study aims to:

- utilize a transformative mixed-methods approach to data collection that is currently not commonly used in science identity research,
- contribute a valid survey instrument that can accurately analyze the relationships among college students’ science identity development, the relevancy of their science learning experiences, and their plans to pursue science professions across intersecting identities, and
- empower male college students of color to shed light upon the role of relevant science learning for these students.
Research Questions

In an effort to contribute necessary and meaningful insight regarding an underrepresented group of students whose voice and presence is often silenced in science classrooms, I explored these three research questions:

1. In what ways, if any, do the science identities, relevant science learning experiences, and decisions to pursue science professions of male college students of color differ from other college students with different intersecting identities?
   a. What is the relationship between students’ science identities and their relevant science learning experiences, and in what ways do these constructs differ across intersecting identities such as race/ethnicity, gender, and socioeconomic status?
   b. Do college students’ science identities and relevant science learning experiences predict their decisions to pursue science professions after college? If so, are there differences when considering intersecting identities such as race/ethnicity, gender, and socioeconomic status?

2. How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?

3. How do male students of color describe the relevancy of their formal science learning to their lived experiences?
CHAPTER TWO: REVIEW OF THE LITERATURE

This chapter elaborates on the experiences and challenges that male students of color face within science learning contexts to elicit an understanding of the role intersectionality plays on their science identity development. Additionally, this literature will also clarify the bridging that appears to exist between the development of these students’ science identities and the relevance of their science learning experiences throughout their schooling, and the potential these two constructs have in the decision male college students of color make to pursue science professions. However, the national context from which these conversations surrounding the connectedness among intersectionality, science identity, and science relevancy emanate needs to addressed first, as what takes place in the classroom is often a microcosm of a macro-systemic structure.

*The State of Underrepresented Male Ethnic Minorities in STEM*

The shortage of students, particularly non-White students, entering STEM related professions after postsecondary education has led science education researchers and science educators to begin wondering whether there is a disconnect between science and students’ learning science in the classroom (Garner et al., 2018; Jegede & Aikenhead, 1999; Mau, 2016; NGSS Lead States, 2013; Lyons et al., 2016; Russell, 2014). This global phenomenon has led science education researchers to increasingly explore the construct of science identity throughout various regions around the world (Archer et al., 2013; Archer et al., 2015; Avraamidou, 2019; Keir & Lee, 2017; Naidoo, 2017; von Solms & Nel, 2017). While the U.S. science classrooms from primary through postsecondary are becoming increasingly more racially and ethnically diverse (Lyons et al., 2016), the shortage of students of color studying STEM in college and
entering these fields professionally still considerably trail that of White students (Byars-Winston et al., 2016; Mau, 2016). Despite the number of programs, foundations, scholarships, and grants aimed at reaching racially and ethnically minoritized groups, Black males, for example, have scarcely increased their presence in science and engineering professions since 2002, trailing behind Hispanic male students (Bidwell, 2015; Byars-Winston et al., 2016; Collins, 2018; Fries-Britt, 2017; O’Brien, Bart, & Garcia, 2020; Strayhorn et al., 2013).

According to the 2019 National Science Foundation (NSF) report “Women, Minorities, and Persons with Disabilities in Science and Education”, Black, Hispanic, and American Natives (including Alaskan Natives) have received science and engineering (S&E) bachelor’s degrees (include science, engineering, health, and other S&E technologies that prepare students for jobs requiring certain technical skills), at a much slower rate than their Asian counterparts when considering their overall population in the U. S. To put this into perspective, when considering U.S. citizens 18-64 years of age in 2017, 14% of the population were Hispanic, 12% were Black, and 5% were Asian. Despite making up 30% of the labor force and 27% of the population, Hispanic and Black individuals received 11% of the doctorates in science and engineering, whereas 31% of the doctorates were awarded to Asian individuals (National Science Foundation (NSF), 2019; O’Brien et al., 2020). Additionally, while there has been an increase in S&E bachelor’s degrees between 1996-2016 for all underrepresented minority groups, there were fewer men receiving these degrees in each of these ethnic groups than women. This presents a gap between gender as one moves from bachelor’s to doctorate level. Interestingly, more Black, Hispanic, and American Native men are receiving engineering degrees than women in these same ethnic groups, but overall, more women are pursuing science and health fields (NSF, 2019; O’Brien et al., 2020).
The Trends in International Mathematics and Science Study (TIMSS) is an international assessment of math and science achievement administered every four years to fourth and eighth grade students since 1995. The TIMSS 2019 U.S. Results support these NSF data with regard the race/ethnicity and gender results (U.S. Department of Education, 2019). While the gender difference in science and mathematics is decreasing and not statistically significant in both science and mathematics, differences in racial groups tells a different statistical story. When considering U.S. racial and ethnic groups’ average scores on the science assessment of eighth-grade students, Black, Hispanic, and American Native students scored significantly lower than White and Asian students, with Black students scoring the lowest by more than 50 points. Similar trends exist in mathematics. For both science and mathematics, these three underrepresented populations were considerably lower than the U.S. average by approximately 30 to 70 points. These same group trends track from the fourth-grade 2019 results, except the difference between Black, Hispanic, and American Native students and White and Asian students is smaller (U.S. Department of Education, 2019). To put this into context, the difference between these racial/ethnic groups significantly increase as children move from elementary to middle or secondary school. As this trend persists through high school and postsecondary institutions, which has been widely supported and observed, fewer individuals from these three populations will enroll in STEM undergraduate and graduate programs and be noticeably less present in STEM careers (Park et al., 2020).

Emphasis on these figures is not intended to disparage or negate the accomplishments or status of any member of these ethnic groups or genders. Unfortunately, history recounts the intentional ways those in power have pitted one marginalized group without socioeconomic power against another to sustain the agenda and status of the ones making the rules (Gay, 2015).
Nevertheless, these statistics do cause one to wonder about what lies at the source of these trends. These trends often find themselves active in the science classrooms, where “there is an understanding and knowledge of embedded social constructs that exist and are built upon unequal hierarchies in which a social group’s access to power and privilege are hindered” (McCurdy, Cruz-Deiter, & Butler, in-press). For example, in one study tracking 71,405 college STEM majors from seven public universities in the U.S. between the years 2008-2013, considerably more Asian and White students declared a STEM major and completed a STEM degree than Black, Hispanic, or American Native students (Mau, 2016). Mau offers that recruiting ethnically underrepresented students should take place while they are in high school, specifically by helping teachers develop and practice culturally sensitive curricula and communication and thereby positively fostering their science and math identities. Once these students do begin to pursue STEM majors in college, support programs and groups need to be in place to alleviate potential obstacles toward successfully graduating and entering into their selected STEM careers (Mau, 2016).

In another study, O’Brien, Bart, and Garcia (2020) shed light upon why there are fewer Black and Hispanic students deciding to pursue careers in ecology and evolutionary biology. Even though this study does not differentiate between gender, they did mention that there are more underrepresented women receiving doctoral degrees and tenure status in ecology and evolutionary biology than men. Their survey was administered to 1906 students in STEM ranging from ages 18-26. The instrument assessed various measures including ecology and environmental knowledge, interaction with role models, religiosity, outdoor comfort level, communal aspirations, educational plans, and the sense of belonging. Key findings included that Black and Latino students expressed more of an interest in graduate level work in evolutionary
biology than White and Asian students; however, for all groups, the sense of belonging in these biological graduate programs was a strong predictor of their interest in graduate studies. The cultural mismatch between underrepresented students and the community of these university programs may be attributed as key factor in the sense of belonging (O’Brien et al., 2020).

Science education for students in undergraduate science majors is pervasive with a culture composed of values, norms, and meritocracy that best aligns with those of White masculinity. Competitive "weed-out" courses and unapproachable faculty are examples of this White dominant culture (Seymour & Hewitt, 1997). This research highlighted the challenge students of color and women experienced in their attempts to thrive in these types of learning spaces than their White male counterparts.

Fries-Britt’s study (2017) examined the challenges Black male collegians experience at predominantly White learning institutions. Interviews collected from more than 200 high achieving Black male undergraduates and graduates in STEM students report the lack of response White faculty gave to their questions when compared to their White peers, the encouragement to leave their major or enroll in less challenging classes despite their success in the program, and less opportunities to engage in research teams. Inherent in these particular students is the confidence to persist amidst differences and power dynamics in a context that frequently questions their identity in these competitive science fields. Their encouragement to “stay focused on the science and push through” (p. 16) from minority science faculty signifies a pervasive consistent racially detrimental narrative that a Black male’s science identity should be prioritized over any other identity they claim as their own (Fries-Britt, 2017). Fries-Britt’s concludes by stating, “Nowhere is [understanding of the complexity and saliency of multiple identities] more important than in the study of Black males where images are typically one
dimensional and negative” (p. 17). Clearly the examination of Black male college students’ intersecting identities in science contexts is an area that is wide-open and critically needed.

This idea of STEM persistence is not limited solely to Black students. Park, Kim, Salazar, and Hayes’s (2020) study of 562 STEM college students found that Black, Latinx, and Asian American students, both male and female, reported having feelings of discomfort or negativity based upon their race or ethnicity during interactions with their STEM professors and faculty. While Black students had grown accustomed to these discriminatory encounters, the Latinx students experienced the strongest negative effect from these faculty interactions regarding retention in the program (Park et al., 2020). These studies like these demonstrably support the gravity of STEM instructor’s power and influence over the longevity of students of color in college STEM programs and future careers.

These studies point out that while race/ethnicity social markers appear to be at the core of the discussion of students of color in STEM, these are not the only social identities that need to be a part of this conversation. When other socially constructed identities, such as gender, socioeconomic status, citizenship, and others are accounted for, new dynamics in regard to power, control, oppression, and hegemonic practices within science learning environments surface. And while the interactions among these identities have always been in existence and at play in established societal spheres, they have either been ignored or deemed insignificant factors in science learning. The findings from these international and national reports and studies are reminders that continuing to ignore these intersecting identities and how they uniquely operate in the lives of MSOCs will be detrimental to how these students view their intellectual capability in science and other STEM fields and hinder the degree to which their diverse and innovative skills benefit society and the world. Examining how these identities interact within the highly
structured hierarchy within groups and systems leads us to utilize a framework and two constructs that specifically tackles these issues, namely intersectionality, science identity, and science relevancy, respectively.

**Intersectionality as a Theoretical Framework**

Intersectionality framework establishes the context by which individuals navigate through society, as their intersecting identities are not formed independently from one another (Lyons et al., 2016; Windsong, 2018). Whether we are aware of it or not, these identities explicate our “everyday experiences of self-identification” (Atewologun et al., 2016, p. 223). Instead they are in constant dialogue with each other, shaping one another, interacting with one another essentially developing a unique identity (Lyons, et al., 2016; Windsong, 2018).

However, inherent in intersectionality studies is the emphasis on the power dynamic that takes place between the decisions that these students make and the identity and role the surrounding society places upon them. In many cases, MSOCs anticipate a science learning environment that is neutral and simply about the science (Lyons et al., 2016). What inevitably welcomes MSOCs in many predominantly White middle-class science learning spaces is a classroom culture that has also been influenced by politics, sociocultural expectations, discriminatory histories, economics, and power (Lyons et al., 2016). By accurately understanding the underlying forces that seem to attempt to prohibit MSOCs’ access to relevant science learning, hope exists that they will be more inclined to approach science in the hopes of pursuing professions in science fields.

Intersectionality examines the oppressions placed upon others because of the intersections of individuals’ socially constructed identities including, but not limited to, gender, race, ethnicity, sexual orientation, religion, socioeconomic status, and political affiliation (Harris
Intersectionality refers to the simultaneous experience of social categories such as race, gender, socioeconomic status, and sexual orientation and the ways in which these categories interact to create systems of oppression, domination, and discrimination (Harris & Leonardo, 2018; National Association of School Psychologists, 2017). Highlighting individuals’ intersectionality affirms the idea that we all have multiple sociocultural spheres in which we operate, and that no one sphere, or identity, can accurately depict all of the ways in which one comes to know who they are. However, it is at the intersections or vectors (Nichols & Stahl, 2019) of these identities that characterize how we move, operate, and interact with each other and the world. (Harper, 2011; Nichols & Stahl, 2019). Characterizing individuals according to one of these identities, the single axis analysis, to appease the social or cultural norms of those in power limits the true formation of their personhood.

The Origins and Evolution of Intersectionality

A surface-level search of intersectionality can lead one to believe that Kimberlé Crenshaw, a Black female law professor and lawyer, developed this framework and idea in the late 20th century as her publications “Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics” (1989) and “Mapping the Margins: Intersectionality, Identity Politics, and Violence Against Women of Color” (1991) are well-known writings in the field of law and academia (Cole, 2009; Harris & Leonardo, 2018). While these articles were products of her legal activism for women of color caught between the web of racism, sexism, and classism, and are writings scholars and researchers typically reference or cite in discussions of intersectionality, this idea of intersecting identities has deeper roots that necessitate chronicling. Before Crenshaw’s coinage of the term,
intersectionality was expressed and described by other women of color and marginalized people in the United States.

In the 1977 Combahee River Collective entitled “A Black Feminist Statement” (Taylor, 2017), a group of Black feminists highlighted their task as “struggling against racial, sexual, heterosexual, and class oppression, and see as our particular task the development of integrated analysis and practice based upon the fact that major systems of oppression are interlocking” (p. 15). In their statement, they clearly acknowledge and explicate the ideas of intersectionality without the use of this exact term. But it is clear that the existence of various ways that discriminatory and marginalizing practices and beliefs are aimed at them because of their gender and race in light of dynamics of societal, cultural, patriarchal, and political systems (Cole, 2009; Harris & Leonardo, 2018; Taylor, 2017).

Cole (2009) and Collins (2017) list several other examples of earlier descriptions of intersectionality in the mid-late 19th century by Black female activist Anna Julia Cooper, a writer and intellectual who demonstrably analyzed the unique way that intersections of social inequalities provided power to some and released oppression upon others through the efforts of colonialism and imperialism (Bailey et al., 2019). Ida B. Wells, another Black female writer/journalist, activist, and contemporary of Cooper, drew attention to the ways in which racism and sexism became intertwined in the excuses given for the national permittance of the lynching of Black men as a way to protect White womanhood (Bailey et al., 2019; Collins, 2017; Wells, 1909). Though Cooper, Wells, and other prominent Black women centered Black women, their efforts towards the undoing of inequities branched outward, “where they entered into coalitions with Black men, White women, middle-class African Americans, and other political actors who could help solve the problems that concerned them” (Collins, 2017, p. 33).
Intersectionality became more embodied in the 1960s and 70s with the rise of Black feminism, women’s liberation movements, student movements and protests, and the growth of Black and non-White studies departments and programs on college campuses (Harris & Leonardo, 2018). Intersectionality as a concept encountered a type of tug-of-war between the professional academics determined to make it their own and these marginalized grassroots intellectuals of color transform to academia’s established ways of theorizing (Harris & Leonardo, 2018). With the coining of the term, giving credit to Kimberlé Crenshaw was a way to legitimize the idea with both academics and those truly engaged in the work of social justice concerning intersections of race, class, and gender (Harris & Leonardo, 2018).

In this 21st century, intersectionality has taken on a more robust purpose as that of a critical social disruption. For scholar-activists, intersectionality operates as a tool to develop a better understanding of the complex, multifaceted nature of social structures and formation (Bailey et al., 2019; Harris & Leonardo, 2018). Movements and initiatives like Black Lives Matter, critical theories LatCrit (Latinx), Dis/Crit (disability), and others span both societal and legal contexts (Collins, 2017; Harris & Leonardo, 2018). These highlight the need to be mindfully aware of the ways oppression interpenetrates established systems, to keep the “unthinking intellectual ‘essentialism’ ” (Harris & Leonardo, 2018, p. 5) of the past in the past, and to continually remember that the struggle for social justice is endless as there will always be that group or experience that is marginalized and deemed voiceless (Harris & Leonardo, 2018).

Connection to Culture

These sociocultural norms or expectations only make sense if individuals are themselves encultured. “Culture can be thought of as a dynamic response of people as they try to make sense
of their position in society in relation to others” (Lyons, 2016, p. 943). It is an ongoing iterative process in which the individual is shaping this cultural environment and being shaped by it at the same time (Lyons, 2016; Smith, 1999; Wood, Erichsen, & Anicha, 2013). Just as the human brain interacts with the internal organs and systems of the body, it is also responding to and interacting with the external environment as well. Just like the brain, culture adjusts its messaging and wiring as needed to maintain the survival of itself (Lyons et al., 2016).

Ideally, culture allows for individuals within it to dialogue and debate from their diverse perspectives all the while developing consensus regarding which cultural tools will help the collective group navigate transitions and shifts in the construction of their unending meaning-making processes (Wood et al., 2013). Culture’s currency is communication. The ways it intentionally or unintentionally transmits information about what it is, how it works, what it looks like, and who is (or is not) part of the culture are keys to its success and sustainability (Parson & Carlone, 2013). Both the explicit and covert symbolic expressions and tools, such as language, are necessary for social understanding to occur and shape our worldview (Hammond, 2015; Parson & Carlone, 2013; Wood et al., 2013). So there needs to be a mutual agreement of sorts among individuals within a culture and between cultures in order for accurate and effective communication and understanding to occur (Wood et al., 2013).

This model of a culture, or culture in general, however is much more complex and complicated when it is lived out and in action. Particular challenges arise when considering the fact that one person can function and move about in more than one culture and inhabit more than one lens from which to view the world (Crenshaw, 1991). Further obstacles exist when one’s membership in one culture—its values, beliefs, communicative and symbolic tools and sensemaking—runs counter to their membership in another culture. Whether this conflict is
external or internal, certain decisions need to be made in order for this person to define and act out what it means to successfully navigate their membership in both cultural communities. Herein lies the core of intersectionality—intersecting identities.

Intersectionality framework exposes the discomfort of dichotomies that many marginalized people live with continually, especially women and people of color in the United States. There was an assumption that the way and culture of those in power would subsume (or should) those without power, influence, or protection to sustain and maintain the control of those in power. Isabel Wilkerson (2020) addresses this idea though likening this sociocultural phenomenon to a caste system:

Those in the dominant caste who found themselves lagging behind those seen as inherently inferior potentially faced an epic existential crisis. To stand on the same rung as those perceived to be of a lower caste is seen as lowering one’s status. In the zero-sum stakes of a caste system upheld by perceived scarcity, if a lower-caste person goes up a rung, an upper-caste person comes down. The elevation of others amounts to a demotion of oneself, thus equality feels like a demotion (p. 183).

Intersectionality emphasizes the power dynamic that occurs between the individuals' decisions and what they deem as being acceptable for them based upon the hegemonic, socially conveyed hierarchy that communicated that group's othering in the first place. The long-lasting effect of one’s cultural identity imprints itself into our brains, ideas, and our knowledge base, preventing us from clearly seeing what is apparent to others (Hammond, 2015).

Wilkerson (2020) continues,

When people have lived with assumptions long enough, passed down through generations as incontrovertible fact, they are accepted as truths of physics, no longer needing even to
be spoken. They are as true and as unremarkable as water flowing through rivers or the air we breathe (p. 184).

However, what was and is often not considered is that everyone in one social group does not act, think, behave, etc. like everyone else in that group (Lyons et al., 2015; Parsons & Carlone, 2013; Smith, 1999). Although intersectionality echoes this idea, it is necessary to also consider the expectations placed upon this framework that it may not be able to fulfill.

Three Approaches in Intersectionality Research

An aspect of intersectionality that forms the development of this study’s methodology is the understanding of Leslie McCall’s (2005) Three Approaches. As mentioned, identity formation is socially bound. With this is the knowledge that one’s socially constructed identity loses its meaning without other members characterized by other identities present (McCall, 2005; Windsong, 2018). If one’s intersectionality is explored, it can be greatly beneficial to examine the intersecting identities of others as well who share the same space or arena of life. This approach is referred to as an inter-categorical approach. The most prominent and initial approach, intra-categorical approaches, only focuses on one social group as a way to highlight specific intersections (Atewologun et al., 2016). Lastly, the anti-categorical approaches attempt to deconstruct analytical groupings altogether (Windsong, 2018). As I further describe in the methodology section, I used the inter-categorical approach as the premise behind Phase 1 of this study. The data collected provides a basis upon which to use an intra-categorical approach for Phases 2 and 3 of the study.
Limitations of Intersectionality as a Theorizing Mechanism and a Research Tool

Like other theoretical ideas, frameworks, and research approaches, intersectionality has its limitations (Bailey et al., 2019; Cole, 2009; Collins, 2018; Harris & Leonardo, 2018). One of these is the use of intersectionality as a linguistic symbol and metaphor (Harris & Leonardo, 2018). Criticisms of intersectionality abound within sociology, psychology, and public health fields, primarily opposing Crenshaw’s visual image of traffic and the flow of cars at roadway intersections.

Consider an analogy to traffic in an intersection, coming and going in all four directions. Discrimination, like traffic through an intersection, may flow in one direction, and it may flow in another. If an accident happens in an intersection, it can be caused by cars traveling from any number of directions and, sometimes, from all of them (Crenshaw, 1989, p. 150).

To critics, this intersection imagery is merely two dimensional, lacking the multiple levels in which these intersections operate, such as at the individual, interpersonal, structural, and institutional scale (Harris & Leonardo, 2018). There is also a sense that the types of identities run parallel to one another, therefore are indistinct from one another. For example, how, in which ways, or to what degree is one’s identity made to be subordinate that is altogether distinct from their race or class? Lastly, the metaphor implies a fixed and unchanging condition (Harris & Leonardo, 2018).

Aside from the visual metaphor, others caution against the use of intersectionality as a theory, in the scientific sense of the term. Essentially, intersectionality “cannot generate testable predictions about the world and therefore can only supplement rather than replace empirical methods” (Harris & Leonardo, 2018, p. 7). Because of its failing by this criterion, it is more
readily used as a theoretical framework or a paradigm, particularly in public health to encompass its utilization more fully in this field (Bowleg, 2012).

Connected to its deficiency as a scientific theory and its metaphorical use, intersectionality lacks an explanatory account of power (Harris & Leonardo, 2018). While intersectionality emphasizes the use of power to subordinate groups based upon the interactions of their identities, it does not specifically address and identify at what point in these intersections the power-subordination dynamic is at play, or how/why one identity within an intersection is operating differently from another (Cole, 2009; Harris & Leonardo, 2018). Power in and of itself is a multilayered and complex assemblage of individual, structural, and cultural factors, each containing some characteristic of power (Bailey et al., 2012; Collins, 2017; Harris & Leonardo, 2018). “Power accrues to and is exercised by individuals, but those individuals are located within structures that serve as silent negotiators in political action” (Collins, 2017, p. 35). Without a complete and explicit operational theory of how power works and is developed, some fear intersectionality may become ineffective and misused like the term diversity, eschewing the very structures, processes, and institutions that formed and benefit from the subordination of marginalized groups (Harris & Leonardo, 2018). Gee’s (2000) four ways to view identity and the identification of power and its sources and Collins’ (2012) phrasings matrix of domination and her domains of power (2018) are helpful ways to support intersectionality’s weakness in this area.

Intersectionality also tends to be misunderstood as a theoretical approach to the detriment of its intended purpose. Of McCall (2005)’s approaches of intersectionality, the use of the anti-categorical approach causes intersectionality scholars to pause at its use in theorizing and in the practice of research (McCall, 2005; Harris & Leonardo, 2018). This approach’s intended
function is to “challenge assumptions about groupings and classifications that reify and reproduce inequalities. Thus, this approach prioritizes fluidity over stability of categories although it makes analysis practically challenging” (Atewologun & Mahalingam, 2018, p. 152). Nichols and Stahl (2019) note that certain feminist theorists utilize the anti-categorical approach to challenge categorization and fixed identity groupings. Another idea is that because these categories are socially constructed, they are not valid or real (Bailey et al., 2019). However, Harris and Leonardo (2018) and Bailey et al. (2019) refute this argument. They and others claim that holding rigidly to the anti-categorical approach can work to undermine research that use the intra- and inter-categorical approaches, as these latter two are dependent upon the categories to address the power-subordination tension at the center of intersectionality. When considering the cause and activism of the Black female originators of intersectional thinking, Bailey and colleagues (2019) put it this way:

…this approach flies in the face of the basic premise underlying Black women and women of color feminists’ insight that intersectionality is not a tool to reinforce simplistic socially constructed categories. Instead, it is a method to expose social and political processes of subordination in order to form a basis for developing justice-seeking group (p. 5).

Much intersectionality research is conducted through quantitative methods. Problematic data collection related to this limitation include how to collect appropriate quantitative data to best analyze multiple groups and identities along multiple axes with the intent of accurately measuring both the individual and the interactive effects (Bailey et al., 2019). At some point, statistical analysis, in order to explore and examine these differences and interactions, needs to fall back upon predetermined group categories of race, sex, gender, etc. This poses a problem, in
that researchers can both lose the ability to detect how the dominating systems that interact as well as fail to recognize the synthetic experiences caused by socially constructed markers. Additionally, the use of a norming group, usually that of the dominant group, can become the standard against which to compare the data from more marginalized groups, which may also discount the social justice aim of intersectional research (Bailey et al., 2019).

Regardless of these limitations, intersectionality as a theoretical framework retains the ability for researchers, scholars, and activists to reexamine the status quo between established ways of perceiving interactions among and between individuals and entities with multiple identities and interactions (Cole, 2009; Collins, 2012; Harris & Leonardo, 2018). This framework enables one to reimagine how relationships of power and subordination would look if the marginalized and their experiences were centered instead of being ignored. Throughout the literature of these and other intersectional scholars is the sense that there will be no one ideal way to use intersectionality as a theoretical framework, a metaphor, or as a data collection method, because the complexity of people’s experiences are simultaneously unique and common in varying degrees and ways (Bailey et al., 2018; Cole, 2009; Collins, 2012; Harris & Leonardo, 2018). The danger lies in refusing to question, critique, and explore, thereby “compromising one of intersectionality’s key political objectives—reinvigorating collective political action that promotes the perspectives and needs of the most subordinated” (Bailey et al., 2019, p. 5).

The implications for studying identity formation through the lens of intersectionality are clear, particularly when one considers the effect deleterious interactions with people and positions of power in various contexts and communities may have upon marginalized individuals (Lyons, 2016). Nowhere is there a better place to assess these effects than in the field of science, specifically science classrooms and learning environments. If every facet of students’ lives and
culture can potentially affect other areas, then the relationship between students’ intersecting identities, their participation (or lack of) in science, and their identification with science needs to take on a more prominent place in educational research, especially as it pertains to students of color (Archer et al., 2016; Lyons, 2016).

Gaps in the Literature

Given the important historical roots and recent evolution of intersectionality, there are still gaps in the research literature that need to be addressed to further the discussion of equity and social justice. Pertinent to my study is the realm of education and the students who are often marginalized by educational structures, policies, and practices. My use of intersectionality as a theoretical framework, therefore, aims to contribute to the existing literature by centering male students of color, utilizing culture as an intersecting identity, and integrating intersectionality research approaches.

Centering Male Students of Color

As the significant history of intersectionality demonstrates, this idea and its outworking was developed by and largely centered women of color, specifically Black women. It has only recently transformed its focus to a broader group of individuals marginalized by other racial/ethnic identities, gender, sexual orientation, ableism, etc. My use of intersectionality framework as a lens to explore male students of color and their science learning provides a unique way of centering males of racially/ethnically marginalized individuals. To some, centering males and their experiences, runs counter to the traditional use and purpose of intersectionality; however, if the intent of this framework is to expose areas of power and
oppression among members of groups, populations, or contexts, then limiting its use to only one group of people limits the strength that this idea can have (Harris & Patton, 2019).

*Culture as an Identity*

As discussed, the purpose of intersectionality is to prevent the conflation of our individual socially constructed identities into one entity. This makes it possible then for the way in which one identity (e.g., sex) works in or is affected by society is distinctly different from the way in which another identity (e.g., race) works in or is affected by society. By doing this, the multiplicative effect of these two intersecting identities becomes more pronounced and explicit. However, this concept becomes less clear when one’s culture becomes entangled within these intersecting identities. Earlier, I described how our culture shapes how we communicate with one another, make meaning from symbolic expressions, and interact with members from other cultures given our culturally-embedded worldview. The ways our culture shapes us are nearly impossible to dissect and categorize into individual intersecting identities yet should notably be included into the discussion and research of intersectionality. “Science education research needs to address questions of how a person forms their identities and how these cultural identities relate to their learning of science” (Lyons, 2016, p. 948). Put another way by Parsons and Carlone (2013), culture has an explanatory potential for the injustice and inequity tied up with science and science education’s history and for science education’s potential to use its power for the good of the people and the environment, and to challenge inequitable social structures. Science education, with cultural lenses, can be used as a tool for counter-hegemony (p. 10).

In this study, the role culture plays was clear, and therefore, my study aims to contribute insight regarding how culture can be, in and of itself, and intersecting identity.
**Integrating Categorical Approaches**

The use of McCall’s (2005) approaches in intersectionality research has been helpful for operationalizing intersectionality as a theoretical framework in studies spanning psychology and education. While there is debate regarding which approach provides the greatest insight upon power structures and oppressive systems within societal contexts (Harris & Leonardo, 2018; Nichols & Stahl, 2019), few have utilized data collected more than one of these three approaches within science education. By integrating both the inter-categorical and intra-categorical approaches in the research design, my dissertation study provides robust support for the use of intersectionality theoretical framework in a more innovative and nuanced way. These integrated approaches can better reflect the dynamics of diversity that is found within today’s science learning classroom environments.

**Science Identity**

Carlone and Johnson’s (2007) seminal research on the science identity of successful women of color provides the foundation for much science identity research. Their model—incorporates one’s recognition as a science person, competence to know and understand science content, and their social performance of relevant science tasks and skills serve—as a springboard from which other science education research in this field can address other issues bound up with identity and underrepresented groups in science. Focusing research on science identity contributes to the conditions of science teaching and learning environments by addressing which students are being promoted or marginalized by science learning expectations, how and whether students view/perceive the experiences, skills, knowledge, and values as being worthy or relevant, and whether (and in what ways) students' developing science identities change as they gain further insight into who they are and who they want to become (Carlone & Johnson, 2007).
A student’s science identity often describes how students: 1) view themselves as being scientists or science-minded, 2) view themselves as being capable of understanding science concepts, and 3) feel represented in their science learning. Identity studies in the science classrooms typically seek to uncover how and why students view themselves as thinking and being like “scientists” or thinking they are not good/smart in science to develop ways to better students, their education, and their future outlook as well (Archer, et al., 2010; Carlone, 2007; Carlone, Scott, & Lowder, 2014; Hazari, Sadler, & Sonnert, 2013; Le et al., 2019). Essentially, “identity is a multicomponent construct through which people internalize experiences, their context, see themselves as members of social groups, and intersect with their personal characteristic (e.g., gender and race)” (Vincent-Ruz & Schuun, 2018). All students are capable of developing science identities in such a way that they are approaching science instead of avoiding it to use the terms by Kim and Sinatra (2018). These terms, approaching and avoiding characterize the nature of science identity development to be one that is fluid, can change, and be influenced by experiences, perspectives, sociocultural/sociopolitical values, and beliefs (Atewologun et al., 2016; Kim & Sinatra, 2018).

Precollegiate Science Identity Research

Much science identity research focuses on understanding obstacles and motivators in shaping the science identity of underrepresented elementary, middle, and high school students. (Archer, et al., 2010; Archer et al., 2015; Carlone et al., 2014; Carlone et al., 2014; Rascoe & Atwater, 2005). These studies offer instrumental information on the characteristics of school science classroom culture, student-student interactions, and student-science teacher interactions as their ethnographic qualitative approaches are based upon extensive interviews and classroom
observations. The figured worlds and identity work frameworks have been used to explain the positioning of ethnically-diverse students in science classrooms amongst their peers (Archer et al., 2010; Price & McNeill, 2013) responding to the classroom culture which is highly influenced by the science teacher’s leadership and example (Carlone et al., 2014). Other frameworks of science identity research in classrooms focused specifically on Black students in their middle, senior high school, and college years (Archer et al., 2015; Rascoe & Atwater, 2005; Russell & Atwater, 2005). These present meaningfully rich contexts for further research in the study of students’ identities while also unveiling a glimpse into the way students’ science identity develops over time, in different contexts, and in various life stages. If much of students’ science identity development occurs within the formal science precollegiate classrooms—how students are introduced to science, how they participate in science practices, and how their understanding of science is assessed—then these learning spaces need to embody an instructional environment that values students’ diverse perspectives, experiences, backgrounds, and ways in which they relate to the world and the meaning-making tools they already have (Kim & Sinatra, 2018).

In “Becoming (Less) Scientific: A Longitudinal Study of Students’ Identity Work from Elementary to Middle School Science”, Carlone, Scott, & Lowder (2014) present insight from a longitudinal ethnographic study of a group of fourth through sixth-grade male and female students of diverse ethnicities and sociocultural backgrounds. The authors’ purpose, “probe more deeply into the cultural (implicit) meanings of science in their [students’] school science experiences” (p. 837), sheds light upon how culturally and ethnically diverse students enter the school science classroom with various prior science interests and experiences and “are capable of and interested in performing themselves scientifically when given robust opportunities to do so” (p. 858). It is the presence or absence of these opportunities that hold great significance for
students of color in the science classrooms. “High-achieving ethnic minorities, and especially African-Americans, face considerable identity work challenges as they simultaneously try to fend off undesirable identities ascribed to them because of their race, but also avoid ‘acting White’ for fear of derision from their ethnic minority peers” (p. 862). Two students in particular, Aaliyah, a Black girl, and William, a Latino boy, appear to be caught in the socio-cultural tension that exists between themselves and their fifth/sixth-grade White male teacher. Both students enjoyed their fourth-grade student-centered inquiry-oriented science teacher who modeled and encouraged creativity, inquisitiveness, exploration, social collaboration, and held students to high expectations. The students’ current science teacher mainly rewarded memorization of correct answers, relied primarily on lecture-based instruction, and held low expectations for authentic student learning. Yet, it was his characterization of Aaliyah as being smart but too loud and William being someone who “really does have ambition” that continues to push the need to expose how students’ science identity can be easily inhibited by traditional hegemonic school structures and in the science classroom. Their research addresses the formidable existence of the power-oppression dynamics, and the revered status quo in formal science learning environments that can significantly mold students’ science experiences, and thereby their science identity in their younger years.

Other studies center middle school aged science learners, their science identity development, and the intersection of these students’ identities. Vincent-Ruz and Schuun (2018) address the heteropatriarchal hierarchies that are built within science education in the United States that produce disparities and potentially affect science-oriented attitudes among certain under-represented students because of their gender and/or race/ethnicity. From their quantitative study of 1322 ethnically diverse seventh and ninth grade students from 19 schools from two
different regions of the country, they specifically addressed three possible influences and determining factors upon their science identity: the interactions students have with influential others, the role students’ prior interest in science, students’ perception of science relative to their performance in their science class, and their perception of the traits of professional scientists (Vincent-Ruz & Schuun, 2018). Of particular interest are the findings related to students’ exposure to real-world science experiences and early science career interest. Through multiple regression, science identity was a reasonably strong predictor of students’ science learning in formal classrooms, but it was a much stronger predictor of students’ engagement in informal science learning settings. This finding is particularly important for students and school communities who lack access to informal science learning opportunities. The authors imply that if students see science in action outside of the classroom, they may be more prone to envisioning themselves in these science careers as well. Additionally, while no significant gaps in science identity were present across students’ age, gender, or race/ethnicity, they did report at higher science identity levels, boys were less participatory in formal and home science learning experiences.

Earlier work by Archer et al. (2010) addresses science identity work and the concepts of doing science and being a scientist in a five-year longitudinal study of 10-14-year-old ethnically and socioeconomically diverse boys and girls in England. Critical to this study was the intent to "interrupt dominant identity patterns of (dis)identification in relation to science in the future" (p.637). This study examined attitudes, values, beliefs, and the reasoning regarding the gendered aspects of science. Students enjoyed science but did not want to pursue science careers. Their focus groups and interactions with these children led researchers to uncover the feminization and masculinization of certain aspects of doing science presented a unique conundrum. The authors
conclude with the idea of a pathway forward and considering “how we might bridge the gap between children and young people’s everyday identities (those that are experienced as desirable, authentic, and conveying status within their daily fields of interaction) and the identities and messages conveyed by school and ‘real’ science’ ” (Archer et al., 2010, p. 637).

The seemingly decreased motivation and interest in science of students in the middle grades (ages 11-13) highlight the disparity of science and STEM career interest in middle and high school aged boys from racial minorities (Archer, DeWitt, and Willis, 2015; Carlone, 2014). Prior research points to issues of equity, social justice, social class, and ethnicity, all of which play critical roles in exploring this issue. However, there may be other cultural elements-values, competing interests, familial priorities—or combinations of specific cultural elements that may provide a different perspective as to the decline of science motivation and interest in middle school students and undoubtedly, these ideas persist through high school and post-secondary education (Hazari et al., 2013; Le et al., 2019). What makes this issue more of a concern is that the scientific capabilities and insights these students possess, often acquired outside of the school environment, may not be noticed and thereby will not receive the necessary nurturing, guidance, and developmental support, potentially limiting access to future educational and career achievement. Instilling learners with the message that they belong and matter in science needs to become a characteristic of students’ formal science learning.

Take for instance, Byars-Winston and colleagues’ (2016) study of 668 underrepresented racial/ethnic undergraduates in the sciences. Their use of science identity and social cognitive career theory as frameworks worked to examine factors that pertain the relationship between these students’ research experiences and their pursuit of science professions. A product of their aim to develop accurate valid survey instrumentation for science identity and self-efficacy were
findings that span K-12 and postsecondary science learning. One being that early childhood, personal and environmental experiences over one’s life shape individuals’ career paths. More directly related to science identity is the sense of belonging. Another is this belongingness to science. These students’ sense of belonging with an academic environment or context correlated with their level of academic achievement and persistence in that area. Therefore, if a student has a high sense of belonging within science, their level of academic success and their persistence in science is high (Byars-Winston et al, 2016).

**Intersectionality and Its Role in Science Identity**

When one considers the early 19th century struggles and activism of the pre-originators of intersectionality and the current 21st century persistent participation and protests of marginalized groups, this desire to belong and to be recognized as they are lies at the core of their message and cry for social justice. Or in other words, We want our experiences and the essence of who we are to matter. This message, grounded in one’s identity, is most clearly presented in social media or news coverage. But does this message move into classrooms, particularly science learning environments? And how do the identity-defining experiences and moments in students’ lives translate into the shaping of students’ science identity that occurs in these classrooms? These questions are not explicitly given in written science curricula, but the hidden curricula (Longstreet & Shane, 1993) speaks volumes about the significance of students’ lived experiences in the science classroom, and what is subtly said or silenced can be the most profound factor in shaping students’ science identities.

It is my hopeful belief that, on the whole, teachers and instructors of science want all their students to understand science and enjoy the process of science learning. However, as the
population of the U.S. becomes more and more diverse the need for educational institutions to become more intentionally and purposefully inclusive and relevant to students of color becomes greater as well. (And as is the case with the term *diversity* I mentioned when discussing the limitations of intersectionality, more diversity does not mean that a thriving and equitable community of science learners has been realized.)

In the science classroom, students from marginalized and minoritized populations often struggle to participate and engage in learning, because many of the values embedded in educational systems represent those of White middle-class households, as the standard for success in science often looks like students from a White middle-class family. These WMS history and culture often clash with the cultural backgrounds and perspectives of non-white groups, leading to a loss of significant connection to science and in the science learning environment (Abram et al., 2014; Jegede & Aikenhead, 1999; Le et al., 2019; Lyons et al., 2016). In these learning spaces, students feel a pressure to lose who they are in order to get access to science learning opportunities (Archer et al., 2016). Many students in such environments may not even question (or know that they can question) why science is represented how it is (Brayboy & Castagno, 2008; Le et al., 2019). The messages students of color receive may eventually lead them to devalue and or question their own identity as well (Lyons et al, 2016).

Yet, one’s identity is multilayered and complex. Individuals’ identities “cannot be homogenized” (Lyons et al., 2016, p. 943), conflated, or made to look like anyone else’s (Crenshaw, 1991). Each person’s identity is essentially composed of multiple intersecting identities that interact in such a way that it necessitates its meaning to be examined from within a broader context of belonging (Avraamidou, 2019; Gee, 2000; Lyons et al., 2016). When one of
these intersecting identities is silenced, a distorted image of that person is created resulting in individuals feeling out of place, unaccepted, and incapable of navigating a true path for themselves in their communities and in society at large (Lyons et al., 2016; Rivera Maulucci & Mensah, 2015). The development of students’ science identities are in fact intricately entangled with their emotions, the environments within which they live, their ethico-political values, and thereby systems of oppression and power (Avraamidou, 2019). The presence or absence of students’ science participation, therefore, may often be a product of these defining attributes of their lived experiences and the ways in which historical traditions and shifts impacted them as cultural beings (Avraamidou, 2019; Le et al., 2019). Their identities allow them to consider the interconnectedness between themselves as a person and their world (Avraamidou, 2019; Gee, 2000).

The fragility of science identity formation and the ways in which interactions of identities in the classroom may make apparent the power-subordination dynamic between students, between the teacher and student, and between the student and science instruction (including instructional materials) necessitate a discussion about the role of the learning environment in science education. In Kim and Sinatra’s (2018) “Science Identity: Interactionist Approach”, the authors highlight several current and creative studies conducted throughout K-16 that in some way address science identity from various perspectives and contexts. Their purpose is to, in a way, critique past science identity literature and research for missing or evading a key components of science identity formation: the interaction between the students and their contexts and whether learners, particularly female and people of color, are afforded or restricted entrance into science in their present and their future (Kim & Sinatra, 2018). They critique Carlone and Johnson’s (2007) framework as it emphasizes how the student fit into the existing science
learning environment. Needless to say, their influential and important framework was the door through which identity work—originally held within the fields of social theory and psychology—entered the realm of science education. Nevertheless, Kim and Sinatra’s criticism is necessary to shift the center of science identity from that which the student is responsible to the responsiveness the research and instructional communities should be held more accountable.

Kim and Sinatra (2018) also question why students should be the ones to cross the border over to the teacher and the learning environment to prove their worth to be included in science learning environments instead of the other way around. This one-way border crossing (Aikenhead, 1996) suggests the persistence of a deficit mindset that all too often targets racially, ethnically, socioeconomically, and otherwise marginalized learners in the classroom. In this interactionist analysis, the emphasis lies on the “fitness” of the science environment to welcome/not welcome (or to encourage/discourage) students as opposed to solely examining how the student feels they belong in a classroom. For example, are there persistent stereotypes, narratives, or framing that signified what a scientist looks like, or is or is not (Kim & Sinatra, 2018)? These types of subtle, but ultimately not so subtle, characteristics of the science learning environment speak to who belongs in science, who does not, and whose voices, experiences, and identities matter.

With this interactionist approach, it is critical to remember that science identity is embedded in social interaction (Gee, 2000; Kim & Sinatra, 2018). How students engage in dialogue, discourse, and community is tied to the recognition they have or develop as a science person (Kim & Sinatra, 2018; Le et al., 2019). Kim and Sinatra (2018) note that this peer recognition was not explicitly addressed in Carlone and Johnson’s (2007) science identity framework. But the idea of who one is in reference to others or in an environment with others is
a part of any identity formation. Identity forms in relationship to and with others (Gee, 2000). Gee (2000) eloquently explains the significance of social interaction in his description of affinity groups:

> What people in the group share, and must share to constitute an affinity group, is allegiance to, access to, and participation in specific practices that provide each of the group’s members the requisite experiences. The process through which this power works, then, is participation of sharing (p. 105).

Peer pressure, as the saying goes, has power. The presence or absence of these affinity groups with peers and how they are constructed particularly in the science classroom (with lab groups, science projects, field trips, presentations, study groups, etc.) contain the power to shape individuals and the group itself, as what happens in any cultural community.

Recognition, a key indicator of identity (Gee, 2000) is inextricably bound up with science identity research, addressed by Carlone and Johnson’s (2007) science identity framework, as it describes how one is viewed or recognized by others as being a “science person” or not (Avraamidou, 2019). The social component of science identity is interconnected with sociopolitical contexts such as cultural norms, values, beliefs, biases, stereotypes, all of which make up the subtexts of socially-constructed identities and uses of power to oppress. Given the background and composition of intersectionality, identity, and WMS in traditional science instruction, the interaction between recognition, belonging, and intersectionality in the learning environment is largely missing from science identity studies (Avraamidou, 2019).

The term “science identity” is becoming more and more visible in science education research, yet it is important to not allow this term to become diluted, divesting it of the learner’s individual perspectives, framing, and tools by which they make meaning of their world inside
and outside of the science classroom. One’s science identity is not developed in a vacuum; but inherent to any human construct, it is influenced and shaped by life experiences, internal reflections, and interactions within relationships, and events over time. For some individuals, certain factors play a larger role than others, so there is no one-size-fits-all or formula that can accurately and adequately confirm which of these factors have more of an effect than others. This supports the argument that Kim and Sinatra (2018) and Avraamidou (2019) propose that the interactions among all of the spheres of students’ lives, the personal as well as the social and political. The use and institution of intersectionality framework is largely absent from science education research (Hazari et al., 2013; Aavramidou 2019; Kim & Sinatra, 2018). Aavramidou (2019) puts it like this:

The need for intersectionality as a conceptual framework for studying science identity is underscored by the dearth of theory and empirical evidence that addresses classroom inequalities, as well as the multiple and interlocking influence of systems of privilege and oppression in science, such as racism and sexism (p. 323).


It is not enough to rely upon “personal narratives of becoming (or not) a science person [but move] toward an understanding of the broader social and political meaning that such narratives might have, consequently affecting social change" (Avraamidou, 2019, p. 327) One way this can occur is by situating science identity within social justice and equity and being an integral part of
what makes up what is truth, knowledge, and power. For example, science education can be made “more accessible to all students by challenging norms, understanding who students are, and reimagining how their identities can operate in a science world” (Le et al., 2019, p. 2). It is here that intersectionality has a great role to play.

**Gaps in the Literature**

Science identity research has made strides in examining K-16 science teaching and learning over the last two decades. However, these studies have not comprehensively addressed all of the ways in which learners’ science identity is developed, influenced, and activated inside and outside the science classroom. I present two specific gaps in science education research literature that my dissertation study aims to address.

The first gap that needs to be further developed in both theoretical and empirical research of science identity is that of the male students of color. Initially aiming to examine the low numbers of women in STEM fields, science identity largely focused and continues to highlight the science identities of girls and women. However, in doing so, the science identities of male learners, particularly non-White males, have been in some ways marginalized in this field of study and practice, often grouped collectively in many studies as simply students of color. In centering male students of color in my dissertation, I hope to emphasize the importance of research that addresses MSOCs’ science identities as their status in pursuing science professions has been declining as well.

The second gap of science identity research that my study addresses is the use of intersectionality lens as a theoretical framework. Students’ science learning is influenced by the attributes and characteristics that make up who they are; essentially their identities and how they
intersect in society and culture outside of the science classroom interacts with how they engage and participate in science inside the classroom. As traditional science teaching is oriented around WMS, it is necessary to explore how intersectionality of the MSOCs interact with their science identity.

Relevance of Science Learning

Ideally, intentionally infusing the awareness and understanding of science identity development and intersectionality in the science classroom is the trajectory I and other education researchers mentioned have for science education for students of color and other socially marginalized learners. However, how this becomes part of instructional practice and educational policy is a different matter. There is a need for concrete practical examples to make these necessary connections to science and identity happen, especially as STEM professions become less diverse and resultingly lack the creative skills and thinking these students have (and want) to share. This calls for a fresh awakening of what it means for there to be relevancy in science learning (science relevancy) for all students.

There are a variety of factors that influence why students decide to pursue science fields in college and science-related professions after completing their college education. One of these reasons is connected to how students generally identify with science in meaningful and relevant ways. While motivation and interest are not central to this dissertation study, these are often products of the relevancy of science learning to students (Russell, 2014; Stuckey et al., 2013). If the interaction of science relevancy and science identity presented in Figure 1 holds true, then there is a wealth of insight to be explored regarding MSOCs’ future in science fields.

Stuckey et al., (2013) describes a thorough history and understanding behind the relevance in science learning (or relevance in science education). Throughout science education
history and that of other content areas as well, relevance in learning has been defined in various ways. From Dewey’s stance, the isolation between life and school occurs, because what children learn or use in one space is not transferable in the other. To a degree, this intent remains a large contributor to how relevance in science learning is used today in many European countries (Stuckey et al., 2013) and in South Africa (Iwuanyanwu, 2019).

According to Stuckey et al., (2013) and their extensive historical lens on relevance in science, there are three dimensions of relevance in science learning, each of which have both an extrinsic/intrinsic and present/future range: individual, societal, and vocational dimensions. I will discuss each of these dimensions will be discussed individually along with two other potential dimensions of relevancy found in the literature. I have designated these dimensions as corners of a triangle to demonstrate the ability for each of these dimensions to interact with each other. The overarching understanding of relevance of science learning implied by these dimensions is that “science learning becomes relevant education whenever learning will have (positive) consequences for the student’s life” (Stuckey et al., 2013, p. 19). The authors also note that science educators can emphasize certain dimensions more than others while developing the lessons depending upon grade level and context. (For example, as students transition from high
school to post-secondary, emphasizing the vocational aspect may be more understandable.) An argument for the interaction between relevancy in science and science identity can also be made in light of these dimensions. Simply stated: the absence of relevance in science learning regarding male students of color may block them from perceiving that science will have positive consequences in their present and future.

*Dimensions of Science Relevancy*

As mentioned, Stuckey et al. (2013) provide a very functional framework from which to understand the existence of three significant ways that science is made relevant to students of all ages in the formal classroom setting. Prior to Stuckey et al., the Relevance of Science Education (ROSE) international survey was developed “to provide theoretical insight into factors that relate to relevance of the contents as well as the contexts of S&T [science and technology] curricula” (Schreiner and Sjoberg, 2004, p. 6). However, the ROSE developers’ use of the word *relevance* may also mean “meaningful, interesting, engaging, important” (Stuckey, 2013, p. 9). One of the ROSE’s key objectives in using relevance as an “umbrella term for a wide spectrum of factors that broadly speak to the affective domain” (Schreiner and Sjøberg, 2004, p. 21) was to gain insight into 14-16-year-old students’ overall interests, attitudes, experiences, career aspirations, etc. as it pertains to vast areas of science and technology education (Kang et al., 2018; Schreiner and Sjøberg, 2004; Stuckey et al., 2013). Criticism of the ROSE instrument is that much of the 247 items align more with the construct of interest than relevance. Kang et al. (2018)’s study aimed to analyze these distinctions between relevance and interest. It utilized Stuckey et al.’s three dimensions as a guide in developing and administering a survey instrument of 25 science-related context-based scenarios. In their international study, the constructs for relevance and
interest were clearly distinguishable among the 574 student participants from Estonia, Finland, and the United Kingdom, averaging 13 years of age. The factors identifying these three relevance dimensions proved to have strong construct reliability with Cronbach alphas >.70, affirming the distinct characteristics of science relevance in learning science. Given this background that contributed toward my development of the Identification of Science Learning Development Survey (ISLDS), there is a hopeful expectation that science relevancy as a construct can be further understood and utilized for research and pedagogical development for diverse populations of postsecondary science students as well.

Despite the support for these three dimensions, a review of the literature of science relevancy in education provides evidence for the presence of two other areas of science relevancy that need to be explored. The next five sub-sections provide descriptions of each of Stuckey et al.’s three dimensions of science followed by the two I have labeled instructional and science-specific dimensions.

**Individual Dimension**

The individual dimension directly relates to students at a personal level. When this is present in the learning environment, science connects to students’ everyday lives, and addresses their curiosities and interests (Archer, 2016; Chamany, Allen, & Tanner, 2008; Cowie, 2010; Kang et al., 2018; Russell, 2014; Stuckey et al., 2013; Williams & Williams, 2011; Yalaki, 2016). Students’ family units, cultural backgrounds, personal experiences and perspectives are incorporated into or tied to science in a way that students can see themselves represented and described (Aronson & Laughter, 2016; Ladson-Billings, 1994; 2006; Russell, 2014). Diverse perspectives and ideas are discussed, respected, and valued (Chamany, Allen, & Tanner, 2008; Russell, 2014). The individual dimension seeks to develop students intellectual and critical
thinking skills and provides opportunities to utilize these problem-solving skills in practical ways.

Different ways of knowing and students’ prior knowledge are welcomed and explored (Aronson & Laughter, 2016; Chamany et al., 2008; Gay, 2010, Ladson-Billings, 1994; 2006; Russell, 2014). This also means that there is positive representation of people in science who look like the students in the classroom, who speak like them, and share identities with them as well. This is key to engaging students of color and different genders as typically the scientists, inventors, and engineers taught in classrooms from elementary through college are overwhelming White European men whose identities and experiences diametrically differ from the majority of learners (and teachers) in these classrooms (Aronson & Laughter, 2016; Ladson-Billings, 1994; 2006; Russell, 2014).

Societal Dimension

The societal dimension integrates social, societal, and global issues into science learning with explicit connection to the real world with real examples and implications (Chamany et al., 2008; Kang et al., 2018; Stuckey et al., 2013). Science learning prepares students to be responsible contributing members of society who have an awareness and understanding of the interdependence and interaction of science and society (Chamany et al., 2008; Kang et al., 2018; Stuckey et al., 2013). Within this dimension, political and economic topics are allowed to interact with science concepts in the socioscientific arena (Chamany et al., 2008; Kang et al., 2018; Koster & de Regt, 2020) Real world issues like global climate change and environmental sustainability addressed, and students are invited to examine them through various lenses (Chamany et al., 2008).
However, students are not on the side-lines as mere receptors of teachers’ opinions and political persuasions but are expected to actively consider and work out how science can contribute to providing solutions to problems that exist beyond the scope of their physical classroom (Kang et al., 2018). Additionally, opportunities may be given to students to activate their understanding of science in these situations in their local communities, allowing them to change their world for the better (Aronson & Laughter, 2016; Ladson-Billings, 1994; 2006; Williams & Williams, 2011). This dimension is one of social action as students share what they are learning in tangible products and expressions; it is in this environment that students can be shaped to become informed citizens and leaders in the world (Chamany et al., 2008; Cowie, 2010; Stuckey et al., 2013).

**Vocational Dimension**

In the vocational dimension, science learning orients students toward science professions and careers by adequately preparing students academically and vocationally to enable their access to professions and careers (Kang et al., 2018; Stuckey et al., 2013; Williams & Williams, 2011). All students are set up for success by giving them access to necessary resources and training that they will need or use in their potential science careers (Russell, 2014). Various types of science professions and fields are presented to them and explained in this dimension; students receive insight into the roles and responsibilities of people who work in these areas (Stuckey et al., 2013). Students are given career-based scenarios to work through from the perspective of the science professional (Kang et al., 2018). The vocational dimension also prepares students for the next grade or level of their science learning progression or college major (Stuckey et al., 2013).
Instructional Dimension

The instructional dimension primarily refers to the tools, methods, and materials used in the teaching and learning of science in the classroom (Russell, 2014). In this dimension, science lessons and the curricula are stimulating and meaningful (Williams & Williams, 2011). Students are engaged in interactive learning that may incorporate a variety of resources like technology, social media, and other digital/virtual learning tools (Russell, 2014). Lecture has been minimized, and more student-centered ways of sensemaking are prioritized through experiential learning, like field trips (Russell, 2014). Students actively collaborate in groups with peers where discussions and debates lead them to learn from and teach each other (Aronson & Laughter, 2016; Ladson-Billings, 1994; 2006; Williams & Williams, 2011). Students are able to utilize prior knowledge, different types of texts, and scenarios to consider activating their science understanding in a variety of ways (Chamany et al., 2008; Russell, 2014; Williams & Williams, 2011).

Science-specific Dimension

The science-specific dimension is primarily concerned with providing students with an accurate representation of science and its sensemaking characteristics. More specifically, the nature of science is explicitly explained and explored (Chamany et al., 2008; Khiske and Lederman, 2006; Koster & de Regt, 2020; Lederman and Lederman, 2014). The accurate history of science is presented by including individuals of all races, ethnicities, genders, and cultures who have contributed to science’s biography (Chamany et al., 2008). Students are actively participating in science practices like asking questions, designing experimentations and investigations, collecting evidence, engaging in argumentation of scientific evidence, and analyzing their data (Aronson & Laughter, 2016; Chamany et al., 2008; Ladson-Billings, 1994;
2006; NGSS Lead States, 2013; Russell, 2014). Students are challenged to think critically about what they are learning and to also confront errors in their reasoning and the reasoning of others (Chamany et al., 2008). Throughout this dimension, the interdisciplinary nature of science should be evident; teachers share and model how science connects to other content or subject areas (Chamany et al., 2008). In short, this dimension enables students to think and act like professional scientists.

Science Relevancy and Preparing Students for STEM Professions

The international research and conceptualization of science relevancy (Kang et al., 2018; Schreiner and Sjøberg, 2004; Stuckey et al., 2013) speaks to the increase of STEM-focused programs and degrees is a global reality (McCurdy, Nickels, & Bush, 2020; Sari, Alıcı, Şen, 2017; von Solms & Nel, 2017). Making science relevant for learners in the science classroom in a variety of ways is not limited to any one age group or grade level. The Next Generation Science Standards (NGSS), built upon NRC’s Framework (NGSS Lead States, 2013), were developed to ensure K-12 students in STEM were adequately prepared with the necessary science-centered, problem-solving and critical thinking skills, necessities for success in college and various careers (NGSS Lead States, 2013). Yet, this shift in primary and secondary levels produces a rippling effect into the post-secondary science classrooms as well. Regardless of whether students enroll and complete STEM courses or majors at community colleges or four-year universities, educational preparation is an integral piece that needs to be sufficiently addressed throughout all higher education programs and policies, and this type of preparation falls within the vocational dimension of science relevancy. “The importance of science and engineering in preparing the technical workforce and a science-literate citizenry has drawn increased attention to the quality
of undergraduate science and engineering education and how it can be improved” (NRC, 2012, p. 9). Undergraduate students’ “confidence in the methods of science and engineering and their understanding of the findings of science and engineering” (NRC, 2012, p. 8) depends upon their ability to critically solve problems and communicate their ideas, reasoning, and understanding effectively in cross-disciplinary contexts that traverse both science and society.

The instructional dimension and science-specific dimension for instructors of science play a very significant role in developing relevant science learning experiences particularly as it pertains to professional development. Post-secondary science instructors and faculty are pursing different ways to improve their instructional practice, assess the effectiveness of their teaching, and better reflect upon and understand how their students learn the core science concepts and practices (NRC, 2012). The utilization of Discipline-Based Education Research (DBER) has been a significant tool in highlighting the questions and issues resulting from the teaching and learning in science and engineering disciplines at the college-level (NRC, 2012). Findings from one DBER study showed that undergraduate students held certain misunderstandings and inaccurate beliefs a variety of science concepts, including those that span spatial scales and take place over long periods of time (NRC, 2012). In addition, studies focused on discipline-specific professional development, suggest that science and STEM instructors’ professional learning opportunities need to include an intentional emphasis on their conceptual change and their beliefs about learning (NRC, 2012).

These types of shifts and use of K-12 instructional strategies are becoming more evident in the classrooms of college and university learners. Michigan State University implemented NRC’s Framework to “change the base knowledge that students leave with and influence what they go on to do” (Satyanarayana, 2019). Watkins and Mazur (2013) recorded that the addition
of peer instruction into a beginning physics course for STEM majors produced an engaging environment in which students participated in discourse about conceptual physics questions and ideas. There were “greater opportunities [for students] to develop and practice critical skills in scientific argumentation, such as asking questions, articulating their ideas, and justifying their claims to peers” (Watkins & Mazur, 2013, p. 40). Additionally, teachers of science may need to implement unique and innovative ways of bringing students’ interests, sociocultural perspectives, and other ideas that are important to them into the science classroom to further engage them in relevant science learning (McCurdy et al., 2020). In short, science teaching needs to be intentional about including and connecting these dimensions of science relevancy to help prepare students for further learning and professions in science.

**Gaps in the Literature**

Even though the literature addresses the need for science teaching to be relevant to students, there is very little use of science relevancy and its dimensions, as a practical construct to study in science education research or as a guide in science teaching practices. In this study, I address this gap in the literature by incorporating science relevancy in both the survey instrument and in the participant interviews of my mixed-method study. In both the quantitative and qualitative phases of my dissertation study, students provide their perspective on the relevancy of their K-16 science learning experiences as their viewpoint on what is relevant to them should be a major aspect of this conversation.

Additionally, when considering the characteristics of science relevancy and science identity, there are clear overlaps and commonalities that may be challenging to differentiate. Theoretically, it is plausible for students to demonstrate an active approach towards science, to
use Kim and Sinatra’s (2018) term, thereby having a strong science identity simultaneously expressing that science has no relevance to them. Consequently, my study addresses this relationship by exploring whether or how these two constructs, science identity and science relevancy, correlate. The survey data analysis also explores science relevancy across demographically-diverse learners, and whether intersecting identities such as race/ethnicity, gender, and socioeconomic status, play a role in how students perceive their formal science learning as being relevant to them. Five MSOCs also provided critical insight into the relevancy of science learning through semi-structured interviews as well.
CHAPTER THREE: METHODOLOGY

*Transformative Mixed-Methods Design*

Intersectionality research in higher education institutions readily utilize survey instruments to gather and examine demographic information about its student population (Harper, 2011; Nichols & Stahl, 2019). Researchers often grapple with the most effective way to collect and accurately measure students’ intersecting identities, while simultaneously capturing a true picture of what it means for these identities to intersect (Harper, 2011). Research framed through the lens of intersectionality warrants a methodological approach that addresses the interaction between social class, privilege, and oppression (Lyons et al., 2016; Windsong, 2018).

Mixed-method approaches can more completely address certain nuances of intersecting identities that can be missed by quantitative measurements alone (Harper, 2011; Lyons et al. 2016). The specific intention of transformative mixed-methods is to promote social justice, includes individuals’ worldview and the knowledge participants have as a result of their life experiences and interactions within a power-infused society (Sweetman, Badiee, & Creswell, 2010). Sweetman, Badiee, and Creswell (2010) framed 10 criteria for transformative mixed-methods largely informed by Donna Mertens and her extensive development and use of transformative mixed-methods research with diverse communities in various international contexts (Mertens, 2007; 2012). Table 1 presents these criteria as questions which Sweetman and colleagues (2010) provided. These criteria are not ordered in a sequential way or order of importance, but they served as a guide in the structure, design, and analysis of the research I present (Creswell & Clark, 2011; Mertens, 2007; Schoonenboom & Johnson, 2017; Sweetman et al., 2010).
Table 1 Criteria for Transformative Mixed-Methods Research

1. Did the authors openly reference a problem in a community of concern?
2. Did the authors openly declare a theoretical lens?
3. Were the research questions (or purposes) written with an advocacy stance?
4. Did the literature review include discussions of diversity and oppression?
5. Did authors discuss appropriate labeling of the participants?
6. Did data collection and outcomes benefit the community?
7. Did the participants initiate the research, and/or were they actively engaged in the project?
8. Did the results elucidate power relationships?
9. Did the results facilitate social change?
10. Did the authors explicitly state use of a transformative framework?

Sweetman et al., 2010, p. 442

Essentially, all components of the research process should be noticeably influenced by this transformative paradigm (Creswell & Clark, 2011; Garnett et al., 2019; Mertens, 2007; Mertens, 2012; Sweetman et al., 2010) For example, having a purpose and framework (intersectionality) that names and confronts issues of social justice, an interaction and equal emphasis between the quantitative and qualitative data, a sequential or concurrent timing of the phases of data collection, an initial point of interface for integrating (or mixing) the data occurring at the design level (Creswell & Clark, 2011). Additionally, Table 2 presents specific locations or stages within this study that have been shaped by transformative methodological approach.

Table 2 Evidence of Transformative Mixed-Method Criteria in Current Research Study

<table>
<thead>
<tr>
<th>Transformative Mixed-Method</th>
<th>Areas in the Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aims to address/advocate for issues of social justice, inequities, etc.</td>
<td>Introduction, Literature Review, Methodology, Findings, &amp; Conclusion</td>
</tr>
<tr>
<td>Aligns with a theoretical framework that focuses on culturally and ethnically marginalized groups, issues of power and oppression</td>
<td>Introduction, Literature Review, Methodology, Findings, &amp; Conclusion</td>
</tr>
<tr>
<td>Guides the structure of the data collection and study</td>
<td>Methodology, Findings, &amp; Conclusion</td>
</tr>
<tr>
<td>Aims at giving a voice to diverse perspectives of the phenomenon being studied</td>
<td>Introduction, Methodology, Findings, &amp; Conclusion</td>
</tr>
<tr>
<td>Incorporates quantitative and qualitative data collection that are equally relevant and occur sequentially or concurrently</td>
<td>Introduction, Methodology, Findings, &amp; Conclusion</td>
</tr>
</tbody>
</table>
### Transformative Mixed-Method Areas in the Study

| Engages participants in the study including their appropriate labeling | Methodology, Findings, & Conclusion |
| Benefits the community and facilitates social change | Findings & Conclusion |

**Rationale for Sequential Transformative Mixed-Methods Design**

Critical to mixed-method research is the rationale supporting the design and data collection of the study (Creswell & Clark, 2011; Mertens, 2011; Sweetman et al., 2010). This study incorporates three sequential phases of this transformative mixed-methods design for very specific reasons. Figure 2 graphically displays the key components of each phase and how the phases are related. Phase 1 survey instrument provides an overall perspective of science identity, science relevancy, and decisions to pursue science professions across different demographics of college students in accordance with an inter-categorical scope of intersectionality (McCall, 2005; Windsong, 2018). Survey participants completed the survey prior to their interaction with or knowledge of the researcher’s identity in any way. While Mertens (2012) advocates for the qualitative data to be collected first, she also highlights Hodgkin’s (2008) study demonstrates a research design that contrasts Merten’s suggestion and also represents the structure I implemented in my own study. Hodgkin first administers a quantitative survey to a large heterogenous group of men and women regarding their social, community, and civic engagement. The qualitative interviews of only women narrowed the focus specifically address how they felt about these community activities and their lives (Hodgkin, 2008).
Figure 2: Transformative Mixed-Methods 3-Phase Study Design

**Phase 1: ISLDS Instrument (QUANT)**

- **Research Question #1**
  - In what ways, if any, do the science identities, relevant science learning experiences, and decisions to pursue science professions of MSOCs differ from other college students with different intersecting identities such as race/ethnicity, gender, and socioeconomic status?

- **Participants**
  - 700+ Survey Responses (N=702) from demographically diverse students enrolled in STEM-related course in Southeastern U.S. state college

**Phase 2: Individual Semi-Structured Interviews (QUAL + quant)**

- **Research Question #2**
  - How do the experiences and intersecting identities of MSOCs shape their science identities and their decisions to pursue science professions?

- **Participants**
  - Purposive sampling of MSOCs from ISLDS responses
  - Five MSOC participants: "Derrick" "Toni" "Orlando" "Fernando" "Miguel"

- **Research Question #3**
  - How do MSOCs describe the relevancy of their formal science learning to their lived experiences?

- **Participants**
  - Five participants from Phase 2: "Derrick" "Toni" "Orlando" "Fernando" "Miguel"
Given the anonymity preserved throughout the survey, the expectation of the survey was to elicit honest responses from participants prior to their potential interview participation. Phase 1 helped to prevent the probability of their responses inadvertently being influenced by my identity, bias, or researcher expectations. Phase 2 and 3, on the other hand, aimed to encourage a small purposive sampling of survey participants to freely share, contribute, and interact individually or in groups of two with me. Additionally, Phase 1 only addresses the quantitative survey data. Phase 2 and 3 primarily center participants’ words, meanings, and narratives from the qualitative interviews and minimally draws connections between the qualitative data to their survey quantitative data from Phase 1. Figure 2 also presents the research design and those how each phase was implemented. The next section presents major components of each of the three phases including the research questions it aims to address, the participants lived experiences, the community and context and other design components of the study.

Phase 1: Identification of Science Learning Development Survey

Data Collection

While this study aims to give voice to the identities of MSOCs in science, it also aims to locate their narrative within a broader context that includes the acknowledging the intersecting identities of other students as well. Windsong (2018) mentions that these inequities in science teaching and learning are not limited to students of color. Given this understanding of intersectionality, Phase 1 of the data collection utilized an inter-categorical approach (McCall, 2005; Windsong, 2018). It aims to answer research question one:

1. In what ways, if any, do the science identities, relevant science learning experiences, and decisions to pursue science professions of male college students of color differ from other college students with different intersecting identities?
a. What is the relationship between students’ science identities and their relevant science learning experiences, and in what ways do these constructs differ across intersecting identities such as race/ethnicity, gender, and socioeconomic status (SES)?

b. Do college students’ science identities and relevant science learning experiences predict their decisions to pursue science professions after college? If so, are there differences when considering intersecting identities such as race/ethnicity, gender, and socioeconomic status?

Survey Participants
The target population of Phase 1 was any student, 18 years of age or older, enrolled in a STEM-related course at Creek State College (CSC), a pseudonym, an ethnically diverse area in Southeast United States. An online survey questionnaire was administered to those students who agreed to the informed consent, located in Appendix B, that described their voluntary participation in the study and the level of privacy and anonymity provided prior to their participation in the study. Participants included students from various demographic and educational backgrounds including 1) those who identify as male, female, or non-gendered, 2) those representing Black, Asian, Hispanic, White or other races/ethnicities, and 3) those who are attending college for the first time, transferring from another college/university, or returning to continue their education from the prior semester.

Creek State College’s enrollment over the last few years hovers around 30,000 students across their four-year bachelor’s degree, two-year associate degree, adult education, and other programs. Table 4 displays enrolled CSC students by gender and race/ethnicity. CSC is a Hispanic-serving institution which means its enrollment of undergraduate full-time equivalent
students that is at least 25% Hispanic students at the end of the award year immediately prior to the date of application (U.S. Department of Education). Hispanic students make up 30% of the total enrollment which accounts for the large participation of Hispanic students all three phases of the study.

Table 3 Creek State College Student Enrollment by Race/Ethnicity and Gender

<table>
<thead>
<tr>
<th>Female Student Demographics</th>
<th>% of Student Population</th>
<th>Male Student Demographics</th>
<th>% of Student Population</th>
<th>Total % by Race</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian</td>
<td>2%</td>
<td>Asian</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Black</td>
<td>10%</td>
<td>Black</td>
<td>6%</td>
<td>16%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>18%</td>
<td>Hispanic</td>
<td>12%</td>
<td>30%</td>
</tr>
<tr>
<td>White</td>
<td>23%</td>
<td>White</td>
<td>21%</td>
<td>44%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>Other</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Unknown</td>
<td>1%</td>
<td>Unknown</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Total Female</td>
<td>56%</td>
<td>Total Male</td>
<td>43%</td>
<td>99%</td>
</tr>
<tr>
<td>No Gender provided</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Demographic categories and percentages taken from the Creek State College website*

Data Collection Procedures

Following approval from the research institution’s and CSC’s Institutional Review Board (IRB), I reached out to the deans of the Biological Sciences, Physical Sciences, Computer Technology and Engineering, and the Mathematics departments to request their faculty’s assistance in administering the recruitment letter located in Appendix A and informed consent to their students through their course digital learning management systems, Canvas. A faculty information letter with the link to complete an optional questionnaire (via Google Form) was emailed either to the deans, who forwarded the information to their department members, or simultaneously to the deans and faculty members of these STEM courses. According to the optional questionnaire and direct email replies from faculty members, 28 professors agreed to distribute the student survey recruitment letter to their students as either an announcement or 0-point assignment within their Canvas courses. While there may be more professors who shared
this information with their students, the breakdown of these professors and the courses through
which the student survey recruitment letter was administered is described in Table 3.

Table 4 STEM Departments and Courses of Survey Participant Recruitment

<table>
<thead>
<tr>
<th>STEM Department</th>
<th>Survey Recruitment in these courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Sciences</td>
<td>Anatomy &amp; Physiology 1 &amp; 2</td>
</tr>
<tr>
<td></td>
<td>General Biology 1 &amp; 2</td>
</tr>
<tr>
<td></td>
<td>Human Biology</td>
</tr>
<tr>
<td></td>
<td>Microbiology</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>Chemistry 1 &amp; 2</td>
</tr>
<tr>
<td></td>
<td>Foundations of College Chemistry</td>
</tr>
<tr>
<td></td>
<td>Introduction to Astronomy</td>
</tr>
<tr>
<td></td>
<td>Introduction to Earth Science</td>
</tr>
<tr>
<td></td>
<td>Introduction to Environmental Science</td>
</tr>
<tr>
<td></td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>Technology and Engineering</td>
<td>Case Study in Business Programming Computer Applications</td>
</tr>
<tr>
<td></td>
<td>Database Management</td>
</tr>
<tr>
<td></td>
<td>Database Management &amp; Administration</td>
</tr>
<tr>
<td></td>
<td>Java Programming</td>
</tr>
<tr>
<td>Mathematics</td>
<td>College Algebra</td>
</tr>
<tr>
<td></td>
<td>Developmental Mathematics Combined</td>
</tr>
<tr>
<td></td>
<td>Intermediate Algebra</td>
</tr>
<tr>
<td></td>
<td>Precalculus</td>
</tr>
<tr>
<td></td>
<td>Precollege Math</td>
</tr>
<tr>
<td></td>
<td>Statistical Methods 1</td>
</tr>
<tr>
<td></td>
<td>Trigonometry</td>
</tr>
</tbody>
</table>

The survey included an item in which participants were able to voluntarily provide their
email addresses to be potentially contacted to participate in the interview (via Zoom) and/or
focus group session (via Zoom) of the study. Participants were informed that no identifiable
information about the instructor, course, college, city, or state would be collected by the survey,
and their decision to participate or not participate in the study would in no way affect their
relationship with CSC, including continued enrollment, grades, employment, or their relationship
with the individuals who may have an interest in this study.

Community of Concern: Creek State College Context

Over the last three years, I have developed a collaborative professional relationship with
faculty at the CSC through various professional development workshops I conducted on
implementing problem-based and interactive learning in equitable and relevant ways for faculty in various content areas. What was evident through my interactions and collegial conversations with these faculty members is that they have a genuine concern for their students and preparing them for their future. During this time, members of the biology faculty expressed a concern for engaging more students of color, particularly male students, in the sciences and other STEM areas. The CSC faculty’s spoken need about their local teaching and learning community greatly aligned with the needs I observed as both a teacher and a researcher. The expectation is that this study will provide a different lens for these faculty members to better understand how a considerable population of CSC students in STEM classes perceive science, science teaching and learning, and potential factors that may affect their participation in STEM field.

Survey Instrument

A researcher-developed practice 45-item survey instrument, the Analysis of College Students’ Science Learning Survey was administered to 167 undergraduate biology students’ science identities and science learning environments. I conducted a practice exploratory factor analysis (EFA) as part of the process for developing an appropriate instrument to address the specific intent of college science learning experiences. However, there were several reasons to not use the practice survey for this current study. The majority of the survey items were categorical in nature and lacked any type of ordinal scale which limited the extent to which a true EFA. While 167 is an acceptable sample according to these sources, concerns regarding communalities among items, expected number of factors and model error, the nature of the survey items existed (Field, 2018; Hahs-Vaughn, 2017). Due to extraneous factors, low factor loadings, or an insufficient number of survey items to justify considering these as factors, this survey was not reliable to use for this current study.
Given the lessons learned from the practice survey, I developed the online survey instrument Identification of Science Learning Development Survey (ISLDS) to reflect criteria and characteristics of two key constructs—science identity and science relevancy—as presented in both empirical and theoretical research. A construct and survey item alignment, provided in Appendix C, provides support for the survey items from literature. Additionally, the ISLDS is provided in Appendix D. The ISLDS is divided into these three parts:

- Part 1: includes 11 items related to students’ science identity (recognition and belonging),
- Part 2: includes 24 items related to science relevancy dimensions of science learning experiences (individual, societal, vocational, instructional, and science-specific), and
- Part 3: includes 30 items related to students’ parental information, academic standing, professional aspirations, and other demographic information.

Part 1 and Part 2 utilize five-option Likert-scale ranging from strongly disagree to strongly agree to better analyze levels of agreement, priority, frequency, etc. (Vagias, 2006). Part 3 incorporates a variety of single and multiple answer multiple choice question items and single line text entry items.

Data Analysis

Intersectionality theory complements the transformative mixed-methods design of this study. More specifically, the survey provides an inter-categorical perspective of intersectionality (McCall, 2005) by exploring the science identity the relevant science learning experiences of college students enrolled in a STEM-related course across intersecting identities. Statistical analysis across varying identities helped examine whether there were differences between MSOC’s science identities, relevant science learning experiences, and decisions to pursue
science professions and other college students with different intersecting identities as shown in Phase 1. In order to answer this overarching research question, the following secondary questions will need to be independently analyzed first:

a. In what ways, if any, do college students’ science identities and relevant science learning experiences differ across intersecting identities?

b. Do college students’ science identities and relevant science learning experiences predict their plans to pursue science professions after college? Are there differences when considering intersecting identities such as race/ethnicity, gender, and socioeconomic status?

Quantitative data analysis utilized IBM SPSS Statistics for Windows, Version 27.0. In order to analyze the relationships and interactions between the latent constructs of science identity and science relevancy, composite scores of each of these constructs were computed. The items in Part 1 of the ISLDS, recognition and belonging science learning community/contexts, were computed into one SI variable and items in Part 2 of the ISLDS, individual, societal, vocational, instructional, and science-specific dimensions of science relevancy, were computed into one SR variable. Further descriptions of these composite scores are found in Table 5.

Pearson correlation was conducted to determine the relationship between students’ SIS and SRS, the two dependent variables.

*Table 5 SIS and SRS Construct and Range Description*

<table>
<thead>
<tr>
<th>Science Identity Score (SIS)</th>
<th>Science Relevancy Score (SRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Students generally do not view themselves as a &quot;science person&quot; or feel as though they belong in science professions or science (Avoiding science, (Kim &amp; Sinatra, 2018))</td>
<td>1 = Students perceive that their science learning overall has not been very relevant to them (Low relevance)</td>
</tr>
<tr>
<td>5 = Students generally view themselves as being a &quot;science person&quot; or feel as though they belong in science professions or science (Avoiding science, (Kim &amp; Sinatra, 2018))</td>
<td>5 = Students perceive that their science learning overall has been very relevant to them (High relevance)</td>
</tr>
</tbody>
</table>
Multivariate analysis of variance (MANOVA) is regularly used as an exploratory analysis in social status and identity studies to detect and compare the mean differences of key demographic categorical variables such as gender and ethnicity on a continuous independent variable (Byars-Winston et al., 2016; Hubert & Morris, 1989; Kang et al., 2019; O'Brien et al., 2020). One-way MANOVAs also account for unequal group sample sizes. MANOVA was conducted to explore the differences, if any, between and within groups, when considering their SIS and SRS. Where the test for the assumption of normality failed, the Kruskal-Wallis H test was used to determine the significance. Additionally, a factorial MANOVA was conducted to determine if the mean SIS or SRS reported differed based upon students’ gender, SES, and race/ethnicity. among all student participants was conducted to answer research question 1a.

For research question 1a, SIS and SRS were used to analyze students’ race/ethnicity, gender, and socioeconomic status factors. The race/ethnicity was operationalized as one of these options identified 1) American Indian or Alaskan Natives, 2) Asian American, Pacific Islanders, and Native Hawaiians, 3) Black or African American, 4) White, 5) Hispanic, Latino(a) or of Spanish Origin, and 7) Multiracial/multi-ethnic.

Parents level of education is typically used as a proxy for students’ socioeconomic status (SES) (Jha & Stearns, 2018; McFarland et al., 2019; Monaghan, 2020). This study aligns to this customary practice, specifically asking participants to select one of these three options: 1) both of my parents/guardians have at a bachelor's degree, 2) one of my parents/guardians has a bachelor's degree, or 3) neither of my parents/guardians has a bachelor's degree. However, there

<table>
<thead>
<tr>
<th>Science Identity Score (SIS)</th>
<th>Science Relevancy Score (SRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>person” and feel as though they belong in science professions or science (Approaching science (Kim &amp; Sinatra, 2018))</td>
<td>very relevant to them (High relevance)</td>
</tr>
</tbody>
</table>
are other pertinent factors that this SES operation cannot accurately reflect the status tradition and non-traditional students who range from 18-63, work, support children or parents, may/may not receive financial aid, etc. To accommodate these types of factors that may also account for their SES, other variables were included in various statistical tests that were conducted, namely, students’ employment status, financial aid status, the type of profession participants’ parents had during the participant’s childhood (science or not), and the level of parental support of participants’ science learning.

A binary logistic regression, using the enter method, was conducted to determine whether students SIS and/or SRS (independent or predictor variables) were able to predict their decisions to pursue science professions after college (dependent variable) to answer research question 1b.

Reliability of the ISLDS Instrument: Factor Loading of Latent Constructs

I conducted an exploratory factor analysis, using principal axis factoring and varimax rotation, to determine the presence and reliability of latent factors of science identity and science relevancy. The measure of sampling adequacy (MSA) is greater than .50. There is 63.067\% of variance explained which exceeds the “rule of thumb” >60\%. There are two factors extracted that have an Eigenvalue >1; these also correspond to the location of the “elbow” on the scree plot. Ideally, factor loadings above 0.6 are preferred. According to the pattern matrix, two factors are present. Factor 1 contains six items greater than 0.6, and factor 2 has five items greater than 0.6.

For SIS, two factors, science recognition and belonging in science, and their accompanying reliability scores are presented in Table 6.
Table 6 Potential Science Identity Instrumentation Components

<table>
<thead>
<tr>
<th>Science Identity Components</th>
<th>Science Recognition</th>
<th>Belonging in Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFA Factor #</td>
<td>Factor 1</td>
<td>Factor 2</td>
</tr>
<tr>
<td>ISLDS -SR Items</td>
<td>1-6</td>
<td>7-11</td>
</tr>
<tr>
<td>Cronbach alpha reliability</td>
<td>.927</td>
<td>.898</td>
</tr>
</tbody>
</table>

For SRS, the EFA and Eigenvalues reported four factors. Factor one included items #10-22 and 24 and reported a Cronbach alpha of .920. The second factor included items #5-9 and reported a Cronbach alpha of .877. Lastly, factor 3 included items #1-3 with a Cronbach alpha of .853. Item 23 did not easily fit into any of the three factors. Upon examination of this item, it is possible that the negative phrasing of the survey item caused confusion among participants thereby making its value of no effect. However, only two items made up the fourth factor. Additionally, this fourth factor reported a -.347 Cronbach alpha.

Considering Stuckey et al.’s (2013) three dimensions of science relevancy, these results highlight the need to explore the presence of at least one more dimension if not two more. Based upon the EFA, the vocational and instructional dimensions from the ISLDS load into one single factor which includes 13 survey items. Additionally, the fourth factor reported a negative Cronbach alpha. In analyzing the literature of these five areas of relevancy in science learning and the meanings and intention of the survey items, Table 7 displays potential factors to be further explored and descriptive labels for each.

Table 7 Potential Science Relevancy Instrumentation Dimensions

<table>
<thead>
<tr>
<th>Science Relevancy Dimension Name</th>
<th>Science Learning Preparedness</th>
<th>Science and Society</th>
<th>Science for Everyday Life</th>
<th>Foundations of Scientific Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFA Factor #</td>
<td>Factor 1</td>
<td>Factor 2</td>
<td>Factor 3</td>
<td>Factor 4</td>
</tr>
<tr>
<td>ISLDS -SR Items</td>
<td>10-19</td>
<td>5-9</td>
<td>1-3</td>
<td>20, 21, 22, 24</td>
</tr>
<tr>
<td>Cronbach alpha reliability</td>
<td>.917</td>
<td>.877</td>
<td>.853</td>
<td>.732</td>
</tr>
</tbody>
</table>
**Phase 2: Individual Semi-Structured Interviews**

**Data Collection**

**Interview Participants**

A critical aspect of this study that greatly connects intersectionality, the theoretical framework, and transformative mixed-methods design is spotlighting MSOCs’ voices in the telling of their lived experiences regarding their identity, science learning, and professional decisions beyond college. For this reason, Phase 2 of the data collection utilized an intra-categorical approach (McCall, 2005; Windsong, 2018). Phase 2 aims to answer research question two: How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?

In order to gain deeper insight into the issues of intersectionality and science identity concerning MSOCs, the qualitative component included data collected through individual semi-structured interviews with MSOCs, the target sample, who previously completed the survey instrument. Purposive sampling was used to select participants from those who provided their contact information in the ISLDS to designate their willingness to participate in the semi-structured individual and/or focus group interviews (via Zoom). A total of 29 MSOCs were emailed the interview/focus group recruitment letter, found in Appendix E. From this group, six students responded and were emailed the informed consent letter located in Appendix F. One potential participant was unable to schedule a time to meet. At this point the recruitment concluded and the Phase 2 participants included five CSC students: one Black male student and four Hispanic male students, ranging in age from 18-28. The Identity Web in Figure 3, adapted from Atewologun, Sealy, & Vinnicombe, 2016, was used to prompt participants’ discussion of how they identify themselves, whether their self-described identities shape how they view
science, their science learning, and future science profession decisions. The participants’ responses and descriptions throughout the interview were used to explore the relationship between MSOCs’ intersecting identities, their science identity development, and their plans to pursue or not to pursue science as a profession to answer research question two: How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?

Figure 3 Identity Web (Adapted from Atewologun, Sealy, & Vinnicombe, 2016)


**Interview Protocol**

Both the individual interviews were recorded and transcribed via Zoom. Zoom offers features such as securely recording and storing sessions "without recourse to third-party software" (Archibald et al., 2019, p. 2), user-specific authentication, and real-time encryption sessions. A unique and separate passcode and Zoom link was emailed to each interview participant within one week of their scheduled interview, and a reminder email was sent to each participant two days before the scheduled interview for each participant. The “waiting room” option for the Zoom session was also activated to increase security of the session.

At the beginning of each interview, I reminded participants of the informed consent information and asked them to again verify their consent to their participate of the interview portion of the study. Participants were asked permission to record their verbal agreement of the interview consent, and then asked if they agree to be audio and/or video recorded through the Zoom’s encrypted password-protected platform. Each participant was given the option of participating in the survey with their cameras off or on and changing their name in Zoom to a name of their choosing to further deidentify their personal information. Participants were also informed that the interview transcription documents will have use pseudonyms as replacements for participants’ names all of which was password protected on the researcher’s computer.

**Data Analysis**

Thematic analysis was conducted on the semi-structured interviews of the five interview participants specifically following these steps (Aronson, 1995; Creswell et al., 2003):

1. **Initial Coding**: Patterns of ideas and concepts that were recorded in researcher notes during the interviews provided the initial 15 codes of the codebook shown
in Table 8. These codes highlighted meaningful or repeated phrases that in some way connected participants to their identity descriptions, science identity, careers in science, relationships, and other experiences (Christoffersen, 2017).

2. **Secondary Coding**: During the next coding round, I re-read each transcribed interview and marked them to identify locations in participant responses that aligned to each of these codes. For example, “VG” designated references to video games, “S/C” designated references to school or college experiences, and so on. Often, multiple codes designations were found within the same location emphasizing the intersectional nature at the core of this study.

3. **Collating Codes**: These codes were collated into larger code categories. For example, video games and STEM became a “STEM Ideas” category. After this step, five code category groups were formed. These categories and any uncategorized codes were assessed to determine their ability to answer the research question. Examples of uncategorized codes included “societal issues” and “sports”. Societal issues as a code was not a persistent enough of an idea to warrant it to be either its own category. However, participants’ references to societal issues as part of their own histories or upbringing enabled it to be incorporated into one of the five themes “perspectives about race, ethnicity, culture, and society”.

4. **Theme Development**: These groups of codes were the source of the themes that were developed to respond to the research question while simultaneously integrating aspects of the quantitative data to develop robust findings for this question.
<table>
<thead>
<tr>
<th>Initial Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money</td>
<td>references to making money, budget, income, the cost of something</td>
<td>the cost of food, student loans, making more money</td>
</tr>
<tr>
<td>Job/Profession</td>
<td>entails the purpose or desire to attain a job, career, or profession</td>
<td>expressing a desire to have their own business or work in a certain company</td>
</tr>
<tr>
<td>Family</td>
<td>any reference to a family member, family member's character, or relationship with family/family member</td>
<td>I have two brothers; I live with my grandmother</td>
</tr>
<tr>
<td>STEM</td>
<td>any reference to science, technology, engineering, or math individually or collectively</td>
<td>Math is different from science because..., scientific method, types of engineering</td>
</tr>
<tr>
<td>Video Games</td>
<td>any description of a video game, how it is made, what it contains</td>
<td>The name of a video game, playing video games</td>
</tr>
<tr>
<td>School/College</td>
<td>any direct connection or reference to school, teaching, learning, college, education in general and specific sense</td>
<td>Enjoying a class, that teacher was boring, attended elementary school in another country</td>
</tr>
<tr>
<td>Peer Community</td>
<td>descriptions of interactions with friends, peers, classmates</td>
<td>Hanging out with this group of people</td>
</tr>
<tr>
<td>Values/Beliefs</td>
<td>types of ideas that relate to what one values, and or believes to be a certain way</td>
<td>Religious beliefs, don't believe this theory,</td>
</tr>
<tr>
<td>Aspirations</td>
<td>what future hopes or goals a person has</td>
<td>I’d like to do this one day,</td>
</tr>
<tr>
<td>Societal Issues</td>
<td>local, national, or international problems, mindsets, or ideas that may be pervasive in certain regions or areas around the world, that can pose to be connected to a political or global sphere</td>
<td>COVID numbers around the world</td>
</tr>
<tr>
<td>Sports</td>
<td>athletic pursuits or games played in competitive fashion</td>
<td>playing sports, admiring athletes</td>
</tr>
<tr>
<td>Character traits or qualities</td>
<td>direct or inferred description of a person, their personality or outlook on life</td>
<td>Being a kind person, feeling sorry for</td>
</tr>
<tr>
<td>Skin color/race</td>
<td>reference to a person's race, physical traits of their body</td>
<td>Light-colored skin, I am tan, I was too brown</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>addresses from the context of where he lives.</td>
<td>From Columbia, people do things very differently here than where I'm from</td>
</tr>
<tr>
<td>Cultural differences</td>
<td>Highlighted difference between us and others due to language, cultural perspective, etc.</td>
<td>They speak a different language than I do</td>
</tr>
<tr>
<td>Age</td>
<td>References to age, periods, or stages of human maturation</td>
<td>As I got older, I am the youngest at work</td>
</tr>
</tbody>
</table>
Phase 3: Individual and Paired Depth Semi-Structured Interviews

Data Collection

The students from the individual interviews were the same participants of the Phase 3 interviews as presented in Phase 3 of Figure 2. Phase 3 of the data collection also utilized an intra-categorical approach (McCall, 2005; Windsong, 2018) as I aimed to answer research question three: How do male students of color describe the relevancy of their formal science learning to their lived experiences? The purpose of the focus group was to explore male college students of color, the target sample, regarding the complexities of their intersectionality and relevant connection to science and science learning in their own words, with their own voices (Harper, 2011). The students’ shared voices, describing the intermingling and co-development of their socially constructed identities and science identities, is necessary to become a source of meaning-making from a cultural perspective that is often missing in science classrooms (Harper, 2011; Lyons et al., 2016). Specifically, this focus group interaction and interview aimed to explore the third research question which addresses the ways participants’ formal science learning relevantly connected to the lived experiences of their intersecting identities as male students of color. The focus group interview questions are located in Appendix G.

Due to scheduling issues and time availability among the participants, however, one focus group including all five interview participants did not occur. Instead, three sessions of interviews were conducted to address the third research question: two sessions each included two participants, and one participant was interviewed separately. Given this necessary modification, these interviews do not align with the expectation of a focus group; for this reason, the Phase 3 data collection will be referred to as individual and paired depth interviews. Paired depth interviews maintain the premise of focus groups, allowing and encouraging the flow of
conversation and development of ideas and thoughts, but occurs with only two interview participants on one time (Wilson, Onwueguzie, & Manning, 2016).

Initially, the culminating task of Phase 3 was to ask each create a 1-slide (or page) collage or visual graphic using PowerPoint or another presentation tool that responding to this question prompt: “What would science learning look like it is was relevantly connected to students like me?” An aspect of intersectionality is to intentionally pursue equity and social justice for those whose voices have not been able to be a part of the conversation or decision-making. As each young man describes his experience verbally and visually, they will be sharing who they are and why their science learning matters and is significant.

Additionally, due to the virtual format, internet accessibility, and the more grouping of the participants, I did not ask them to create a collage or visual presentation slide. Nevertheless, the participants did respond to the same question verbally to describe what their presentations would include.

Data Analysis

Initial coding of each interview transcript followed a similar thematic analysis with the exception of comparing the developed themes to the five science relevancy construct components from the ISLDS. These serve as a second lens through which to further analyze the initial codes. Subsequent themes from these secondary codes along with data from Part 2 of the ISLDS will be used as findings for the third research question.

The following steps were conducted in the coding process for this third phase of the study:
1. **Initial Coding**: Patterns of ideas and concepts that were recorded in researcher notes during the interviews provided the initial 15 codes of the codebook shown in Table 9. These codes highlighted meaningful or repeated phrases that in some way connected participants to their identity descriptions, science identity, careers in science, relationships, and other experiences (Christoffersen, 2017).

2. **Secondary Coding**: During the next coding round, I watched each video recording while correcting any errors from Zoom’s automated transcription platform and marking specific locations in participant responses that either aligned to each of these codes or provided a more descriptive phrasing for each code. Unlike research question two, research question three focused more on the relevancy of science learning than each participant’s individual identities so there were very similar terms each participant used simplifying the coding terms I used. For example, “interactive” generally designated references to interactive learning activities in the classroom.

3. **Tertiary Coding**: I re-read each transcript, noting specific excerpts of potential quotes or responses, and confirming, revising, or adding to the initial codes. Following this step, six additional codes were added to the initial code list. The complete code list and its coherence to the five dimensions of science relevancy from the ISLDS is located in Appendix H, signifying which dimension(s) each code aligns to these dimensions with an “x”. This triangulation between the Phase 3 interview responses, the Phase 1 ISLDS science relevancy dimensions, and the science relevancy literature provides a source of validity to the analysis process of this study.
4. Theme Development: The themes used for grouping these codes were categorized based upon the five dimensions of science relevancy identified in the ISLDS. These groups of codes were the source of the themes that were developed to respond to the research question while simultaneously integrating aspects of the quantitative data to develop robust findings for this question.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher traits</td>
<td>the character, personality, or emotions of teachers in general including their approach or view of teaching and learning</td>
<td>The teacher was approachable; my teacher was very passionate about chemistry</td>
</tr>
<tr>
<td>Instructional Style</td>
<td>How the subject area, topics, and concepts to students is presented and taught in the classroom</td>
<td>The instructor lectured and then wrote the notes on the whiteboard</td>
</tr>
<tr>
<td>Student-Teacher</td>
<td>the degree to which the teacher understands and knows their students to help teaching and communicate ideas in helpful ways</td>
<td>My teacher knew how to explain the idea to me in a different way</td>
</tr>
<tr>
<td>Connection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands-on Learning/</td>
<td>Opportunities for students to actively participate in</td>
<td>It’s easier to learn when it is not just on paper</td>
</tr>
<tr>
<td>Interactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Future-Focused</td>
<td>Ideas or goals related to academic success, moving forward, future expectations</td>
<td>I’d like to own a business one day</td>
</tr>
<tr>
<td>Purposeful/practical</td>
<td>The reasoning and the significance of the class/instruction is clearly presented and promotes sense-making</td>
<td>I did not understand why we were learning this.</td>
</tr>
<tr>
<td>The learning</td>
<td>References to student engagement, creativity</td>
<td></td>
</tr>
<tr>
<td>experience/environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology and art</td>
<td>How STEM and art have been implemented in the science classroom</td>
<td>There is art in how things are designed and engineered</td>
</tr>
<tr>
<td>Real-life/real-world</td>
<td>The use of authentic problems and scenarios to prepare students for learning science in real ways</td>
<td>The tasks in class should be more realistic</td>
</tr>
<tr>
<td>examples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to materials</td>
<td>The use of necessary materials for teaching and learning</td>
<td>In class, I’d like to use the same tools engineers use every day</td>
</tr>
<tr>
<td>and resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundational concepts</td>
<td>The emphasis on basic science topics and concepts</td>
<td>It’s important to know about things like the water cycle</td>
</tr>
<tr>
<td>of science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Job and career</td>
<td>Providing ways for students to learn about and practice the work of real science professionals</td>
<td>It would be nice to have more opportunities for internship</td>
</tr>
<tr>
<td>preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process of learning</td>
<td>Steps students need to take to understand science</td>
<td></td>
</tr>
<tr>
<td>and concept attainment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field trips</td>
<td>Leaving the class to explore local areas that use science as part of their service or work in the community</td>
<td>Students visiting a local water treatment plant</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sense of awe and wonder</td>
<td>Expressing amazement at the intricacies of science processes in the natural</td>
<td>I’m very curious and want to learn more about things I don’t know</td>
</tr>
<tr>
<td></td>
<td>phenomena</td>
<td></td>
</tr>
<tr>
<td>Visual representations and media</td>
<td>The use of pictures, graphs, videos to represent science processes</td>
<td>Seeing like visuals of cells and what we’re learning helps me understand</td>
</tr>
<tr>
<td>integration</td>
<td></td>
<td>better</td>
</tr>
<tr>
<td>Open-minded</td>
<td>Viewing a topic or issue from another’s perspective</td>
<td>We should be able to see the world and ideas from another point of view</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Being able to discuss, share ideas, and work with others to complete a task</td>
<td>Finding different ways for students to connect in the classroom</td>
</tr>
<tr>
<td></td>
<td>or project</td>
<td></td>
</tr>
<tr>
<td>Use of concrete examples</td>
<td>The implementation of realistic scientific materials/models used to teach</td>
<td>When professors use examples, real examples, it helps motivate students</td>
</tr>
<tr>
<td></td>
<td>science concepts</td>
<td></td>
</tr>
<tr>
<td>Cultural differences</td>
<td>how different cultures teach/learn science</td>
<td>Back in my country, we did a project a to figure out how to show electricity</td>
</tr>
<tr>
<td>Accessible/inclusive of multiple</td>
<td>Variety of ways students can express and demonstrate their understanding</td>
<td>All of us students don’t learn the same</td>
</tr>
<tr>
<td>modes of learning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Establishing Validity and Reliability for Phases 2 and 3**

There are several ways in which this study addresses its trustworthiness, or validity (Cypress, 2017; Morse, 2002; Weaver-Hightower, 2018). The “careful recording and continual verification of the data” (Cypress, 2017, p. 257) is necessary to maximize trustworthiness of a study, particularly those conducted by a single researcher. Throughout the methodology and findings, I draw attention to specific examples of validity as it pertains to that section or insight being presented. However, these main sources of validity for Phase 2 include: member checking, methodological coherence, data triangulation, and researcher reflexivity.

**Member Checking**

All five participants expressed great interest in checking over the written portion of their interviews as I presented them in the study. However, given the timing of the interview and data analysis coincided with their study and their final exam schedules, I have only received
responses from two participants. (The messages to one participant returned an error message back signifying that his email address, the only contact I had for him, had been changed.) The two participants who replied back expressed excitement at reading the full study when completed, and they affirmed that my descriptions of them were accurate.

Methodological Coherence

Morse et al. (2002) advocates the implementation of methodological coherence as a way to institute researcher responsiveness in verifying qualitative data analysis. “The interdependence of qualitative research demands that the question match the method, which matches the data and the analytic procedures” (Morse et al., 2002, p. 18). Cypress (2017) defines validity as not being “a single, fixed, or universal concept but rather a contingent construct, inescapably grounded in the processes and intentions of particular research methodologies” (p. 257). This iterative process should be constructive and responsive, taking place during the process of analysis as opposed to following the analytical process which is more evaluative in nature (Morse, 2002). Throughout the data analysis process, I actively engaged in methodological coherence in several ways; Figure 4 graphically presents one example of researcher
responsiveness and reflective steps in the development of research question two.

Prior to data collection, the second research question was phrased “What is the relationship between Black male college students intersecting identities, science identity development, and their plans to pursue science as a profession?”

Initially, this question needed to be revised as it was more aligned with that of quantitative research. Following dissertation committee feedback, I changed this question to signify data that would be collected through qualitative interviews. As the sample changed from Black male students to male students of color, and while I was engaging in the coding process, it became evident that question of “what role science identity played” did not align with the theoretical framework of intersectionality. This second version also did not allow for connectedness between the sociocultural aspects of participants’ narratives that greatly

Figure 4 Methodological Coherence Example of Research Question #2 Development

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Initially, this question needed to be revised as it was more aligned with that of quantitative research. Following dissertation committee feedback, I changed this question to signify data that would be collected through qualitative interviews. As the sample changed from Black male students to male students of color, and while I was engaging in the coding process, it became evident that question of “what role science identity played” did not align with the theoretical framework of intersectionality. This second version also did not allow for connectedness between the sociocultural aspects of participants’ narratives that greatly
contributed to where they currently found themselves academically, professionally, and socially. The interactions among the various spheres of their lives needed to be accounted for in such a way that presented their intersecting identities in action. In communicating this to my research committee, I wrote:

As I keep research and existing literature as a guide, the phrasing for the revised RQ#2 makes more sense theoretically as well as practically. Inherent in the first phrasing, at least in my mind at the time, was the interaction between these students’ social identities and what those entail, however the question didn’t make this explicit. I believe the revised question is truer to the focus of the study overall, provides necessary speaking points and interactions with the survey data and will naturally connect with RQ#3. Further reflection on the theoretical and data analysis along with further feedback challenged me to revise this phrasing once again to better fit the data and the coding process:

I agree. The “interaction” term is problematic. After reflecting upon it since I emailed, I thought this “interaction” would be challenging to code for in a clear way. As I’ve been researching analytical procedures for interview data, I am planning to use thematic analysis. The initial coding would then come from patterns of ideas/content I recognized while conducting their individual interviews…So in keeping with the interview data, the questions asked, participants’ responses, and the overall theme of the study, I think a better RQ #2 is: “How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?” I believe that the interaction between the students’ intersectionality and science identity will probably be a finding. This is meaningful because attention to this specific interaction in science education research is greatly lacking.
The iterative process of reading and re-reading the interview transcriptions, coding and developing themes, examining the literature and research, and revising the research question to provide as much accuracy and veracity to the research process and to the participants’ contribution to the study adds to the validity of Phase 2 of the study.

Data Triangulation and Integration

One type of triangulation, data triangulation, includes the use of two or more sets of data to help establish the validity of a research study (Creswell & Miller, 2000; Cypress, 2017; Morse, 2015; Weaver-Hightower, 2018). Cypress (2017) provides an example of crosschecking collected data and their interpretations within and between categories of participants in Phases 2 and 3 of the qualitative portions of the study. Similarly, throughout the findings of the study, I reference a participant’s excerpts or descriptions with each that of the others to highlight a common finding, theme, or piece of information that surfaced. I also integrated trends from the ISLDS data to highlight similar themes that surfaced from the individual and paired depth interviews to provide evidence of a specific claim I am seeking to establish. Lastly, I shed light upon the reviewed literature that exhibits a direct connection to participants’ statements or examples to support the viability of my argument as it pertains to the research question.

Researcher Reflexivity

A major threat to validity in qualitative research is the bias I bring in as a person conducting the research. Attending to reflexivity, or the process by which “researchers actively engage in critical self-reflection about their potential biases and predispositions” (Cypress, 2017, p. 259) plays a critical role in establishing the trustworthiness of the researcher (Creswell &
Miller, 2000) and also strengthens the depth of the analysis (Weaver-Hightower, 2018). Researcher reflexivity is also a characteristic of critical paradigm research that generally centers unjust or unequal practices that detrimentally affect members of particular sociocultural spheres and identities (Creswell & Miller, 2000; Smith, 1999; Weaver-Hightower, 2018). As the researcher, my personhood with all of my histories, perspectives, and experiences, are unintentionally an attribute of the methodological processes. I address this point in various ways to both acknowledge and critique my particular lens so as not to detract from the participants’ words and meanings while still focusing on purpose of this research.
CHAPTER FOUR: RESULTS AND FINDINGS

In addressing MSOC, it is highly significant that the majority of research addressing underrepresented students often presents a comparative perspective in which the status, achievement, and levels of students of color are compared to that of their White counterparts. This can be viewed as normalizing Whiteness thereby using being White as the norm or the standard to which all non-White students must attain or pursue (O’Brien et al., 2020). Unfortunately, this narrative has entrenched itself throughout a multiplicity of contexts in the U.S. society including within communities of color. It is a hope that this research can contribute to the de-normalization of Whiteness as part of its trajectory towards the pursuance of social justice and equity, specifically within science education and science education research. However, this hope and expectation comes with implications of how best to approach the discrepancies between the quantity of people of color within science or STEM fields given their overall population of the country. There are challenges when describing the quality of life many communities of color have throughout the country that are generally very different from White or predominantly White communities. Given these types of statistics, it may be tempting to draw conclusions based solely upon race or ethnicity, however caution should be taken in this presumption. There are more factors at play in the lives of all communities that belie this simplistic outlook. Herein lies the foundational work of intersectionality and why it is significant to hear from those whose stories become conflated with their race or ethnicity.

Quantitative analysis of the survey instrument for Phase 1 presents comparisons between and among sex, race/ethnicity, first generation college status, and others. These numerical findings are essentially screen shots of life experiences relating directly or indirectly to science
learning through the reflection and responses of students’ self-reporting. Inherently, there are hidden interplays that have occurred behind their responses that may not be effectively drawn out from this instrument. The individual and paired depth interviews provide a deeper dive into the experiences of five of these survey participants that help to add a 3-dimensional orientation to aspects of the survey data from the participants’ own words and lives. Throughout the findings, references to the survey data and interview data will be presented with the goal of mixing and synthesis that presents a fuller and more complete picture together.

Lastly, in keeping with my intention to open up space in science education research to these students’ marginalized voices and lived experiences, all of which align with the purposes of intersectionality and transformative mixed-methodology, excerpts of student responses will be presented verbatim, as each interviewee spoke them to me. Each of these young men speak English, but to varying degrees. In the event their grammar or subject-verb agreement are not aligned with formal English, I aimed to provide enough context to help the reader understand the intention behind the speaker’s words and ideas. However, I refrained, at times, from adding too much interpretation for fear of inserting my own personal intention or inaccurate inference that would reflect my own bias and sociocultural lens as a substitute for theirs.

**Phase 1: Science Identities and Science Relevancy**

The target sample of Phase 1 was any student enrolled in a STEM-related course at CSC. The data collected during Phase 1 explored research question one that asks:

1. In what ways, if any, do the science identities, relevant science learning experiences, and decisions to pursue science professions of male college students of color differ from other college students with different intersecting identities?
a. What is the relationship between students’ science identities and their relevant science learning experiences, and in what ways do these constructs differ across intersecting identities such as race/ethnicity, gender, and socioeconomic status?

b. Do college students’ science identities and relevant science learning experiences predict their decisions to pursue science professions after college? If so, are there differences when considering intersecting identities such as race/ethnicity, gender, and socioeconomic status?

The key findings for this research question include 1.) overall, male students’ SIS and SRS were lower than female students when at least one parent had a bachelor’s degree than when their parent(s) did not have a bachelor’s degree, 2.) SES plays an interactive role with gender and with race/ethnicity to a degree in increasing Black and Hispanic male students’ SIS and SRS, and 3.) students’ SIS, gender, and race/ethnicity largely predicted their decision to pursue science professions after college.

Despite wanting to maintain student participants' racial and ethnic identity, especially given the research focus on identity, modifications to the race/ethnicity groupings were made to retain optimum statistical power and effect size. Tables 10 shows the grouping of the initial sample and Table 11 shows the modified racial/ethnicity grouping categories. Note the small sample size of the Native Hawaiian/Pacific Islanders and America Indian/Alaska Native students.

*Table 10 Raw Demographic Data of ISLDS Participants*

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Hawaiian/Pacific Islanders</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>America Indian/Alaska Native</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Asian/Asian American</td>
<td>7</td>
<td>27</td>
<td>34</td>
</tr>
<tr>
<td>Multiracial/multiethnic</td>
<td>26</td>
<td>36</td>
<td>62</td>
</tr>
<tr>
<td>Black</td>
<td>26</td>
<td>91</td>
<td>117</td>
</tr>
</tbody>
</table>
### Table 11 Modified Demographic Data of ISLDS Participants

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanic</td>
<td>49</td>
<td>135</td>
<td>184</td>
</tr>
<tr>
<td>White</td>
<td>96</td>
<td>199</td>
<td>295</td>
</tr>
<tr>
<td>TOTAL</td>
<td>206</td>
<td>496</td>
<td>702</td>
</tr>
</tbody>
</table>

Prior to data analysis, SIS and SRS scores were examined for missing values and the degree to which MANOVA assumptions were met. These assumptions of MANOVA were tested: multivariate normality of dependent variables, linearity (an aspect of multivariate normality), and homogeneity of variance-covariances. One-Sample Kolmogorov-Smirnov Tests for normality were conducted for SIS and SRS across gender and race/ethnicity groupings. Assumptions for normality across SIS were met for Black, Hispanic, APAN, and multietnic males and APAN female participants; however, this assumption was violated for White males and females, and Black, Hispanic, and multi-ethnic females. For SRS, normality was achieved for males in all five race/ethnicity groups and for APAN females. However, normality for SRS was violated for Black, Hispanic, White, and multi-ethnic females. This violation is best explained by the proportion of differences in sample sizes between these groups as well as the higher frequency of females in these race/ethnicity groupings. Transformations of the SIS and
SRS were conducted however, even fewer groupings retained their normality. However, MANOVA is robust towards violations of normality, even in the case of unbalanced cell sizes when there are more than 20 cases per cell (Hahs-Vaughn, 2017).

Matrix scatter plot was conducted to analyze the linearity of the dependent variables SIS and SRS. Additionally, a correlation matrix showed a moderately strong correlation between these two variables, $r(700)=.622$, $p < .001$. Because $r < .70$, the risk of redundancy and statistical efficiency remains valid and meeting the assumption of linearity.

A one-way MANOVA was first conducted to determine whether differences in SIS or SRS are present according to students' gender. Both Box’s test of equality of covariance and Levene’s test of equality of error variances were both statistically non-significant, signifying that the assumption for homogeneity of variance-covariances for SRS regarding gender was met. While there was no difference for SIS found across gender, there was a statistically significant difference in SRS across gender, $F(2,699)=3.855$, $p=.022$, Wilk's Lambda=.989, partial $\eta =.011$. According to female students, their science learning experiences were more relevant to them ($M=3.6495$) than science learning experiences were to male students ($M=3.5297$).

To analyze whether any differences were present in SIS and SRS regarding race/ethnicity, a one-way MANOVA was conducted. Box’s test of equality of covariance was statistically non-significant, but Levene’s test of equality of error variances was statistically significant, signifying that equality of variance-covariances for SIS and SRS regarding race/ethnicity had been violated. However, MANOVA is generally robust to the violation of heteroscedasticity, particularly due to the very large sample sizes (Hahs-Vaughn, 2017). Because of the violation of this assumption, Pillai’s trace omnibus test was used to report the level of
significance. There is no statistically significant differences in SIS and SRS regarding race/ethnicity, Pillai’s Trace=.014, F(8, 1394)=1.254, p=.264, partial $\eta^2=.007$.

The final MANOVA was conducted to examine whether any main effects of gender, race/ethnicity, and SES were present. The SES variable was dummy coded into a dichotomized variable such that 0=neither parent received a bachelor’s degree and 1=at least one parent had received a bachelor’s degree. An interaction effect exists between gender and SES such that the effect of SES on SIS and SRS is not the same for females as it is for males, Pillai’s Trace=.011, $F(2, 681)=3.820, p=.022$, partial $\eta^2=.011$ as displayed in Table 12.
### Table 12 Multivariate Tests of SIS and SRS

<table>
<thead>
<tr>
<th>Effect</th>
<th>Multivariate Tests*</th>
<th>Value</th>
<th>F</th>
<th>Hypothesis df</th>
<th>Error df</th>
<th>p-value</th>
<th>Partial Eta Squared</th>
<th>Noncent. Parameter</th>
<th>Observed Power²</th>
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<td>681.00</td>
<td>.000</td>
<td>.927</td>
<td>8614.451</td>
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<td>.000</td>
<td>.927</td>
<td>8614.451</td>
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<td>2.00</td>
<td>681.00</td>
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<td>.007</td>
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<td>2.00</td>
<td>681.00</td>
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<td>.007</td>
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<td>.005</td>
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<td>.005</td>
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<tr>
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<td>.011</td>
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<td>12.962</td>
<td>.723</td>
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<td>4.00</td>
<td>682.00</td>
<td>.015</td>
<td>.018</td>
<td>12.447</td>
<td>.816</td>
</tr>
</tbody>
</table>

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Multivariate Tests

a. Design: Intercept + Gender + Race/Ethnicity + SES + Gender * Race/Ethnicity + Gender * SES + Race/Ethnicity * SES + Gender * Race/Ethnicity * SES
b. Exact statistic
c. The statistic is an upper bound on $F$ that yields a lower bound on the significance level.
d. Computed using alpha = .05
There was a significant main effect between groups when considering the interaction of gender and SES for both SIS, $F(1, 682)=5.374$, $p=.021$, partial $\eta^2 =.008$, and SRS, $F(1, 682)=6.867$, $p=.009$, partial $\eta^2 =.010$ as displayed in Table 13. The mean differences of SIS and SRS regarding the interaction between gender and SES are found in Table 14 and Table 15, respectively. Overall, male students’ SIS and SRS were lower when at least one parent had a bachelor’s degree than when their parent(s) did not have a bachelor’s degree, and female students’ SIS and SRS were higher when at least one parent had a bachelor’s degree than when their parent(s) did not have a bachelor’s degree.

Table 13 Tests of Between-Subjects Effects for SIS and SRS

<table>
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<tr>
<th>Source</th>
<th>Dependent Variable</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
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<td>Corrected Model</td>
<td>SIS</td>
<td>20.361a</td>
<td>19</td>
<td>1.072</td>
<td>1.336</td>
<td>.153</td>
<td>.036</td>
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<td>SRS</td>
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<td>.661</td>
<td>1.308</td>
<td>.170</td>
<td>.035</td>
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<td>4130.230</td>
<td>5150.955</td>
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<td>.010</td>
</tr>
<tr>
<td></td>
<td>SRS</td>
<td>4162.967</td>
<td>1</td>
<td>4162.967</td>
<td>8232.396</td>
<td>.000</td>
<td>.013</td>
</tr>
<tr>
<td>Gender</td>
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<td>.446</td>
<td>1</td>
<td>.446</td>
<td>.556</td>
<td>.456</td>
<td>.001</td>
</tr>
<tr>
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<td>SRS</td>
<td>.743</td>
<td>1</td>
<td>.743</td>
<td>1.469</td>
<td>.226</td>
<td>.011</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>SIS</td>
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<td>4</td>
<td>1.231</td>
<td>1.535</td>
<td>.190</td>
<td>.009</td>
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<tr>
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<td>SRS</td>
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<td>4</td>
<td>.264</td>
<td>.523</td>
<td>.719</td>
<td>.003</td>
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<tr>
<td>SES</td>
<td>SIS</td>
<td>.044</td>
<td>1</td>
<td>.044</td>
<td>.054</td>
<td>.816</td>
<td>.000</td>
</tr>
<tr>
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<td>SRS</td>
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<td>1</td>
<td>1.260</td>
<td>2.492</td>
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<tr>
<td>Gender * Race/Ethnicity</td>
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<td>.691</td>
<td>4</td>
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<td>.341</td>
<td>.850</td>
<td>.002</td>
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<td>Gender * SES</td>
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<td>4.309</td>
<td>5.374</td>
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<td>.008</td>
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<td>.010</td>
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<td>Race/Ethnicity * SES</td>
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<td>4</td>
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<td>SRS</td>
<td>4.120</td>
<td>4</td>
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<td>Gender * Race/Ethnicity * SES</td>
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<td>8.615</td>
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<td>2.154</td>
<td>2.686</td>
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<td>4.848</td>
<td>4</td>
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<tr>
<td>Error</td>
<td>SIS</td>
<td>546.853</td>
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<tr>
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<td>SRS</td>
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<td>702</td>
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<tr>
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<td>701</td>
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<td></td>
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<tr>
<td></td>
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a. R Squared = .036 (Adjusted R Squared = .009)
b. R Squared = .035 (Adjusted R Squared = .008)
c. Computed using alpha = .05
Table 14 Mean Differences in Science Identity Scores

<table>
<thead>
<tr>
<th>Gender</th>
<th>Parent(s) without a bachelor’s degree</th>
<th>Parent(s) with a bachelor’s degree</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3.764</td>
<td>3.508</td>
<td>-0.256</td>
</tr>
<tr>
<td>Female</td>
<td>3.457</td>
<td>3.666</td>
<td>+0.209</td>
</tr>
</tbody>
</table>

Table 15 Mean Differences in Science Relevancy Scores

<table>
<thead>
<tr>
<th>Gender</th>
<th>Parent(s) without a bachelor’s degree</th>
<th>Parent(s) with a bachelor’s degree</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3.732</td>
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</tr>
<tr>
<td>Female</td>
<td>3.620</td>
<td>3.703</td>
<td>+0.209</td>
</tr>
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</table>

There was also a significant main effect between groups when considering the interaction of gender, race/ethnicity, and SES for both SIS, $F(4, 682)= 2.686, p= .030$, partial $\eta^2 = .016$, and SRS, $F(4, 682)= 2.397, p= .049$, partial $\eta^2 = .014$. When considering SIS and SRS, shown in Table 16, Black and Hispanic male students’ scores were higher when at least one parent had a bachelor’s degree, whereas White, Asian/Pacific and American Native, and Multiethnic male students’ scores were lower when at least one parent had a bachelor’s degree. When considering SIS and SRS for female students, Black, Hispanic, Asian/Pacific and American Native, and Multiethnic female students’ scores were higher when at least one parent had a bachelor’s degree while White female students’ scores were lower when at least one parent had a bachelor’s degree.

Given the focus of research question one, it is necessary to address MSOCs, in light of the other student group identities, specifically as it pertains to gender, race/ethnicity, and SES. There is no definitive trend regarding MSOCs in general as it pertains to SIS. For example, APAN and multiethnic male students have the two highest SIS when no parent has a bachelor’s degree, yet they have lowest two SIS when at least one parent has a bachelor’s degree. When considering the total mean SIS, multiethnic male students’ SIS were in the middle of the 10
student identity groups. Even though Black male students’ SIS increase when at least one parent has a bachelor’s degree, they had the lowest SIS when SES = 0 and the lowest total mean overall whereas Hispanic males’ SIS from SES=0 to SES =1 increases their total mean overall. Even with a slight decrease in SIS, White male students’ total SIS mean does not change its order or ranking. Essentially, when considering the continuum of SIS, 1-5, all groups of students exhibited at least a moderate view of themselves as being a science person and belonging in science; they also appear to be approaching science in some way. However, Black male students did not view themselves as being as much of a science person, belonging in science, or approaching science as other marginalized groups such as Black, multiethnic, or Hispanic females or Hispanic males.

Table 16 Total Mean of Groups’ Gender, Race/Ethnicity, and SES

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>Mean, SES = 0</th>
<th>Mean, SES =1</th>
<th>Mean Difference</th>
<th>Total Mean</th>
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<tr>
<td>SIS</td>
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<td>3.500</td>
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<td>-.043</td>
<td>3.6458</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hispanic</td>
<td>3.450</td>
<td>3.768</td>
<td>+.318</td>
<td>3.6252</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiethnic</td>
<td>4.091</td>
<td>3.464</td>
<td>-.627</td>
<td>3.6329</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asian/Pacific and American Native</td>
<td>4.432</td>
<td>3.182</td>
<td>-1.25</td>
<td>3.7374</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Black</td>
<td>3.313</td>
<td>3.565</td>
<td>+.252</td>
<td>3.4266</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>3.725</td>
<td>3.610</td>
<td>-.115</td>
<td>3.667</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hispanic</td>
<td>3.524</td>
<td>3.627</td>
<td>+.103</td>
<td>3.5744</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiethnic</td>
<td>3.212</td>
<td>3.677</td>
<td>+.465</td>
<td>3.444</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asian/Pacific and American Native</td>
<td>3.511</td>
<td>3.852</td>
<td>+.341</td>
<td>3.6961</td>
</tr>
<tr>
<td>SRS</td>
<td>Male</td>
<td>Black</td>
<td>3.438</td>
<td>3.612</td>
<td>+.174</td>
<td>3.5048</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>3.649</td>
<td>3.527</td>
<td>-.122</td>
<td>3.5751</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hispanic</td>
<td>3.422</td>
<td>3.529</td>
<td>+.107</td>
<td>3.4813</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiethnic</td>
<td>3.839</td>
<td>3.320</td>
<td>-1.519</td>
<td>3.4599</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asian/Pacific and American Native</td>
<td>4.313</td>
<td>3.000</td>
<td>-1.313</td>
<td>3.5833</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Black</td>
<td>3.521</td>
<td>3.552</td>
<td>+.031</td>
<td>3.5348</td>
</tr>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>3.697</td>
<td>3.617</td>
<td>-.08</td>
<td>3.6568</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hispanic</td>
<td>3.626</td>
<td>3.741</td>
<td>+.115</td>
<td>3.6821</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiethnic</td>
<td>3.451</td>
<td>3.789</td>
<td>+.338</td>
<td>3.6204</td>
</tr>
</tbody>
</table>
When analyzing the total means for SRS, each group reported that their science learning experiences have been more than moderately relevant to them. When SES=0, Black and Hispanic male students had the two lowest SRS, meaning that they view their science learning experiences as being less relevant to them than any of the other groups; when SES=1, these male students’ SRS was higher, though their total mean SRS remain in the bottom third. According to the total mean, four of the five male race/ethnicity groups—Black, Hispanic, White, and multiethnic—and Black female students have the lowest SRS. Only those Black male students with SES=1 had SRS in the top half of all ten groups, exceeding the other four male identity groups. Additionally, four of the female race/ethnicity groups—APAN, multiethnic, Hispanic, and White—comprise the top highest SRS when SES=1.

Taking these results into consideration, Black and Hispanic male students’ SIS and SRS increase when at least one parent with a bachelor’s degree. In fact, all female non-White groups also experienced higher SIS and SRS when at least one parent with a bachelor’s degree. However, APAN and multiethnic males students SIS and SRS were lower when at least one parent with a bachelor’s degree. Therefore SES, appears to have played an integral role in how these student view themselves as a science person and belonging in science (SIS) and perceive their science learning experiences to be relevant (SRS) to them, though there are other factors at play that were not aspects of this study and analysis.
Predicting Decisions to Pursue Science Professions

Logistic regression was conducted to determine whether students’ SIS and SRS predict their decisions to pursue science professions after college. Overall, the binary logistic model specified fits the data well ($\chi^2_{model}=166.734$, df=2), with the explanatory variables approximately accounting for 30% (Ngelkerke R Square) of the differences between decisions to pursue a science profession after college or not that are considered in this study. The Hosmer-Lemeshow Test provides additional confirmation that this model fits the data well as it is ideally not statistically significant (HMT=9.384, df=8, $p=.311$). This is reassuring in that this value is not caused by a lack of power given the sample size (N=702). Only one predictor, students’ SIS, significantly predict students’ decision to pursue science professions, $b=1.291$, Wald $\chi^2(1)=81.636$, $p<.001$.

When considering SIS, SRS, gender, presence of a science mentor, SES, and race/ethnicity, the binary logistic model specified fits the data well ($\chi^2_{model}=200.349$, df=10), with the explanatory variables approximately accounting for 35.2% (Ngelkerke R Square) of the differences between decisions to pursue a science profession after college or not that are considered in this study. The model accurately predicts 76.8% of the cases. The Hosmer-Lemeshow Test provides additional confirmation that this model fits the data well as it is ideally not statistically significant (HMT=6.213, df=8, $p=.623$).

Of these six variables presented in Table 17, students’ SIS, $b=1.448$, Wald $\chi^2(1)=87.475$, $p<.001$, gender, $b=.851$, Wald $\chi^2(1)=16.587$, $p<.001$, and race/ethnicity, Wald $\chi^2(1)=10.456$, $p=.033$, were statistically significant in predicting students’ decisions to pursue a science profession after college.
Table 17 Significance of Predictor Variables for Students’ Decision to Pursue Science Professions

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp(B)</th>
<th>95% C.I. for EXP(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Race and Ethnicity</td>
<td>10.456</td>
<td></td>
<td></td>
<td>4</td>
<td>.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race and Ethnicity(1)</td>
<td>.408</td>
<td>.286</td>
<td>2.028</td>
<td>1</td>
<td>.154</td>
<td>1.503</td>
<td>.858</td>
</tr>
<tr>
<td>Race and Ethnicity(2)</td>
<td>.791</td>
<td>.252</td>
<td>9.841</td>
<td>1</td>
<td>.002</td>
<td>2.206</td>
<td>1.346</td>
</tr>
<tr>
<td>Race and Ethnicity(3)</td>
<td>.425</td>
<td>.429</td>
<td>.982</td>
<td>1</td>
<td>.322</td>
<td>1.530</td>
<td>.660</td>
</tr>
<tr>
<td>Race and Ethnicity(4)</td>
<td>.465</td>
<td>.354</td>
<td>1.731</td>
<td>1</td>
<td>.188</td>
<td>1.593</td>
<td>.796</td>
</tr>
<tr>
<td>Gender(1)</td>
<td>.851</td>
<td>.209</td>
<td>16.587</td>
<td>1</td>
<td>.000</td>
<td>2.342</td>
<td>1.555</td>
</tr>
<tr>
<td>SES</td>
<td>3.359</td>
<td></td>
<td></td>
<td>2</td>
<td>.187</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES(1)</td>
<td>.164</td>
<td>.254</td>
<td>.416</td>
<td>1</td>
<td>.519</td>
<td>1.178</td>
<td>.716</td>
</tr>
<tr>
<td>SES(2)</td>
<td>-.310</td>
<td>.224</td>
<td>1.908</td>
<td>1</td>
<td>.167</td>
<td>.733</td>
<td>.472</td>
</tr>
<tr>
<td>SRS</td>
<td>1.448</td>
<td>.155</td>
<td>87.475</td>
<td>1</td>
<td>.000</td>
<td>4.253</td>
<td>3.140</td>
</tr>
<tr>
<td>SRS</td>
<td>-.021</td>
<td>.172</td>
<td>.016</td>
<td>1</td>
<td>.901</td>
<td>.979</td>
<td>.699</td>
</tr>
<tr>
<td>Constant</td>
<td>-4.918</td>
<td>.605</td>
<td>66.113</td>
<td>1</td>
<td>.000</td>
<td>.007</td>
<td></td>
</tr>
</tbody>
</table>

a. Variable(s) entered on step 1: Race and Ethnicity, Gender, Had a Science Mentor, SES, SIS, SRS.

As students’ SIS increases (approaches science), the likelihood of them deciding to pursue science profession increases. For every unit increase in SIS, the odds of a student deciding to pursue science profession increases by a factor of 4.253. To analyze the categorical variables, Table 18 provides the necessary coding. The odds of a student deciding to pursue science profession after college decreases by a factor of .432 when the student is male.

Compared to White students, the odds of a Hispanic student deciding to pursue science profession after college is increased by a factor of 2.206.

Table 18 Categorical Variable Codings

<table>
<thead>
<tr>
<th>Race and Ethnicity</th>
<th>Frequency</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>294</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Black</td>
<td>117</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Hispanic</td>
<td>183</td>
<td>.000</td>
<td>1.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>APAN</td>
<td>43</td>
<td>.000</td>
<td>.000</td>
<td>1.000</td>
<td>.000</td>
</tr>
<tr>
<td>Multiethnic</td>
<td>61</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SES</th>
<th>Frequency</th>
<th>Parameter coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both of my parents/guardians have a bachelor’s degree</td>
<td>163</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Additionally, a one-way ANOVA was conducted to determine the mean difference in SIS and SRS between students who had a mentor in science and those who did not have a science mentor. There is a significant difference between these groups of students when considering SIS, $F_{\text{Welch}}(1, 286.989)=56.040, p<.001$, whereas students who had a science mentor had a higher SIS ($M=4.00$) than students who did not have a science mentor ($M=3.478$). Following this same trend, students who had a science mentor also had higher SRS ($M=3.804$) than those who did not have a science mentor ($M=3.564$), $F(1, 699)=13.287, p<.001$.

**Relationship between Science Identity and Decisions to Pursue Science Professions**

An assumption can be made that it is likely that students who have a strong attraction towards science will probably also have a desire to continue to incorporate science in their lives beyond their formal educational experiences. The ISLDS results support this claim in that there is a strong positive correlation between students’ science identity and their decisions to pursue science professions, $r(697) = .466, p<.001$. Essentially, students who have decided to pursue science professions after college graduation are more likely to recognize themselves as being a science person and belonging to the science learning community. It is critical to emphasize that
one’s science identity is not static or set in one particular place or moment in time. It can be shaped and developed by societal, relational, academic, and professional factors over time.

*The Lived Experiences of Five Male Students of Color in STEM*

Phases 2 and 3 address the second and third research questions, respectively. These questions narrow the focus of this study by presenting a more microscopic view and personal perspective of the lived experiences of five male students of color who participated in the survey. These semi-structured individual and mini-group interviews allowed me to gain information about these young men’s background, learning experiences, aspirations, relationships, and other meaningful identity-shaping factors. Before presenting the findings for each of these questions however, I briefly introduce each of these young men individually to gain greater insight about their lives, their concerns, and their voices. These bio-sketches found in Table 19 describe the context of our initial Zoom interview, each participant’s status as a student at Creek State College, their self-identifying terms from the Identity Web in Figure 3, and a name and a quote that captures a prevailing aspect their personality throughout our interaction. These descriptive names serve to counter persistent deficit labeling and inaccurate representation of male students of color in science and STEM in education research by signaling their personalities and how they approach STEM fields.

*Table 19 Interview Participant Bio-Sketches*

<table>
<thead>
<tr>
<th>Participant Name</th>
<th>Student Status</th>
<th>Self-Selected Identity Web Descriptors</th>
<th>Personality Attribute Quote</th>
</tr>
</thead>
</table>
| Derrick the Curious Researcher | Recently received a Bachelor’s in Health Sciences from CSC. He continued at the college to pursue a nursing degree | • Male  
• Heterosexual  
• Non-disabled  
• U.S. Born  
• English- 1st language  
• Christian  
• Young (28 years old)  
• Person of color | ...most of my questions have to do with like just wondering how people came up and did what they did...we look at the like engineers...but like how the heck did anyone come up with the first |

98
<table>
<thead>
<tr>
<th>Participant Name</th>
<th>Student Status</th>
<th>Self-Selected Identity Web Descriptors</th>
<th>Personality Attribute Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toni the Critical Thinker</td>
<td>A senior in a technology magnet high school and is pursuing an Associate of Arts degree</td>
<td>▪ Dark-colored skin</td>
<td>...how you solve the problem...are just different ways to think critically and there’s obviously...the information, do what you will with it and that’s I think critically and that’s also really cool.</td>
</tr>
<tr>
<td>Orlando the Practical Motivator</td>
<td>A student at CSC for three years who is planning to become a computer engineer.</td>
<td>▪ Male ▪ Heterosexual ▪ Born outside of the U.S. ▪ English as 2nd language ▪ Christian/Catholic ▪ Young (22 years old) ▪ Continuing generation college student ▪ Working class</td>
<td>I have to explain them...that they can do it...and it’s going to be something that is going to benefit them in the future.</td>
</tr>
<tr>
<td>Miguel the Reflective Explorer</td>
<td>An adjunct professor at a different state college and is enrolled in CSC to pursue an Associate of Science degree in video game development Has a bachelor's degree in Computer Science from Venezuela</td>
<td>▪ Male ▪ Heterosexual ▪ Born outside of the U.S. ▪ English as a 2nd Language ▪ Young ▪ Light-colored skin ▪ White (Caucasian/Venezuelan) ▪ Hispanic ▪ Continuing generation college student ▪ Working class</td>
<td>Even for doing a manual job, you need some kind of intelligence...you need the skills...</td>
</tr>
<tr>
<td>Fernando the Bridge Builder</td>
<td>In his first year as a CS student who began attending CSC after his job ended due to Covid</td>
<td>▪ Male ▪ Heterosexual ▪ Born outside of the U.S. ▪ English as a 2nd Language ▪ Christian/Catholic ▪ Non-disabled ▪ Young ▪ Hispanic ▪ 1st generation college student ▪ Working class</td>
<td>I always want to have this dream job of being a civil engineer since I was a toddler.</td>
</tr>
</tbody>
</table>
Phase 2: Shaping the Science Identities of Male Students of Color in STEM

Phase 2 of data collection aimed to answer research question two that asks: How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions? The target population included MSOCs enrolled in a STEM-related course at CSC; five MSOCs—Derrick, Toni, Orlando, Miguel, and Fernando—were the participants of the Phase 2 semi-structured interviews. The key finding is that their future-focused mindsets, connectedness to technology, engineering, and math, and science experiences and ideas greatly shaped their decisions to pursue science professions. Interacting with these themes were the participants’ relationships with meaningful others and their perspectives about race, ethnicity, culture, and society.

Based upon the transformative mixed-methods research design, I integrated the quantitative and qualitative components of the research findings for research question two by first presenting the relationship between survey participants’ science identities and their decision to pursue science professions, paying special attention to the five interview participants results. Next, the overarching themes regarding science identity and decisions for professions in science interaction will be presented from the thematic analysis of the individual interviews.

To focus this insight toward the five male students of color interviewed in Phase 2 of this study, their composite science identity scores (SIS) and decisions for professions in science (DPS) are provided in Table 20. All five interview participants have high composite SI scores exceeding the average for the survey participants, N=702, M= 3.59. Compared to the other five participants, Fernando has the lowest score and reported that he has decided to not pursue a profession in science. Even though Toni’s SI score was higher than Derrick’s, Toni remains undecided regarding a future profession in science. These numbers are helpful, but they do not tell the complete story. The specific factors that contributed (and continue to contribute) towards
the shaping of each of these young men’s individual SIS-DPS interaction are not as easily analyzed quantitatively. These five participants’ responses and reflections throughout the interviews, the qualitative component of this study, present the backdrop against which these survey responses take on new meaning and understanding.

Table 20 Interview Participants' Science Identity & Decisions for Professions in Science

<table>
<thead>
<tr>
<th>Interview Participant</th>
<th>Science Identity (SI) Score</th>
<th>Decision for Professions in Science (DPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derrick</td>
<td>4.09</td>
<td>Yes</td>
</tr>
<tr>
<td>Toni</td>
<td>4.36</td>
<td>Undecided</td>
</tr>
<tr>
<td>Orlando</td>
<td>4.91</td>
<td>Yes</td>
</tr>
<tr>
<td>Miguel</td>
<td>5.00</td>
<td>Yes</td>
</tr>
<tr>
<td>Fernando</td>
<td>3.73</td>
<td>No</td>
</tr>
</tbody>
</table>

Lived Experiences, Science Identity, and Decisions for Professions in Science

There are events, intentions, and life that exist behind and beyond these numbers that can only make sense when these students of color share these moments in the individual interviews. In answering this research question, five themes developed as a result of the thematic analysis of these interviews. Three of these themes describe primary interactions to better understand of the relationship between SI and DPS. These three primary interactions include participant’s 1) future-focused mindset, 2), connectedness to technology, engineering, and math, and 3) science experiences and ideas. However, the activities and outworking of these SI-DPSP shaping factors are enveloped by two secondary but significant factors, participants’ relationships with meaningful others, and their perspectives about race, ethnicity, culture, and society as presented visually in Figure 5.
The term secondary in no way means unnecessary; however, these factors are threads that run throughout each participants’ telling of their lived experiences in relation to their intersectionality, science learning, career plans, and aspirations. Figure 6 uncovers the specific potential pathways that connect all five themes to make sense of participants’ SI-DPSP dynamic.
The three primary themes will be presented individually and will include supportive quotes and examples from participant interviews. Yet, these themes cannot be presented as separate silos from one another; because they often appear to work in tandem, so the interactions are important to consider.

**Future-Focused Mindset**

It was clear throughout each interview that these gentlemen had already been thinking about their future professions and aspirations for quite some time. At the beginning of the interview, they were asked to share their short-term and long-term goals. However, throughout our hour-long conversations, a fuller picture of the reasons behind their future-focused mindset
regarding particular professions in a science or another STEM field became more developed and nuanced. Generally, each participant’s reasoning emphasized their plans for success, stability, and security in pursuing specific careers.

Derrick’s primary goal in pursuing higher education and a science profession is to make more money and increasing his pay rate. Initially, he wanted to become a surgeon or a Doctor of Osteopathic Medicine, because he was greatly interested in medicine, specifically natural medicines, and specialties that deal with human body systems. While he recently graduated from Creek State College with a bachelor’s degree in health sciences, he is continuing to pursue a nursing degree. Part of his reasoning is wrapped up in the frustration at being bald and that the hair treatment clinics he explored did not seem to be able to help Black men regrow their hair. When I asked whether he still aspires to be a surgeon one day, he shared:

I don’t know about now…it’s really more selfish than anything, like getting my hair back and stuff like that…like knowing the truth, so I can actually make the right decisions in my own personal life. And if I’m working in a field that can give me experience in that, and I can help other people while helping myself, I think that’d be great.

Toni, Orlando, and Fernando, and are pursuing engineering programs at Creek State College and plan to transfer to a local state university upon the completion of their associate degree. While he had not yet decided on a college minor, Toni expressed his desire “to either work a really big company” or own his own company. His reasoning was a combination of having a sense of job security, giving back to his mother, and helping people in the community some way. His relationship with his mother was very evident.
…like making money like to repay her would be really nice and then because of how hard she works…I want to be able to do the same thing whenever I’m a parent. So, either owning a business or being in a position where I have…safety is really nice.

Looking back retrospectively on the past in light of one’s current status and expectations provided another angle to view the students’ future-focused mindset. Acknowledgement of either past mistakes, choices, or simply unpreventable challenging situational events enabled several participants to look towards their future goals through a new self-reflective point of view.

Derrick acknowledged that he “messed up” his first attempt in pursuing a degree when his mother gave him an ultimatum and the option to “go to college or join the military”. He shared that he tried both options. When asked if he completed coursework at the first community college he attended in 2016, he replied, “Yeah, completed some…that classes that I [was] interested in, I’ll just say I got an A and then the ones I didn’t care about that I had to take for my degree I failed.” He continued to share how he enrolled in Creek State College with some prerequisite coursework credits, and a new sense of focus, as he graduated with a bachelor’s degree in December of 2020.

Miguel’s status as a native of Venezuela demonstrates a future focus as he reflects upon the years he spent as a refugee in the United States:

I think I didn’t mention I’m a refugee. I came here to the West from Venezuela. I submitted that an asylum…I’m waiting on it. It takes time…back in my country, I was working a software company…You know, coming from an office job, coming there to the U.S. …it takes time to find a job, like an office job or something similar to what I was doing. So, at the beginning, I took whatever I found…I worked in construction. I work in farming. I worked in warehousing. I also waited tables in a restaurant. You need a bunch
of working-class jobs. I was, you know, I was kind of like in a bubble...even though things were bad. I came to...[the] States with that mindset...“I’m a professional. I need a professional job”.

Miguel continues to describe how the experience of having to work in manual jobs when he immigrated to the United States, humbled him, and it made him “appreciate everything more”. Even though he expressed gratitude with his current status of working as an adjunct professor, owning his own tutoring business and online store, he still considers himself to be a member of the working class.

Another aspect of this future-focused mindset is the concept of preparation. All of these men considered what steps they needed to take now or in the future to be prepared for them to accomplish a certain important goal.

Miguel’s experience as a refugee—struggling to find a professional office job in the United States—motivated him to “be better, to learn more”, proving to be one of the reasons that he enrolled at Creek State College. Even with a bachelor’s degree, he found it very difficult for him to find work. He adds, “I feel like companies don’t feel like [that bachelor’s degree is] good enough, maybe...it’s not an American bachelor”. He states this “misconception” that a Venezuelan bachelor’s degree is not as good as an American was why he has been taking strategic steps to enroll in college. “I wanted to have like an American degree, in this case an associate. And I think I believe, I still believe that that’s going to help me in the future to get, to get a new position, a new job.”

Fernando expressed similar sentiments as Miguel. Shortly after Fernando applied for his permanent resident card, the global pandemic began. He was laid off of his job. “I was like free in my house you know, and so I decided to start like studying full time.” He has had several jobs
since living in the United States, including as an office assistant, a collection representative, in a car dealership, and a scheduler for an air conditioning company. Yet, his reflection upon those life experiences are not wasted.

I say [I am in the] working class, because um, yeah I mean I am from the lower class… I mean it doesn’t mean that I’m going to be like this forever, but you just give me an idea of for… being like what did that, where did that start right? And what I will expect to be, and I don’t want to lose you know, like that identity.

Planning for the future entails taking practical steps toward these goals and taking advantage of unexpected opportunities that arise. For example, Orlando took more humanities classes prior to enrolling in college, because he knew he would learn more English in those classes. When asked why he selected Creek State College, Orlando responded,

I heard so many you know, like reviewed that it’s a nice school, and it’s actually near where I live and also they have so many programs…I’m going to be honest, but it’s actually cheaper than going straight to any University in all the States.

He continued that the cost of higher education was important for him because of his immigrant status and not being able to receive financial aid. He also researched computer engineering careers and realized the demand of engineers in countries throughout the world. He readily explores websites like LinkedIn to learn more about local opportunities in engineering and has connected with individuals who work at Siemens, a company where he would like to work. Connected to Orlando’s proactive approach for preparing for his future is the reality of his family’s immigrant status as well. In Venezuela, his father was a lawyer and his mother worked in a laboratory. Nevertheless, he shares, “So well my mom, she works at cleaning and my dad works with Uber and Lyft. It’s kind of like sad, because they, I mean, they’re actually
professionals, but they cannot [be here].” Considering the future and taking steps in that direction is part of Orlando’s contribution to make life better for his family as well as himself.

At times, these students shared their dreams, aspirations, or ideal situations they could imagine or consider. Toni expressed that if he had all of the resources he needed, he would have a business in biochemical engineering, because even though it is “super hard…it’s both chemistry and engineering”. Miguel spoke about working for Pixar or Disney Imagineering as a 3-D animator. His research about the animation job industry has him making plans to one day move to California or New York where the opportunities to flourish in this technology field are greater. Fernando shared that he has been wanting to build bridges since he was a toddler. He describes the grandness of the famous bridges in San Francisco [the Golden Gate] and Dubai as well as the impressiveness of the Great Wall in China.

*Connectedness to Technology, Engineering, and Mathematics*

The importance technology, engineering, and mathematics (TEM) have to all of these young men cannot be overstated. The ISLDS was administered through various STEM courses at Creek State College, which increased the probability that potential interview participants would come from areas of microbiology, chemistry, physics, computer science, engineering technology, or trigonometry courses, for example. For these young men, TEM enable people to peak into, navigate, and create the future in innovative and practical ways.

Video games was one of the initial codes during the data analysis. Derrick, Toni, and Miguel provided a wealth of insight regarding the role video games play in the development of their connection to science, relationships, and their future endeavors and interests. The excitement with which these students described the details about video game play or design underscores the significance this example of TEM holds in their lives and relationships.
Aside from playing basketball and other sports in middle and high school, playing video games was also a big part of Derrick’s adolescent years. Video games were an initial point of interest in science for him.

I was huge video game[r] actually in middle school and elementary. I was playing video games all the time. Okay, I think I learned more science from the video games [than I did in] school, though, which is probably… where I learned most of my science.

He described several video games in detail such as Splinter Cell, his first Xbox game, and HALO. Splinter Cell was an espionage game where the character would sneak into foreign countries to get certain intel. He admired the special agent in these games because they did “cool stuff”. Derrick admitted that he probably played it too many times. HALO was his game of choice during high school. It took place in space in which a big ring, the halo, was built to be a peaceful environment for civilization though inevitably, war and fighting would ensue.

Toni’s interest in video games seems to match Derrick’s enthusiasm. Just like Derrick, Toni enjoys the fighting games.

I’m a very big fighting game fan… I play Super Smash Bros a lot. I like Pokémon obviously, I’m a Nintendo kid… But recently, I’ve been going to a game called Hades, which is rogue-like, and it’s fantastic. I mean, it was like the number one game [of the year]!

Toni shared that while he would like to play more than he does. He mentioned that he is more interest in the “game culture than actually playing video games”. He continues to stay current and knows “a whole bunch of games”, but he does not have as much free time to invest in playing them.
Derrick’s experiences echo the game culture Toni mentioned. He recalls video games being a major topic of conversation with his friends and peers as they would often play together after school. They were always waiting for the “next big game”. He said that they “look more and more real…the stories are getting better and better…and the graphics [too].” He asks if this would fall into the category of computer science and mentioned that “it wasn’t the game itself, [but] it was more of the stuff in the game” that was most interesting to him. Things like the weapons, the technological advances, lasers, etc. that sparked his curiosity. He said that an intriguing aspect of the science in video games present glimpses of what “we’re capable of”.

Toni zeroes in on the specific way video games address certain aspects of science, specifically highlighting a YouTube channel called Game Theory. He describes that when this show first began about seven years ago, the host would discuss a specific video game and the “cool thing that can happen in the video game” and whether these events would actually be able to occur in reality.

I remember one who was talking about BioShock, which has a city underwater, and he talked about…what erosion is and here’s why all the reasons why the city wouldn’t work. It would be worn away in this…amount of time. Here’s what the acid in the water would do to it.

The direct relationship between the technology and story of video games to science is evident. Additionally, Derrick’s reflection of his mother presents a unique interaction among TEM, science, and relationships. I asked him whether he thought his mother would consider him to be a science learner. Derrick was unsure as to what his mother would say. He told me, “I don’t know because she doesn’t even play video games. I don’t think [she] cares about science at all.” To him, it seemed, that engaging in video games was a form of a science language, so to speak.
Despite Derrick and Toni’s obvious interest and investment in video games and gaming culture, neither of these young men are pursuing careers in the video game industry. Miguel, however, expressed a clear path he is taking towards a career in video game development. He is taking “anything to do…with engineering and technology because those are [the] programming [classes]…Right now [I’m] taking a simulation and computer design class…those kind of classes are kind of like in-between science and arts.” Miguel adds that in order to create the 3D animation and computer graphics that are found in video games or 3D animated movies, “you need to be artsy.”

From Miguel’s perspective, art is integral to designing and creating visual animations and one needs to be proficient regarding using the appropriate computer software. Additionally, he explains, “And you need to know math, or you need to know…the technical stuff. And I mean, I like both [of these] as a career, because even though I like science, I also like arts.” To Miguel, a career in video games and other 3D animation represent the culmination of the different fields he enjoys exploring and the different characteristics of who he is as a person and a son.

…you know, the way I grew up, my father is an engineer…a civil engineer. He…used to work in a architecture company…building buildings, designing stuff and all that. He also worked for many years in the oil industry. But my mother, she was a kindergarten teacher…she got a bachelor in the fine arts. So, my mother is an artist, so I can have both…I’m sort of in the between.

Orlando’s approach to technology has a very similar approach as Miguel’s in that he describes technology as a central juncture where variety of academic fields, careers, “almost everything” meet, communicate, and progress. The descriptive verbal picture he provided was
that “technology is holding hands with …health…the environment… humanities.” He sees technology everywhere and provides his reasoning as well.

Everything that you see is technology and people say… just only a computer… a table is technology, because you have to design it, you have to make the parts, you have to put them together to make it work… technology is holding hands with all those aspects that are in there.

Orlando presents both the practical everyday functions TEM contribute to society such as solar panels, hybrid cars, and even Google. He discusses how people say that “math doesn’t really matter, but it actually matters because everything that is around us has math… like the shape [design] of a bottle of water…” But at several places in our interview, he describes TEM as a pathway to better society and prevent, or rather, avoid events like the pandemic in the future. He wants “to make life easier for everyone” and doing this also ensures that he will “create… new stuff” as well.

Earlier in the interview, I asked Orlando why he wanted to pursue engineering. He shared that his older brother was studying engineering in Venezuela, but because of the war and dictatorship, his family had to escape. His brother taught him some of the concepts of computer engineering and encouraged Orlando to move in that direction as his grades in science classes were good. The encouragement and motivation from his family cannot be easily detangled from Orlando’s connectedness to TEM, nor can it be distilled of his experience as a refugee fleeing a war-torn country that he hopes to help one day.

In analyzing Fernando and Toni’s interview transcripts, I discovered that they referenced or described mathematics 20 and 27 times, respectively. (Derrick had 0 mathematics references and Oscar and Miguel both had 8.) Additionally, they were the only two interview participants
who, according to their ISLDS responses found in Table 12, had decided not to pursue science (Fernando) or were undecided about pursuing science professionally (Toni). Fernando’s composite SI score is the lowest of the five students as well, meaning that he does not identify as strongly with science as the others do. What Fernando’s interview contributes to these statistical findings is evidence of a strong connection he has with mathematics. Whereas much of Toni’s references to mathematics center around various topics like his teachers, coursework, academic goals, and problem-solving approaches, Fernando’s primarily describes math as something he loves to do.

For example, when I asked Fernando whether he would have considered himself to be a science learner when he was younger, he replied,

I would say ‘no’…I mean that I was so in love with math and physics, even chemistry…balancing equations and balance atoms, I love that, and I was the best at it.

You know, I even had the chance to help other students…

In other parts of the interview, Fernando expressed that he loved learning and doing math. He explained, “I just believe that mathematics is more than, than science...I just think math is connected to everything…that science need math to prove…experiments…Math is just the start for everything.” Mathematics is the language that seems to be a way that Fernando connects with his classmates and the world around him. He described that he liked knowing that in physics, “there is only one correct answer…that you can go this way, you can go right”. He has several books about engineering with challenging equations. But even though he does not understand them now, he says, “I just keep them there you know because I know…one day, I’ll understand them.”
These characteristics of math align with Fernando’s desire to build bridges, but they also provide insight into his care for the environment and our world. Throughout the interview, he describes his interest in rechargeable batteries and renewable energy resources to help utilize electric cars and solar panels.

To Fernando, mathematics and science are clearly two very distinct subjects and fields, and mathematics is the more fundamental and meaningful of the two. In exploring his interview responses with a closer lens, his survey responses are less of a puzzle and more of a unique and interesting discovery.

*Science Experiences and Ideas*

Science identity construct is guided by individuals’ recognition of themselves as a science person and how others view them. Individuals may express how they feel as though they belong in science learning communities. Science identity also encompasses the knowledge and understanding individuals have about science, how to conduct science tasks, or communicate effectively about science to others. These science-oriented findings aim to share how certain interactions with science and other factors within these students lived experiences may contribute to a clearer picture of these students’ science identity development, particularly how or if these factors lead to them deciding to pursue science fields beyond their college classrooms.

With this understanding, I will be presenting these young men’s responses graphically followed by significant excerpts from their interviews that connect to other themes. Several interactions between science and their future and TEM have already been described; this section will focus more specifically interactions with the secondary themes.
Derrick’s connection to science was very apparent from the beginning of the interview and much of the lived experiences that he shared demonstrate clear interactions among science and relationships with meaningful others and his perspectives about race, ethnicity, culture, and society. After I asked Derrick what made him choose health science, he eagerly replied, “I love science, and I love…my health. And uh, I’m a pretty nerdy guy too. So that may have a lot to do with it.” From Derrick’s Science Identity Web in Figure 7, it becomes evident that Derrick has high expectations for science that are simultaneously existential and empirical. For example,
Derrick strongly connects science to his Christian beliefs, socio-ethical issues, and the attainment and access to money or financial resources.

After he says that he views science as “like finding answers…like finding truth”, I asked him if he could give me an example.

like as far as like who I am, my… identity, you know, like why I’m Black, why everyone cares about color, you know, in terms of history and like… why the religion argument is such a big deal. Why people, you know… um… why some people get paid more than others… that's been huge for me. Like as I learn more, I kind of get more questions so.
That can go on and on.

Derrick describes science as a central idea from which or through which ways of thinking and moving about in the world emanate. Throughout our conversation, Derrick mentions money and its significance to his life and well-being. He connects money very plainly to a primary interest in his life: having a healthy and fit body. He describes how he considers himself a scientist because he likes to experiment with which types of food he can eat after working out to reduce soreness. He researches and discovers that antioxidants like pomegranates are good for this reason. “I hate feeling sore after a workout I hate it, so I really try to experiment with what I eat afterwards to see what makes me feel better after workout.” However, the pomegranate juice in the “nicely shaped bottle” and the whey protein shakes he drinks after the juice, he explains, can be “kind of expensive”. Later, he shares that he really loves salmon, because it is really good and easy to prepare. However, salmon can be very expensive for him and his budget. He then connects science, religious beliefs, and economics by saying that if a person wants to eat salmon instead of pork, “which is supposed to be unhealthy, if you like, [read] like in a Bible” but cannot afford to, this presents a challenging situation. In one sense, he acknowledges that pigs are easier
to raise than salmon; however, he is confused as to why something that is healthier for a person costs more than something that person thinks is unhealthy. He does not know if this reasoning entails common sense or science, but he mentions that deductive reasoning aspect connects this real-world concern to science.

Derrick admits that he was not the science learner he is now in his formal K-12 schooling. He makes a statement about hanging out with people who looked like him, and that he and these peers were more focused on entertainment and sports than science in school. He then says, “I feel like scientists save the world at this point…and we were kept away from that and other people took it for themselves, you know…and that would make a lot of sense, in my opinion.” He continued to explain “Well, as a dark-skin Christian man, you know, I feel like um…I don’t know. It’s just um…[long pause] I don’t know how to explain it. But like a lot of people…[long pause] I forgot the question.” After probing into the reasoning behind the connection between science, his race, and his faith, he shared the only story of his K-12 science learning he vividly recalled:

I'm just guessing. I'm not sure why I wasn't interested in science more. But I loved zoology, so that was something. Like our professor, he taught us about you know, the different types of animals, kingdoms, and I love learning about how we're all related and stuff like that. And I love arguing with my teacher, now that I remember, about evolving from monkeys and Charles Darwin. ‘Cause I really don't believe it, you know?

After sharing this recollection, I said, “Okay.” And he quickly added in a more emphatic and serious tone: “[I] don't believe it at all. [pause] I hate looking at monkeys, 'cause…that, and they don't look anything like us or act like us, you know.” Without adding more meaning to the words that he spoke, the sharp change in his voice and vocal inflections resembled a mixture of
both hate and deep hurt. At this point, it seemed more respectful for me to not probe further into these deep feelings that had surfaced. Instead, I moved on to ask him the next and final question of the interview.

**Toni the Critical Thinker**

![Toni's Science Identity Web](image.png)

*Figure 8 Toni’s Science Identity Web*
When asked for the reasoning behind the terms he chose to describe science, Toni said, “I know science as a growing what you know type of idea. So, you could take what you know, and you expand upon it as much as you possibly can.” This “growing what you know” made him consider the different types of sciences that exist and how they have “specific parts” and skills. He differentiates between science and math in that science is more “hands-on where you have to physically …see stuff…through microscope of just in life with your eyes”. He mentions that science is much more “free-form”. A person, from his view, can have an idea and potentially be able to pull from multiple scientific approaches or fields to “create a hypothesis from on random piece of information from a completely different type of science.” He describes himself as being “a pretty active science learner” and that even though he has peers who are not taking a science class, he cannot imagine himself never taking science.

Toni describes himself as being “a very curious person”, as shown in Figure 8, and that he wants to learn science she he “can learn about stuff”. He says that he likes critical thinking a lot. He used video games as an example of critical thinking. “…I remember writing a paper on like…how critical thinking is specifically right there in…fighting games.” He mentions how players have to figure out how not to get hit in the game and how to strategize to survive. He highlights problem-solving as being critical thinking as well, drawing attention to science and how he reverse-engineers problems to find a solution. One statement he made about his mindset towards studying science that stands out in a particular way:

I think I learned early on that it’s better to understand something than just to memorize it. So…understanding a topic is really just makes it so it’s a lot easier to like, know about it and luckily everything I’ve done…helped me realize that.
He then lists a series of questions he asks himself as he studies chemistry, for example, that shed more light on Toni as a critical thinker:

So, if I were to explain this to someone, how would I do it…What are the best ways someone could learn it…What are the best ways I could learn it technically… and then also, if, if I’m learning this now, what does it mean… how am I going to use this is…it is it actually important…how does it connect and everything else? And I think the ‘how does it connect and everything else?’ works well when I try to reverse engineer and answer…that way is the reason I can find some answers in non-typical ways if I don’t remember a formula or something.

It is possible that Toni’s science-centered characteristics may simply be part of his natural personality. However, it was very evident that much of Toni’s connection to science is largely oriented around his formal science learning, especially as it pertains to his teachers and professors of science. Even though Toni’s favorite science is chemistry, he has very clear images and detailed stories about the different areas of science instruction from his elementary through his high school teachers. He recalls liking the teacher that taught math and science more than the teacher who taught English and social studies when he was in fifth-grade. Toni participated in clubs like Odyssey of the Mind throughout his schooling. He recalls being a part of a select group of advanced students who explored Oobleck and paper airplanes to learn about aerodynamics on Fridays. He is able to recount many of his science teachers and critiquing their instruction with adjectives like “boring”, “strict”, “really good teacher”, “really bad teacher”, and “fantastic” to name a few. Though it is not possible to specify the degree to which Toni’s SI was shaped by his science teachers, their instructional delivery and passion in teaching science were
not lost on his memory or his view on what relevant science teaching should be. I will address his contributions to this topic more deeply for research question three.

Academic grades are very directly connected to Toni’s relationship with science and his science teachers, particularly prior to attending Creek State College for dual enrollment. He described his eighth-grade science teachers as being “fantastic” and “absolutely phenomenal…and I actually got a 100 in the entire class”. Receiving good grades in his classes is very important to Toni, as well as surrounding himself with peers who are smart and hard-working. He stated,

… in high school, … I was lucky enough that in sophomore year I made friends with like really smart kids, … I don't have that many friends that like are slackers luckily, because I feel like if I’m friends with slackers than I’d slack off.”

He also shared how he thought his mom and his classmates or friends never would consider him as being a science learner, though maybe some of his teachers would. In middle school, he would have been thought of as a “smart kid”. To his parents and peers, he probably would be referred to “maybe just as a learner in general”.

Toni’s SI did not appear to have a direct interaction with his Hispanic ethnicity, though he did mention studying to impress a girl he liked in middle school, only to be informed by her friend that Toni was too “brown”. He recognizes his that he can be “seen as like normal-ish” because English is his first language, despite having tan-colored skin. He also mentioned that there have been few Hispanic students in his A.A. program and described the general makeup of students’ demographics he’s observed at the college so far. “I know there’s a lot of African Americans with a lot of Asian people…a couple of Arabic people who go [the Creek State College], but a lot of them have light skin, there are very few, like very dark-skinned people.”
Toni is aware of race and ethnicity, but as a student of color, these societal factors do not seem to greatly shape his participation in science or his science identity.

**Orlando the Practical Motivator**

![Orlando's Science Identity Web](image)

*Figure 9 Orlando's Science Identity Web*

Orlando esteems science very highly. He provided ways and processes that science has been a regular aspect of everyone’s everyday lives: “The electricity, the how we get the water … from the lakes or from rains. how that bed is made … to mill work.” He also recognizes that there is an aspect of science processes that makes people research in formation to determine what is real science and what is fake. He discussed how theories play a role in this decision-making process, but there are other aspects to consider. He explains,

…some theories…are not true, like for example, some people say “Oh yeah it's saying that people think that the world is flat”, that is not true…I know that sounds as a theory, that's why I say, not all these theories are right. But some of them are right… You always
have to be, you know, very logical and visualize like the panorama when you read stuff [on websites], like you have to like imagine…double think what you're reading so you can understand in real life.

Looking closely and figuring out how different pieces of information make sense and fit together are necessary components of science to Orlando. These components are not ostracized from real life but are a part of life and society regardless of whether people recognize it or not. Figure 9 echoes how greatly Orlando’s emphasizes the importance of science for everyone.

Given that most of Orlando’s schooling occurred in Venezuela prior to immigrating to the United States, his comparisons between his science learning contexts are key findings in understanding the shaping of his science identity. He attended private school in Venezuela from elementary through middle school; he completed his sophomore through senior year of high school at a local high school where he lives in the United States.

In his home country, he learned more about how computers, primarily on paper as there were not as much access to technological educational resources in Venezuela. However, he did more laboratory work in his science classes in Venezuela than he did in the U.S. science classes. Much of the science instruction in his U.S. classes was lecture-based. Speaking about his biology class he said, “…so I didn’t enjoy it that much…it was fine, but we didn’t do that much of lab as well”.

Orlando would be considered to be a people-person, very friendly and is not shy. He said that his teachers and peers very much think of him as a science learner. He said that once they begin conversing, they ask if he plans on being an engineer or working in a science lab, because he knows “a lot of stuff”. He continued by saying, “sometimes I wear my glasses, and they say ‘Yeah, you like a scientist, or like a nerd or something like that.’ ”
His outgoing personality, Venezuelan upbringing, and strong connection to science has led him to critique his peers who were born in the U.S. and speak English as their first language. “…it’s funny…because I have friends in college, even for now for Chemistry. They were born in this country, and they don’t like really wanna’ do what they’re supposed to do, like study…” He is often the one leading and motivating his classmates to have Zoom study session and encouraging them to take advantage of the privileges and financial aid resources that can access as U.S. citizens.

Yet, Orlando does not view his refugee status, his Hispanic ethnicity, or his English language learning as factors that have detrimentally affected his science learning. He told me of a phrase that he said he loves “That if others can do it, you can do it…and I think that’s what I tell my friends that you know, some students, like me, like if I can do I, you can do it…” He reminds himself and others that if he can do all that he has accomplished in five years, being a non-English speaker, then they can do it too. “I’m not smarter than you or anything”, he tells his peers, “you just need motivation about it.”
Miguel’s experiences with science have overlapping themes as Orlando’s. As an immigrant from Venezuela, Miguel’s critiques about science in the U.S. come from the perspective of being an adjunct instructor at a college and a college student simultaneously. He recently had a research paper assignment as part of his English course in which he was to write about any topic in public education. He chose to research about science implementation in the schools. He chuckled and mentioned that it was “funny” in an ironic way that I was interviewing him regarding a very similar topic.
Unlike the other interview participants, Miguel did not immediately list characteristics of science for his science identity web. Instead, he began sharing from his own research and observations he was finding:

…people don’t really know too much about science… people have a lot of misconceptions about science in general… right now, with the Covid…[Dr. Fauci]… saying sensible things and intelligent things you know, things that we need to do… it's like people don't care about what he's saying…

From Figure 10, it is evident that for Miguel, science makes sense. It is logical, factual, and is intended to help protect and prevent harm. He continues to provide why he thinks the U.S. public have misconceptions about Covid and other science-related issues stating that “science in general and STEM is like, it’s not mainstream [in the educational institutions].” He speaks about the budget constraints many schools and colleges have that essentially limit resources for science laboratories and higher education programs. He says, “And I think people is getting, is paying too much attention to arts and humanities, I mean…I’m not saying that it’s bad. But it's like people don't understand what science is and they don't want to do it.” He connects the lack of interest people have in science to the U.S. STEM workforce.

“I think people is losing interested… and it's bad, because the … United States are very innovative and technological country…these big companies are like hiring people from other countries…immigrants and … a lot of people from China and India are coming to the States working these professions… politicians are blaming immigrants…but that's …not the whole truth … Americans are not studying science anymore…you don't have enough people to fill…positions.
Miguel expressed a great passion and interest in science that was sparked as a child and STEM began as a child. He used to watch science shows and nature documentaries on the Discovery Channel. He recalls getting a science kit from his father for Christmas. He shared, “I had my own telescope when I was like 10 years old, and one of my dreams is, was going to the NASA on the being like an astronaut, or whatever.” He is clearly still very much connected to astronomy and space exploration. He talked about a group he meets with to observe astronomical phenomena together like last year when Jupiter, Saturn, and Mars were all aligned. When I asked him if someone called him tomorrow to be on the first manned flight to Mars, he responded emphatically, “I’ll do it for free!”

Miguel’s science experiences were not only a part of his informal learning but in his formal education as well. He was very active in school science clubs throughout his elementary and college years in Venezuela. He talked about one college professor in particular who was trained at Massachusetts Institute of Technology (MIT), worked for Cisco for 20 years, and then moved back to Venezuela to teach at the college. He recalls this professor helping him learn how to assemble electrical circuits. Miguel took seven math classes in college, however he said he hated chemistry, unlike Fernando.

When asked about his friends and family considering him to be a science learner, he is very sure that they do see him in science. He explained that sometimes they will seek him out to get his opinion and insight on something they read online like, for example, the pandemic.

As we ended the interview, he described himself as someone who was “very crafty and creative”, to which he says characterizes Venezuelans, because they have had to learn to make things work. He also said that he likes gather facts about different viewpoints about a topic to
evaluate the pros and cons before making decisions. He values the scientific method process, critical thinking, and problem-solving in making everyday decisions about life.

Fernando the Bridge Builder

![Image of Fernando's Science Identity Web]

Figure 11 Fernando’s Science Identity Web

Fernando’s schooling was very different from the other interview participants. Like Orlando and Miguel, he grew up in a Latin American country and immigrated to the U.S. during his senior year in high school. However, in Colombia, Fernando’s home country, he attended a Montessori school. He describes the methodology of this pedagogy as “kind of learn with, with your eyes, right, and kind of touch everything”. He expressed great gratitude to his mother for enrolling him in the Montessori school for his pre-kindergarten through junior year of high school. He recognized that even though his parents “had good economic composition”, it was
still an expensive investment. However, Fernando said that “it was something that really helped myself becoming what I am today.”

His exposure to the natural world and the surrounding environment was formative in his connection to science.

Biology, like we went to…mountains, you know, just to…see our various animals, and do some theory of where they leave you know… what they do and what will be the outcome of, or … what these animals will do next, and I remember that …

Despite the non-traditional science teaching and learning of his school, he admitted that he was not a science learner in elementary or middle school as his first passion was soccer. But now, he definitely considers himself to be a science learner, and thinks his peers and family members would think this about him as well. He added that in Colombia, politics and history are science courses, recalling that they are also “the study of something”.

Experiential science learning was a part of his schooling in Colombia that greatly shaped Fernando’s perspective about teaching and learning. When he moved to the U.S. at the beginning of his senior year, he did not learn much science as he was trying to learn the language. It has been his college classes at Creek State College that have re-connected him with the idea of learning by doing.

But something that I’m really learning right now in college, I have a chemistry, general chemistry class, and we're doing some experiments and that's…awesome I mean, I believe that outcome of doing, you know, like the way learning by doing it, it is one of the greatest, I mean…it's the best for me, is the best way to learn and that create some great insights in your mind, so you can focus more you know.
The transition to virtual learning during the Covid-19 pandemic has affected how he interacts and learns chemistry the classroom environment. He and his peers have formed a group chat to help them study. The in-person lab sessions have been helpful, but because most of the course is taught through Zoom, he and his classmates sometimes struggle “listening to some lectures of just reading some chapters. The textbook, he says, are very think and hard to comprehend: “…you know… we have to basically teach each other, because they're very dense and [the course is] going so fast and that's a problem…like with the Zoom … science and chemistry it's it gets really, really hard for us.”

Similar to Orlando and Miguel, Fernando says this ethnicity and cultural identity have nothing to do with the way he learns science. He does, however, see himself to have the same science characteristics that he listed as part of his science web. He says that he is a problem-solver, particularly in physics and part of science is addressing how one thinks or what one knows to be accurate. “I believe science… it's something that you have to constantly challenge yourself and challenge others’ opinion right, just to prove it wrong or…just or just to be liking the same pathway.”

As I described earlier, Fernando loves physics and math, but he also enjoys learning about renewable energy resources which is presented in his science identity web in Figure 11. He shares, “…it’s for…our good…for the world of Earth… I mean it is proven that we might have 40 years more of fossil fuels…we are still like taking it for granted…40 years might seem far, but it’s not that far.” He does not keep his views on these weighty science issues to himself. He likes having facts to talk to people who do not believe the same way or who may be swayed by conspiracy such as his coworkers or customers. He values these types of discussions and arguments when the facts are involved.
As our conversation was coming to an end, Fernando described different ways that people learn.

…we are different, right? Like it doesn't matter the ethnicity, like we all we all kind of learn different. And at the end of the day, schools think about us as a …
generality…Some schools just focusing on the small amount of students…that super top, but they forget about the rest, the majority…it’s about the confidence…you’ll receive from your professor.

He says that most students in school or college will not be pursuing a STEM career, so it is important for them to have confidence that they can do well too.

Phase 3: Male Students of Color in STEM and the Relevancy of Science Learning

Phase 3 seeks to respond to research question number three: How do male students of color describe the relevancy of their formal science learning to their lived experiences? The target population included MSOCs enrolled in a STEM-related course at CSC; the Phase 2 participants were the same participants interviewed in Phase 3. The key findings for this research question include how these MSOCs described the significance of the science teacher, the classroom as an interactive environment, and the foundational characteristics of science.

First, I will present key findings from the themes developed from the thematic analysis. Quantitative data from the ISLDS will be integrated throughout these findings to highlight points of connection between the two types of data. This integration will serve to support the transformative mixed-methods research design and contribute toward the study’s validity.

The Phase 3 individual and paired depth interviews interview questions in Appendix I were designed to elicit participants’ responses concerning their formal schooling and experiences as science learners and potentially how their intersecting identities contributed toward or were
effected by how relevant these science experiences were. The questions included the terms “relevant” and/or “meaningful” intentionally to allow participants to describe their experiences and life stories in whatever ways made sense to them. There were times that I needed to rephrase or reword questions to provide clarity regarding the intent of the question’s meaning or use terms that Orlando, Miguel, and Fernando would understand better being English Language Learners. Nevertheless, the questions were not specifically aligned with the phrasing of the ISLDS science relevancy items. Yet, in the analysis of the phase three interviews, it became clear that the responses these students provided regarding the relevancy of their science learning experiences, and the resulting codes and themes, largely represented the content of each of the five dimensions of science relevancy: individual, societal, vocational, instructional, and science-specific. These interview findings and overlap with the ISLDS items and the interview participants’ survey responses contribute towards the validity of this research.

Just as the themes from research question two interacted with one another, there is no clear way to dissect any one of these SR themes from one another. The participants’ description of science teachers—their personality, their interaction with students, their instructional style—was clearly the predominant and most influential factor that affects the relevancy of science learning for them. Addressing the model science teacher, therefore, becomes the first theme that will be addressed. However, throughout their descriptions, the science teacher simultaneously shapes and is a part of the formal science learning environment itself, making it challenging to determine where the teacher ends, and where the classroom environment begins. Nevertheless, the science learning classroom is the second main theme that will be addressed. The third theme, or factor of relevant science learning, is the concept of science that encompasses the subject and representations of science from the participants’ perspectives. Encompassed within the
classroom and science theme are several important points of connection including the learning activities, instructional approaches, the collaborative environment, the integration of STEM and other subjects, future career preparation, students’ personal interests, values, and cultural connections.

At times, the descriptions provided will not be attributed to anyone participant but will instead represent their collective voice and consensus that occurred during the interview or became apparent during the data analysis. However, I do present individual participants’ examples, experiences, and exact responses to contribute a specific context and a deeper meaning of significance to the theme. Following each theme’s description, findings from the ISLDS will be given to exemplify the synergy between these the SR dimensions and the participants’ thoughts and experiences.

The Teacher

How teachers present themselves and interact with their students was one of the primary ideas that these students described when they responded about relevant science learning experiences. They liked having teachers who are genuinely passionate and excited about teaching and about what they are teaching. Fernando’s chemistry teacher in Colombia was someone who, even without having the actual lab and materials, could explain the details of the lab so well that Fernando could easily understand the process. He describes his teacher as “one of the greatest” and someone who was very formative to Fernando as a learner. Miguel appreciated his teachers who shared about their own experiences, backgrounds, and accomplishments. To Miguel, this can be a source of inspiration to students, making them think, “Okay, if the professor can do it, maybe I can do it as well.”
Toni describes other teachers who “don’t listen, they don’t like to talk to their students, they talk at their students” (Toni’s emphasis, not mine). He shared how motivating and inspirational his elementary science teacher was and how he “pushed him forward personally” and was instrumental in guiding him into the field of STEM. In another example, he describes a teacher who became irritated that all of the students’ didn’t know the answer: “…it’s their job to help students, so instead of getting mad that all the students don’t know the answer, they then change the lesson to better accommodate their students”. An ideal teacher-student interaction for Toni would be someone who takes a “hands-on approach and one-on-one approach but less like the teachers [who are] on you all the time”. He adds that he would like teachers to who give him and other students the space to figure the problem out, but who are also available and accessible for help and guidance as needed.

These personality traits are linked to how they interact with their students. Being approachable to students and having an “honest communication between student and professor” is a valuable trait to these students. They talk about how teachers communicate to them can develop students’ confidence in the class and in what they are learning. Therefore, when teachers provide opportunities for students to dialogue with them, answer students’ questions and encourage students’ curiosity, the meaningfulness of this relationship and the learning is enhanced.

It is not the content knowledge that is the most important trait of a model teacher. Fernando compared his highly respected chemistry teacher he had in Venezuela to one in the U.S. who knew the information but did not know how to best communicate content to his students. Being able to get the attention of the class and engage them is critical from Fernando’s perspective. He gave a possible scenario of a classroom of future chemists, but whose professor
is not able to get the best out of these students. These students may “just give up”. The student-teacher connection is very important to establish trust and safety in the learning environment and classroom community.

Derrick adds to the conversation by recounting a personal story about the need for teachers to be patient with their students: “Like when I was young, I remember specifically, like my mom…she came to school because I was failing the class…[she had] gotten a teacher switch for me, and then my grade started to improve in the class.” Even though the event of his middle school years was foggy and unsure of the details with this teacher, he knew that the learning environment was better, and his experience improved. This finding points to the teacher being the critical entity that forms the learning space and how it engages and interacts with its students.

Having teachers who are open-minded and can see other perspectives on an issue. Orlando sharing about his science teachers in his Catholic school would avoid teaching about evolution because of the tension between science and religion around this topic. He explained that if teachers limit what they teach based upon their own beliefs, it is possible that their students are not being exposed to information that they need to learn. Toni contributed about teachers who do skip over or avoid this topic, “by not doing it, they’re sort of antagonizing…making it so instead of them [science and religion] being sort of together, it’s a split between the two”, making students feel as though they have to choose one or the other.

The Classroom: An Interactive Environment

The description of the classroom learning environment was described in multiple ways throughout the interviews. The most consistent term participants used to describe the learning environment was interactive. The classroom learning environment that incorporates labs,
projects, and other activities that allow these students to use their hands to design products and
conduct experiments contributes toward these students’ science relevancy.

   Overwhelmingly, these students spoke about the need to have an interactive learning
environment, one which gets “rid of the normal talking, talking”, in Fernando’s words. Instead of
the traditional lecture-based style of instruction or “copying everything on the whiteboard”, they
described the need to have more opportunities for students to collaborate, work together, and
share ideas. Orlando explains: “When there’s more teamwork, like in science classes, it makes,
of course it makes the class more interesting…make the person to not be shy about their ideas.”
Toni shares how the appropriateness of instructional materials needs to be considered before they
are implemented into a course. He describes his chemistry textbook, that should be intended to
teach, appears to be structured for “someone who already knows what they’re doing, and it’s not
really made for someone who’s just getting into [chemistry].”

The science classroom needs to foster exploration and trial and error. Derrick spoke about
college, specifically his biological science class, being a “gateway for like, people to learn stuff
safely”. He explained:

   Okay well, you know we can just buy a microscope today and just…do the science stuff,
   but we won’t really have the discipline and like they stuff they teach us in school…you
can actually look at these bacteria and…we can do these tests ourselves. But you know,
it’s not always safe.
He continues to describe that bacteria growing in his oven can become problematic and is a
safety hazard. He really appreciates having a place to tap into his curiosity in a way that is safe
but still allows him to explore and inquire with the proper guidance.
Fernando mentioned having to write and “just do everything on paper” in his Colombian school and not being able to do many labs. He commented that being able to do “the actual work” in the U.S. classroom heightened his connection and interaction in his science classes. Despite Miguel’s dislike of chemistry, he became more participative when they were in the laboratory “practicing with chemicals”; this connects to his thinking that students should be creating things in the classroom.

The participants also discussed the different ways of teaching that are beneficial to their science learning and understanding. The use of videos, multimedia, and visual representations allowed them to see the process or an organism’s features more accurately than reading about its description or having their teacher explain it verbally. If Miguel had to visit some of his former teachers in Venezuela, he said that he would let them know of other ways to find engaging content for their students using Google or YouTube to help them learn animation.

Incorporating real-world problems, tasks, and scenarios were other approaches that characterize an interactive learning environment. Toni shared about a local field trip to the water treatment plant he attended while he was in school. He explained how the local site helps the students become connected to their community where they live.

*Foundational Characteristics of Science*

Research question two described each participants’ identity with science specifically related to their decision to pursue a science profession. However, the third research question aims to filter the connection between science and their professional plans to simply pay attention to how each views science in a general sense. Even though they may not want to pursue science, they may still feel that science learning is relevant to their lives and their future.
To gather their views about science, I challenged each participant a couple of questions that challenge them to share what images, pictures, or phrases come to mind when they think about how their science learning experiences have been relevant to them or their identity and background. I tried not to give too much guidance on how to respond, but allowed each student made sense of this question in their own way. Miguel said that he would show something that he created by hand or from 3D printing. He took a second to show me an airship he designed and made through the 3D printing process shown in Figure 12. (I took a screenshot of Miguel’s airship by pausing the video recording during data analysis; however, Miguel’s face was too exposed, and the image of the airship was out of focus. To protect his anonymity and to provide a clearer image of his handiwork, during my request to seek participants for member checking, I asked if he would provide a picture of the airship only to include into the study. The image in Figure 12 was one of the pictures he took and shared with me.) He said, “I can, you know it's very, very nice. It took me like 20 hours, just to print all of this. But I’m kind of proud of it.” He explained the ways this model can help learners see the connectedness among math, physics, engineering, and also art. “You need to have real measurements, real life measurements just to you know so every count, because that airship is just tiny little pieces that I put together.” I also asked him how science teachers would understand more about him from this design. He responded, “I’m a fan of a kind of like old school retro styles on animation and designing,
because that airship is kind of like steampunk, which is not really popular anymore.”

Fernando, Orlando, and Derrick’s responses included images of living things or parts of nature, among other technology or engineering related responses. Toni’s response, however, encapsulated the essence of the others’ description. Unsure of whether this was the type of response I wanted as the interviewer, he said, “a kid in amazement…just a kid looking up [at] like a teacher, that’s just bewildered [at what he] was learning about”. For Toni, the sense of wonder and awe at the natural and technological world should be at the heart of science learning. This image echoes Orlando’s belief that science is “very important for all students to learn a little bit about it, even though, if they want to go to humanities, they should learn about science.”

All five students seemed to view science as a foundational school subject which can be open to potential learning challenges like the vast amount of content and vocabulary inherent to
the various fields of science. Toni mentioned the importance of students having a strong science foundation and the impact of their first introduction to science in their early years.

…you need to learn science…like all of those kinds of probably mostly like your college sciences just because it gives you the foundations to better understand everything else in life…But I also feel like some important ones…even earlier…that first introduction to science is extremely important because it’s the first step that a lot of kids have into that field…what they themselves might really like.

The exhaustive amount and complexity of scientific terms that exist in learning science can be intimidating. This becomes magnified when the instruction is conducted in a different language than the learner. In both of their individual interviews, Fernando and Orlando described the struggle they had during their first year of U.S. school environments as English Language Learners (ELLs). Learning the language was priority, and therefore, did not pay as much attention to the content of their high school science classes. In describing his experience as a new immigrant in an English-speaking science classroom, Fernando shares, “…the first semester definitely was, was something hard for me…like you know and science by basis…you’re talking about more sophisticated language and so…I couldn’t even…keep up with the, with the language, you know.”

Incorporating authentic applications of science was common thread in these interviews. Terms like “real-world”, “real life”, “everyday things”, and “hands-on” helped to connect the interactive attribute the ideal science learning classroom with the processes of doing science itself. For example, Orlando mentioned that similar laboratory experiments scientists do should be integrated into the science classroom. He provides a situation in which a student takes a job in a biological field after college, but he was not properly prepared because he was not exposed to
the necessary materials and processes needed. Toni says science needs to be more tangible and project-based. He shared about making a water wheel in which the movement of the blades, made out of plastic spoons, in water became the point of energy conversion to electric and light energy as the attached bulb illuminated.

With the exception of Miguel, all of the other participants referenced some component of biological science as having a particular meaning to them. Fernando thoroughly enjoyed his biology class in Colombia and shares how learning about nature made him more mindful of caring for the environment. “I’m actually looking at a big tree that I have in front of my window and like just thinking about the color you know? And I remember, I don’t know how to pronounce these in English, photosynthesis.” Later in the interview he says that although he wants to be a civil engineer, he very much wants to be someone who aims to sustain and preserve the environment in any way he can. Derrick described parts of the natural world as well, particularly emphasizing the human body and other living things. He says that science makes more sense to him if he can connect it to the human body, “the best made…out of all the organisms.” Then Derrick makes a profound statement: “I feel like the more I understand science, the more I understand myself”. This connects to his personal interest in his health and keeping his body fit, however, this may also hold deeper meaning for him as well.

The reasoning behind and the explanation of the purpose of scientific concepts was an unexpected finding that appeared to connect the integration of STEM topics and career preparation to science. Science needs to be viewed as being practical and useful to students beyond the exam, as Orlando mentioned. Miguel describes the interconnectedness between math and science in animation and how critical it is for these processes to be adequately explained to students aspiring to be animators: “You have to be very observant…use a lot of physics…in this
software, they are basically physics simulators…we have like properties of gravity or collisions…People don’t think that we have to study science just to make cartoons, but yes, you have.” From Miguel’s point of view, students should be exposed to these professional expectations while they are still in the classroom.

Similarly, Toni thinks that students should “have examples and opportunities to figure out” science career options in one’s early high school years. He thinks that the structure of science requirements often leads to students taking courses that do not provide the best starting point for understanding the expectations of certain fields of science. Toni links this discussion to the point that science teachers need to explain “the purpose of a topic”. Orlando described students asking, “Why am I doing this?” or “Why did the college want me to do it?” The disconnect, they said, comes when the science lesson’s topic is viewed as an arbitrary concept, leading learners to think that it is not really necessary or important. But implementing authentic situations and scenarios enable students to maneuver and problem-solve as though they are already in the field. The sentiment, therefore, from all participants was that the purpose—when explicitly provided—drives students’ motivation and understanding which results in their learning. When the purpose is tightly affiliated with the work of real professionals, the relevancy to students’ lives, interests, and futures becomes stronger.

According to Table 21, the participants have relatively strong science relevancy scores; overall, their formal science classroom experiences have been mostly relevant to them. Interestingly, Fernando’s SR is slightly higher than the other participants when considering his SI was the lowest.

Table 21 Interview Participants’ Science Relevancy Scores

<table>
<thead>
<tr>
<th>Interview Participant</th>
<th>Science Relevancy (SR) Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derrick</td>
<td>3.96</td>
</tr>
<tr>
<td>Toni</td>
<td>3.92</td>
</tr>
</tbody>
</table>
While the ISLDS could not evaluate all of the possible ways in which science classroom learning experiences are relevant to these students’ lives, but there are potential explanations. When considering each of the five SRS dimensions from the ISLDS, presented in Table 22, these students’ scores on those items designated as being specific to science content are the lowest. These findings may carry helpful tools for better understanding of what science relevancy is and how it speaks to the idea what it really means to be scientific.

Table 22 Interview Participants’ Science Relevancy Scores by ISLDS Dimensions

<table>
<thead>
<tr>
<th>Interview Participant</th>
<th>Individual</th>
<th>Societal</th>
<th>Vocational</th>
<th>Instructional</th>
<th>Science-Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Derrick</td>
<td>4.00</td>
<td>4.80</td>
<td>3.83</td>
<td>4.50</td>
<td>2.80</td>
</tr>
<tr>
<td>Toni</td>
<td>4.00</td>
<td>3.80</td>
<td>4.00</td>
<td>4.50</td>
<td>3.40</td>
</tr>
<tr>
<td>Orlando</td>
<td>3.75</td>
<td>4.00</td>
<td>4.67</td>
<td>3.25</td>
<td>4.00</td>
</tr>
<tr>
<td>Miguel</td>
<td>4.75</td>
<td>3.80</td>
<td>3.50</td>
<td>3.50</td>
<td>3.40</td>
</tr>
<tr>
<td>Fernando</td>
<td>4.00</td>
<td>4.40</td>
<td>4.50</td>
<td>4.75</td>
<td>2.80</td>
</tr>
<tr>
<td>Total</td>
<td>4.10</td>
<td>4.16</td>
<td>4.10</td>
<td>4.10</td>
<td>3.28</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: CONCLUSION

The purpose of this 3-phase transformative mixed-methods study was to use intersectionality theoretical framework to explore the science identities and relevant science learning experiences of male students of color in STEM and their decisions to pursue science professions after college. I explored these three research questions:

1. In what ways, if any, do the science identities, relevant science learning experiences, and decisions to pursue science professions of male college students of color differ from other college students with different intersecting identities?
   a. What is the relationship between students’ science identities and their relevant science learning experiences, and in what ways do these constructs differ across intersecting identities such as race/ethnicity, gender, and socioeconomic status?
   b. Do college students’ science identities and relevant science learning experiences predict their decisions to pursue science professions after college? If so, are there differences when considering intersecting identities such as race/ethnicity, gender, and socioeconomic status?

2. How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?

3. How do male students of color describe the relevancy of their formal science learning to their lived experiences?

Pursuing this purpose helped to elucidate key areas of the study, while also recognizing that there are many interactions that remain to be disentangled and better understood. To begin
the conclusion of this dissertation research, I address ways the findings connect to the literature, highlighting specific contributions this study makes to existing gaps in intersectionality, science identity, and science relevancy research. Implications will be presented as wonderings and questions as I reflect upon all phases of this study and how they can inform science education researchers, science instructors, and policy makers. I also address limitations of this study and necessary changes and recommendations for other researchers to consider. Lastly, I end with final reflections and expectations for this work.

Discussion:
Connections and Contributions to the Literature

The Intersectionality-Science Identity-Science Relevancy Framework

In discussing the different ways these findings connect to the literature, I draw attention to the proposed framework I presented in Figure 1. Prior to conducting this study, I constructed this graphical model to explain the relationship between intersectionality, science identity, and the relevance of science learning largely based upon the literature of existing frameworks within these fields. Carlone and Johnson (2007) and Stuckeley and colleagues (2013) were the initial sources from which I gleaned the outline of the two constructs of science identity and science relevancy, respectively. However, upon further reflection of this proposed framework, wider and more thorough review of pertinent literature, the exploratory factor analysis and minimal findings from all three phases of data collection, a more accurate graphic of the framework is found in Figure 13.
The Intersectionality-Science Identity-Science Relevancy Framework (I-SI-SR) provides a model to consider exactly how intersectionality theoretical framework and the constructs of science identity and science relevancy interact and contribute toward the decisions students make to pursue science professions or not. There are clear similarities and differences in the features between the proposed framework of Figure 1 and the I-SI-SR Framework of Figure 13. In comparing these frameworks, I will note meaningful ways the latter framework contributes insight regarding gaps in the research literature.

*Similarities Between Framework Models*

There are several symbolic similarities between the proposed and more accurate framework including details such as shapes, colors, and placement of these concepts within the model. For example, the circular shape of intersectionality and science identity are also the same; the circle speaks to the idea from literature that one’s identity is not rigid but is malleable and continually being formed and shape. The color green often represents and symbolizes nature, living things, the environment, and the like, so to me, this made sense to represent science...
identity as green; although, the shade is more vibrant in Figure 13. Other features detailed below create unique connections between the literature and the findings of this mixed-method study.

**Integrating Inter- and Intra-Categorical Approaches of Intersectionality**

In both framework graphics, the intersecting identities, intersectionality, is gray. This color represents the idea that how one moves about in life is not always as clear or definitive—or black and white—as one would hope. The intricacies of life are complex and murky at times. This gray also represents the debate regarding the best approach for studying intersectionality found within the literature (Harris & Leonardo, 2018; McCall, 2005; Nichols & Stahl, 2019; Windsong, 2018). There is no one clear-cut path toward untangling the ways our identities intersect and shape them and the systems within which we live. Sometimes, we must, be mindful of the gray and use a combination of tools to aid us in our sensemaking. My approach in the sensemaking process of intersectionality was to integrate both the inter-categorical and intra-categorical approaches in my research design. This contributed a richer and more nuanced way of using intersectionality theoretical framework as I not only highlighted MSOCs’ voices and perspectives (intra-categorical), but also gained insight from students with various intersecting identities (inter-categorical). The “gray” also appeared within the Phase 1 findings, specifically in that the interaction of SES did not affect the SIS and/or SRS outcomes for all students or even marginalized students in the same way. Having at least one parent with a bachelor’s degree increased the SIS and SRS of six of ten the student identity groups, two of which were Black and Hispanic males. This finding aligns with the MSOCs’ lived experiences they conveyed during their interviews in Phases 2 and 3. However, the fact that the SIS and SRS of four of the identity groups were lower when at least one parent had a bachelor’s degree underscores the complexity of intersectionality research and the current approaches used to bring clarity and understanding.
Exploring these intersections through these two approaches opens up further research opportunities to further analyze the role of SES on SIS and SRS for all science learners across identity groups.

**Integrating Intersectionality and Science Identity**

Another notable feature of these framework models is the placement of these intersectionality and science identity. These ideas are set apart from each other and are distinct entities. Yet, for the sake of science education research, each of these concepts are critical to wrestle with, critique, and utilize, not separately but simultaneously and conjointly. The call to utilize intersectionality alongside and within science identity studies is gaining momentum within the field of science education research (Avraamidou, 2019; Hazari, 2013; Kim & Sinatra, 2018; Le et al., 2019). My study’s integration of these concepts in the purpose, introduction, review of literature, methodology, and findings helps to validate these scholars’ vision and need for science identity research to be more intentional about centering the voices of marginalized students in science, such as MSOCs.

**The Science Relevancy Bridge**

The final two important similarities are the shape and positioning of science relevancy construct, or relevance of science learning. The double-pointed science relevancy arrow connects the intersectionality and science identity circles. Few studies have utilized science relevancy as a construct (Kang et al., 2018; Schreiner and Sjøberg, 2004; Stuckey et al., 2013) and, while there are references to relevancy in science identity research (Archer et al., 2016; Cowie, 2010), few, if any, have provided empirical evidence for a direct relationship between these two far-reaching constructs as part of science teaching and learning research or practice. Kang et al. (2018) primarily drew distinctions between aspects of Stuckey et al. (2013) that seemed to correlate
relevancy with interest, but connections to science identity were not explicit. In reviewing the literature, both science relevancy and science identity appeared to be linked in some way.

Phase 1 correlation data contributes critical evidence toward the relationship between science relevancy and science identity. The moderately strong positive relationship between these two constructs further supports the close connection science relevancy has within the I-SI-SR Framework. One interpretation is that as science learning becomes more relevant to students, the more students will view themselves as being a science person and feel as though they belong in science. They will be on a trajectory to approach science, to use Kim and Sinatra’s (2018) terminology. Additionally, the double-sided arrow provides a pathway for aspects of students intersecting identities to interact and communicate with their science identity as it develops and changes.

**Differences Between Framework Models**

Having addressed the ways in which both frameworks in Figure 1 and Figure 13 are similar, there are very clear differences in graphical features of these models. These features also represent critical insights gleaned from the literature and/or findings from this dissertation study. There are also additional aspects of the I-SI-SR Framework that will be addressed along with my reasoning regarding their necessary inclusion into the framework moving forward.

**Modifications to Intersectionality and Science Identity**

To better represent a more comprehensive view of intersectionality, I added culture, religious belief, and language to the I-SI-SR Framework. Culture often encompasses what people believe and value, their country of origin, the language they speak, customs they celebrate, and their overall worldview (Hammond, 2015; Lyons, 2016; Parsons and Carlone, 2013; Smith, 1999; Wood et al., 2013). A key example of culture is found in the language one speaks.
Language is a critical cultural tool that forms and shapes meaning, relationships, and societies. Throughout Phases 2 and 3, four participants reflected on the role their Spanish-speaking played as a part of their culture and their acclimation to the cultural context of the United States. For all participants, the language they spoke signified their citizenship and/or relationships with others who shared or did not share the same language. Another example of an aspect of culture is religious belief. Students’ religious beliefs were highlighted in O’Brien and colleagues’ (2020) study addressing the status of MSOCs’ in environmental and evolutionary biology majors. While religious affiliation was not an item on the ISLDS, several of the five students I interviewed in Phases 2 and 3 discussed their relationship with religion/faith in some way. For these students, and others as well, separating their faith in God or supernatural being runs counter to who they are. Examples of this identity from Phase 2 are addressed in implications of the study. These and other aspects of culture may be intricately interconnected and thereby, they are not easily dissected from one another, appearing to work as an identity in and of itself. For these reasons, adding culture, language, and religious belief to the framework provides a more complete glimpse of the uniqueness of both this study and its participants.

The components of science identity graphic has also been changed from the proposed framework of Figure 1. While Carlone and Johnson’s (2007) framework provided an initial foundation for the use of science identity in my dissertation, further research of other science identity literature, primarily Avraamidou (2019), Le et al., (2019), and Kim and Sinatra (2018), emphasized the sense of belonging created by the science learning community, or classroom. This perspective seemed to be more fitting and appropriate for the purpose of my study. As a result, the terms “competence” and “performance” were replaced with “belonging” in the I-SI-SR Framework.
Decisions to Pursue Science Professions

One of the most apparent additions is the rectangular box representing students’ decisions to pursue science professions. A key reason for adding this aspect was to better emphasize a key piece of the purpose of this research. The background, introduction, and much of the literature review emphasize the decline of MSOCs in science and STEM fields, so it was necessary to add this integral part of this study. Students’ decisions to pursue science professions were also key components in research question one, which I will address now and research question two, which I will discuss in a later section.

The second part of research question one explores, through logistic regression, what factors or variables can predict students’ decisions to pursue science professions after college. Between SIS and SRS, SIS significantly predicted students’ pursuit of science professions. When considering other factors such as gender, race/ethnicity, SES, presence of a science mentor, SRS, and SIS, only gender, race/ethnicity, and SIS significantly predicted students’ decisions to pursue science professionally, reflected in Table 16. Because of this predictive effect of these factors, there are two curved arrows pointing toward the rectangular box, one arrow moving from the science identity circle and the other arrow leading from the intersectionality circle. (Note that race/ethnicity and gender are preceded by an asterisk (*) to denote their contribution in the logistic regression.) These quantitative findings contribute beneficial data to the relationship between science identity development and students’ future decisions in science. How MSOCs identify with science appears to be significantly related to their continuance in science fields.

Dimensions of Science Relevancy

Another difference between these two frameworks is the modification of the dimensions of science relevancy. The three dimensions of relevance of science learning—individual,
vocational, and societal—provided by Stuckey et al. (2013) were changed to better reflect both the literature and the results from the EFA of the ISLDS participant data. A thorough review of the literature (shown in Appendix C) revealed potentially other dimensions, namely instructional and science-specific, that are not explicitly addressed or specified in Stuckey et al. (2013). As a result of incorporating these five dimensions of science relevancy to the ISLDS items, the EFA resulted in four factors with strong Cronbach alpha reliability values shown in Table 6.

I named each dimension after reviewing each of the ISLDS items that comprise each factor, determining how the items within each factor related to one another. For example, “Science for Everyday Life” includes these ISLDS items:

1. My science classroom experiences provided me with practical life skills.
2. My science classroom experiences made connections to my everyday life.
3. My science classroom experiences integrated knowledge I could use immediately.

Also, unlike Stuckey et al.’s (2013) dimensions, I have included some form of the word “science” to clearly highlight the focus of this construct. As shown in Figure 13, each of these four resulting ovals representing one of the dimensions of science relevancy interact with the others in some way. Only the ends of the science relevancy arrow are visible to draw attention to the construct label and its dimensions.

The Presence of Power

The most prominent addition to the initial framework is that of power. The use of intersectionality in any context inevitably addresses issues of power or power dynamics. Given that I discuss aspects of power in the context of intersectionality throughout the introduction and literature review, it was, necessary to include power in the more accurate I-SI-SR Framework.
Without recounting the literature on power and how it can be used to oppress individuals based upon their intersecting identities, it is helpful to mention that power, as described within intersectionality theoretical framework, can be hidden within systems of economics, societal norms, legislations, and other seemingly invisible structures and processes that overwhelmingly and deleteriously dominate certain groups to sustain a hierarchical privileges of other groups (Gay, 2015; Lyons et al., 2016). A potential reason why science identity research has not utilized intersectionality framework may be the belief that the classroom is void of such power structures as students are simply learning information about the natural world (Brayboy & Castagno, 2008; Le et al., 2019). Unfortunately, and often unintentionally, power dynamics are at play to some degree within formal science learning contexts (Aikenhead, 1996; Carlone et al., 2014; Le et al., 2019; McCurdy et al., in-press).

These three octagonal and red-outlined shapes represent potential ways power is present within science classrooms. I used the shape of stop signs, because for some students, particularly marginalized learners such as MSOCs, the presence of these power dynamics inhibits them from moving forward. These power “stop signs” can keep them from persisting in science and STEM in various ways. Tackling each of these three power stop signs in the I-SI-SR Framework separately is challenging as there is considerable overlap among them. However, I do tease out specific ways aspects of the findings from all three phases connect and/or contribute to the literature presented.

The first power stop sign is “Societal Messaging” that is placed partly inside of the intersectionality circle, signifying that societal expectations, cues, or messages students’ receive from and within society may shape their perspectives. One of these messages regarding science focuses on gender. Archer et al.’s (2010) tackles the student participants’ gendered views on who
can do “real” science or be scientific, namely male students are better at different types of
science than female students and vice versa. Key to my intentionality in connecting
intersectionality and science identity was also centering MSOCs. Much of the literature and
research of both intersectionality and science identity focuses on females, girls, and women. By
focusing on these learners in STEM, this study challenges preconceived and deficit-based ideas
about both gender and race/ethnicity and science learning. For example, from Phase 1, there
were no significant differences between male and female students’ SIS. One gender is not more
fit for science than another. However, nurses and other health science professionals are majority
female (NSF, 2019; O’Brien et al., 2020). An example from Phase 2 is Derrick’s pursuit of a
nursing degree; undoubtedly, he is the only male in many of his classes. The messaging on who
can or who should pursue certain types of sciences clearly prohibits students from actively
pursuing these fields. Hazari et al. (2013) provides a new perspective by incorporating science
disciplinary identities to better address the ways societal effects of gender in sciences has
oriented students toward one type of science or another. Nevertheless, as these and other studies
conclude as I do with mine, the presence of this power stop sign is very real and present within
science learning environments.

The second power stop sign is “Traditional WMS” that is placed between the science
relevancy and decisions to pursue science professions sections on the framework. At the root of
this power dynamic is the way in which science is taught, the instructional materials used (or not
used), the norms for language and discourse, etc. are geared for White, middle-class male
learners. The incorporation of this stop sign in the framework largely comes from the discussion
of WMS in literature including Jegede & Aikenhead (1999), Abram et al. (2014), Archer et al.
(2015), Carlone et al. (2014), Le et al. (2019), to list a few. These scholars address the disconnect

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students of color and/or from marginalized cultures may feel to how science is taught and presented drawing a close to both science relevancy and science identity. While certain items on the ISLDS elicited students to describe examples of the gender and race/ethnicity of the scientists primarily presented in their science learning classrooms, the key findings from Phase 1 are not specifically equipped to provide a direct connection to traditional WMS.

For example, while there were no significant differences between race/ethnicity groups’ SIS and SRS, when attending to the interaction of SES with gender and race/ethnicity, a different perspective regarding the SIS and SRS of Black and Hispanic male students begins to surface. Black and Hispanic males students’ SRS was the lowest when they did not have a parent with a bachelor’s degree. This finding alongside other empirical studies that report the decline of Black and Hispanic males entering various science fields (Byars-Winston et al., 2016; Mau, 2016; NSF, 2019; O’Brien et al., 2020; Park et al., 2020; U.S. Department of Education, 2019) may be helpful to furthering this discussion of the ways traditional WMS instruction may have influenced them regarding science in some way. A related example from my interview with Fernando and Orlando during Phase 3, and one which I describe in more detail later, is the science learning environment in the U.S. for non-English speakers; again, the intimate relationship between language and culture is pertinent here. Relevant connection to science is challenging to attain if the science instruction limits access to understanding in one’s native tongue (McCurdy et al., *in-press*).

The third power stop sign is “Only One Way to be Scientific”, which borders the science identity circle in the I-SI-SR Framework and is very closely related to the “Traditional WMS” stop sign. This power dynamic tends to communicate to students the idea that individuals who are scientific always excel in science academically, perform a certain way in the science learning
environment, or interact with other students or with their science teachers in a certain way that establishes them as being a “science person”. These themes are addressed by the studies mentioned in the first two stop signs above, however, Le et al., 2019 provides insight on the role student-student interactions have upon their science identity development and expression in the classroom. This study also draws attention to teachers’ hidden perspective that one way of teaching science fits all learners.

There are two examples from the findings that help to support the presence of this power stop sign in the framework. The first being Toni’s emphasis, from Phase 2, on grades he received in his science classes and the peers he surrounded himself with. Toni is clearly a very intelligent critical thinker in various areas of science, yet at times it seemed as though the grade he received in his science classes communicated his capability and success in the class. Additionally, his references to being “lucky” to have friendships with “really smart kids” who are not “slackers” also infer the idea of “only one way to be scientific” may be an aspect of what has shaped Toni’s science identity. A very different example came from Fernando’s Phase 1 data and Phase 2 interview. According to Phase 1, Fernando does not have plans to pursue a science profession, (though his acuity for physics and engineering was very evident from my interviews with him) which aligns with his SIS that was the lowest of the five MSOCs interviewed. However, his SRS was the highest among these five young men, though statistically, his SRS should be lower than those whose SIS is much higher than his. This small quantitative difference, though not statistically significant, does run counter to the “only one way to be scientific” power dynamic that better aligns with Toni’s outlook. Yet experiences and perspectives in Fernando’s life have led him to consider success from a different perspective; it is one that appears to put the responsibility on the school and classroom environment instead upon any fault or lack of the
learner, or upon their ethnic or cultural background. He stated that “schools think about us as a … generality…Some schools just focusing on the small amount of students…that super top, but they forget about the rest, the majority…it’s about the confidence…you’ll receive from your professor”. Essentially, being scientific does not look the same way for each student and, from this researcher’s perspective, there is a story that lies within the statistic and within each science classroom.

The I-SI-SR Framework and the Science Classroom

As the literature and findings attest, these power dynamics are real and present within science learning spaces, supporting their presence within the I-SI-SR Framework. This framework, therefore, is a model that can be beneficial in connecting intersectionality, science identity, and science relevancy within real science classroom research and practice. Like scientific models, it has the potential for theorizing relationships among ideas and constructs to elucidate information about the interactions that take place within many science classrooms in the U.S. and other areas as well in which certain students are marginalized by gender, race/ethnicity, SES and other intersecting identities. To present a better context of this framework, I again modified the graphic representation to portray a science learning classroom as a result of the Phase 2 and Phase 3 interviews I conducted with the five MSOCs, Derrick, Toni, Orlando, Miguel, and Fernando. This visual “story” is shown in Figure 14.
Figure 14 The Science Classroom Story by Five MSOCs in STEM
In this story, the themes that surfaced during my interviews with these five MSOC provide the backdrop of the occurrences in a science classroom with culturally diverse learners from various backgrounds and lived experiences.

…The story begins with the teacher introducing herself and engaging her students by asking them about who they are, what does/does not interest them in science, and what goals, hobbies, and aspirations they have. She shares examples from her background to connect with theirs and leads the students in sharing their prior science knowledge, culture, and other insights with her and with each other. Students are challenged to consider how these science concepts prepare them to address meaningful societal issues, as well as prompting them to examine the scientific principles contained within their favorite video game and hybrid car their parents drive. Visual representations, labeled pictures, and graphic organizers are integrated into the instruction. Lessons integrate technology, engineering, and mathematics to better prepare them to solve real-world problems they may encounter in any one of many science professions their teacher has them explore. Students use their hands and their minds as they collaborate on the most effective procedure to solve the scientific problem posed to them. Textbooks are references, as needed. Students access free online and current science articles to investigate environmental and sustainability concerns from different cultures and societies around the world; students learn about the research global scientists are addressing in real time. The teacher contacts nurses, scientists, engineers, and lab technicians from local industries and companies to set up in-class speakers and on-site field trips to expand her students’ view of science outside of the classroom walls. The
teacher gives the class clear purposes behind the science concepts and tasks, and students find relevancy and confidence in this story’s science classroom...

The five male students I interviewed were not White but were either Hispanic or Black. Three of them were born outside of the U. S. so only two of them had English as their first language. Even though at least one of their parents had a college education, they all fit into the working-class socioeconomic level. Despite the ways the three power stop signs, and potentially others, seemed to be directed toward them throughout their K-16 science learning experiences, they have persisted in making decisions about their current and future professions in a science or other STEM field. The “story” above comes from aspects of the lived experiences they shared during their interviews and their perceptions and observations about their own learning along the way. Just like every other student who enters into the four walls, or virtual space, of a classroom, what initiates science relevancy for them, from their perspective and words, is the teacher. The examples of instructors and professors who guided and encouraged them were pivotal in furthering and developing their approach towards science and scientific thinking. Consider the image in Figure 14. A specific way the teacher can counteract the power dynamics that may be inherent fixtures in the classroom is by providing a genuinely welcoming and interactive space in which students feel they can both belong and contribute. However, there are other individuals and structure-makers that play key roles in these environments. In order for other stories of science classrooms to resemble relevant, purposeful, and future-oriented environments these five MSOCs described, reframing social justice in the science classroom needs to be addressed.
Implications: 
_Intersectionality and Social Justice in Science Classrooms_

The “story” of a relevant science classroom that positively shapes MSOCs’ science identities is not unattainable, even amidst the ways societal messaging, traditional WMS, and the only one way to be scientific and other “stop signs” may inhibit MSOCs and other students from even considering that science may be for them. The implications this study highlights help to bring in the narrative of social justice that often accompanies intersectionality-centered movements. But how does social justice look in the science classroom?

It is significant to remember the transformative mixed-methods that guided the design of my study. This approach aims to build and empower a community and voices of people in equitable ways. The strength of intersectionality and transformative approaches are to shed light on inequitable power structures, work to dismantle them, and support the community from which the participants are members. So, central to this study is how these findings will contribute to science education research, science teaching, and science education policy makers in an effort to push this conversation beyond the print of this paper to active steps for marginalized students of color. An additional aim is to share these findings and insights with the CSC faculty, particularly those who allowed me the opportunity to enter their classrooms in a virtual way.

**Being “Normal-ish”: Ethnicity, Language, Class, and the Culture of Science Education**

In the introduction, I addressed the hegemonic structures that are actively present in the traditional science teaching of U.S. classrooms today. WMS is generally taught as the only way to view scientific knowledge. In these learning spaces, the White middle class is perceived as normative, often to the exclusion of others’ ways of thinking, living, and speaking. This idea is directly related to a phrase that Toni said during my interview with him.
In explaining his identities from the Identity Web, Toni commented about being able to be “normal-ish” comparatively to his peers in school, primarily because of English being his first language. Even though his parents were immigrants from Columbia and his mother received college education there, Toni identified as being a part of the working class. His mother worked several jobs here in the U. S. but does not speak English as well as Toni. He mentioned that while he has light-colored skin and speaks English well, he is sometimes reminded of his Hispanic heritage when listening to his mother reminisce about her childhood, recognizing he has points in his life that are very connected to being Hispanic and a person of color. Toni considers himself “lucky” that he is able to not stand out in a negative way because of his culture and background. And while this “ostracization” he mentioned is a characteristic of our nation’s history with race and immigration, this way of thinking is also very present within classrooms learning environments.

When considering the culture of science, Fernando and Orlando both described their struggle to learn science content and vocabulary their first year of high school in the States, so they could focus on learning the language. While this is a reasonable and practical task for anyone entering a new country, it makes me wonder if, underlining this language-learning process, was the desire was to speak English well enough that they did not stand out as much. Students’ acclimation to a new school and classroom is already embedded with challenges and anxiety for them as newcomers; when coupled with the inability to communicate in the same language as the majority cultural group, students can allow frustration to overwhelm their ability to persist in the process. O’Brien and colleagues (2020), Mau (2016) and others specifically address the cultural climate of science and STEM programs that ostracize students of color in
these fields, because they do not feel as though their backgrounds are not seen, valued, or included into the framework of science learning communities.

Clearly, this was not the case with Fernando and Orlando, as they are thriving, but this mindset of hidden curricula needs to be a critical conversation in science education community. Social justice, in this case, calls for the intersections of students’ varied cultural and lived experiences to be normalized, not just in one science teachers’ classroom but throughout district and college-wide curricular materials, syllabi, instructional frameworks and practices.

As practitioners, we need to ask ourselves:

- Are we modeling the tentative, collaborative, encultured, and diverse nature of science, and the global scientific community in the classroom if non-English speaking students have to first assimilate and cross the bridge to us before they are deemed able to learn and understand science content?
- In what ways do we give students from different cultures the opportunities to teach us and their classmates about the ways science is taught or incorporated within their communities, families, or home countries?
- Have we met with the on-campus English Language Learning facilitator to receive tips and strategies to help their non-English speakers better understand science without undue anxiety over language learning?

For policymakers, curricula developers, school district leaders, superintendents, college administrators:

- Is science education curricula weighed down with a bombardment of vocabulary, abstract concepts, and written texts that prevent a clear understanding of the main
overview and purpose of science concept to all learners in visibly and relatable ways?

- Have you sought out collaborative partnerships with corporations, businesses, and organizations that specialize in supporting culturally- and linguistically diverse science learners through projects and on-the-job internship opportunities?

- Are STEM programs and clubs like Lego Robotics, and Science, Engineering, Communication, Mathematics, and Enrichment (SECME) (originally, Southeastern Consortium of Minorities in Engineering) being made accessible—by membership, fees, translators, and transportation—for marginalized students of color to freely attend and participate or are the guidelines and application process shaped in such a way that several power stop signs are posted, making it insurmountable for students outside of the “norm” to be welcomed?

- Is their access to study or help sessions to decrease the opportunity gaps English Language Learners experience as they struggle to keep up in their core subject courses?

- What funds are available to purchase district-wide/college-wide access for online and interactive science learning materials, labs, etc. instead of students only having dense, text-heavy, textbooks that add frustration and confusion?

International assessments like TIMSS, as mentioned earlier, report the decline of Black and Hispanic students’ science and math proficiency, specifically male learners in upper elementary and middle grades; this analysis aligns with the decline of men of color in certain STEM professional fields. As a science education researcher:
Are these types of large-scale studies and instrumentation being utilized at the national and state level to develop and refine science standards like Next Generation Science Standards (NGSS)?

How does the research on achievement gaps of Black and Hispanic male students differ from the opportunity gaps due to intersections of gender, race/ethnicity, and socioeconomic status? This type of synergy needs to be further explored to dismantle the idea of what it means to be a “normal” science learner in the classroom and promote social justice efforts system-wide.

“They Don’t Look Anything Like Us”: Religious Beliefs, Race, Gender, and Science

Religious belief, faith, and God were mentioned in varying ways throughout Phase 2 and 3 interviews. For example, Miguel questioned why there was no reference to other faith beliefs like Buddhism, atheism, or agnosticism on the Identity Web. Miguel shared that his friend who was driving him to get a COVID test during the interview was from Puerto Rico, had red hair, and was Buddhist. Miguel, though his mother is religious, considers himself to be an atheist-leaning agnostic. He did not identify with or see himself represented by the Christian/Catholic or Jewish/Islam dichotomy options on the Identity Web. His point was well-taken as it made me reflect upon the tools and materials we use, more specifically, I use, as part of the research process. This reinforced how our biases, perspectives, and beliefs as researchers are also part of the data collecting and data analysis process, often unknowingly. This also sheds light upon the role religious beliefs play in how we view and interact with the world and others’ identifying
beliefs that are contrary to our own. Another example of both of these insights came from Derrick’s interview.

Derrick expressed a strong stance against scientific statements surrounding the evolving of humans from monkeys while sharing his science learning experiences. Herein lie potential entangled ideas that bring scientific and sociohistorical ideas within the same sphere of race and identity. Recall Derrick’s very firm pronouncement “I hate looking at monkeys because…they don’t look anything like us or act like us…” shortly after describing how he enjoyed learning about animals, the classification of organisms, and how “we’re all related”.

A simple Internet search can reveal how geneticists and other biologists have confirmed that human beings, chimpanzees, and apes share close to 99% of their DNA. The way these primates’ behaviors, gesturing, and certain physical characteristics resemble those of *homo sapiens* to the casual observer can easily conflict with Derrick’s emphatic claim. And yet, this short and firm response he gave during the interview, caused me to only respond “Okay” without probing further. Sensing I struck a nerve, I continued with the next interview question. But what lies behind Derrick’s reaction and change of tone? There are potential layers and layers of intricate reasons that lie within the answer to this question. Derrick’s reading of and belief in the Christian Bible may be a contributing factor to a degree, and to clarify, I can only speculate as I did not ask him to explain. However, I believe the core of his repulsive stance towards monkeys, or any other primate, may have been planted by the way Black people have been caricatured as primates throughout U.S. history through texts, media, jokes, and other social contexts and artifacts. The dehumanization of Black men in our country has seeped into every facet of society and systems. Any reminder of this, i.e., a high school science teacher stating humans evolved from an animal whose image was used to degrade Black bodies, would quite possibly produce
disdain from someone who otherwise admires scientists and loves science, as was apparent in his interview. Again, while I do not know this for sure, I am inclined to position myself in this aspect of wondering and questioning. I know how it felt to sit in science classrooms and having the very same repulsion to this very same science topic while sitting in a classroom of mostly White classmates, being taught by a White teacher who probably could never have known how uncomfortable it was to sit still during that lesson. Listening to Derrick’s change of tone and demeanor was not foreign to me. In his attempt to make sense of being a “dark skin Christian man” and the world of science, the recollection of this topic and high school memory seemed to become a trigger, a stopping point that was followed by the longest pause in a very full and interesting interview conversation.

Science and religious faith, particularly that of Christianity have been at odds in both of these sub-cultural spheres in the U.S. for decades. The tension between these ideas is also very present in the science classroom as well (O’Brien et al., 2020). The response from science teachers may vary from avoidance to adamant preaching on either side of the debate. Toni and Orlando shared their own experiences with this topic as both of them identify as Christian and/or Catholic. Orlando described hearing the teachers at his Catholic school in Venezuela describe evolutionary science in negative ways, and Toni described having teachers who either avoided the topic or were fine with discussing both. While I have personally made sense of the science of evolution as an adult, what is strikingly clear is the what much of the literature review addresses: The outworking of one’s science identity cannot take place outside to the contexts in which one’s identities intersect. In science learning therefore, the intersection of religion, race, history, and scientific ideas and theories should not be ignored or overlooked. Researchers in this space have started exploring how and why college biology and evolution professors (like mine) veer away
from any mentioning of faith or religion when this part of students’ identities are often life-shaping and valuable to who they are, how they were raised, and how they want to live in society. However, this conversation needs to push through to the lower grade levels. Derrick’s experience occurred in high school, not college.

Social justice in the science classroom needs to draw upon empathy and integration of social sciences. This is an area of professional development that could greatly be helpful for science instructors from K-16, particularly for teachers who, like myself, were late to learning about how these two meaningful ideas can reside harmoniously and collaboratively.

For policymakers, curricula developers, school district leaders, superintendents, college administrators:

- Have you provided opportunities for teachers and instructors to receive professional development regarding the teaching of controversial topics in the diverse science classroom?
- How do the curricula and instructional materials for middle and high school science address religious and cultural beliefs that may overlap scientific information?
- What opportunities exist for science instructors to collaborate with social studies instructors to develop instructional lessons or units in which students investigate the intersections of religion and science across key science topics? What support could be given to incorporate this type of unit within the instructional timeline or course syllabus?

For science instructors:
• Do we tend to overemphasize the learning of facts instead of the cognitive processes and critical thinking process of science?

• Have you considered external resources like Biologos that may be able to support your instruction of evolution while being sensitive to its controversial nature for students’ religious and racial/ethnic beliefs and worldviews?

For science education researchers:

• How can research of science and religion take place in middle school classrooms without jeopardizing students’ connections to their families and communities?

• What insights can be learned from Indigenous people groups whose knowledge systems intricately interweave their connection with the land and with the cosmos (Abrams et al., 2014)?

To Derrick and others like him, the science experiences and ideas can be positive or negative based upon how their science instructors address these difficult topics. To counter issues of power in these types of situations, the approach calls for creativity and a wider understanding of the ways race, gender, and religion intersect.

The Science Teacher as Science Mentor

This final area of wonderings of implications orients around the science classroom. The students’ responses and thoughts expressed during the Phase 3 individual and paired depth interviews were very similar. The primary topic of relevant science learner was the teacher. Teachers’ personality, how they teach, how they interact with students, and how open they are to learn and try new things themselves. Clearly, these young men, while planning pursuing STEM fields, would be open to science instructors who value these students’ experiences, interests,
backgrounds, and plans for the future. To them, the teacher was the leader and guide of the classroom learning environment. Paulo Freire (1970) describes how teachers should not be the main actor in the classroom but present themselves as a part of the learning community, engaging students’ in critical thinking, debate, and posing problems to discuss and solve. Miguel talked about his former professors in Venezuela being open to learn how to use and incorporate more digital learning tools to show their students how the components of STEM all work together. He spoke fondly of one professor who shared about his life experiences as he was teaching. Toni had elementary teachers who played instrumental roles in steering in towards science and engineering. Orlando provided wisdom about science instructors providing the reasoning behind what they teach and how it relates to students’ lives and the world. The gravity of teachers’ words and actions upon their students goes without saying. However, I wonder if science teachers perceive of themselves as science mentors as well.

While the presence or absence of a science mentor was not a focus of this study, the data presented in the results and in literature is clear that students with a meaningful positive science mentoring relationship actively approach science to a greater degree than those who do not have a such a science mentor. Science mentors are critical to the success of students’ deciding to and persistence in pursuing science professionally, especially for students of color (Carlone & Johnson, 2007; Kim & Sinatra, 2018; Byars-Winston, 2010; Stets et al., 2017; Strayhorn et al., 2013). Given this information, in what ways can teachers be prepared to view themselves as science mentors to their students or to students in general?

Connected to this is the professional development necessary to provide teachers with the proper skills, resources, and materials used in STEM professions in the science classroom. Miguel and Orlando specifically posed questions about having teachers better prepare students
for the STEM workforce and internships in these ways. Evidently, these students viewed science and the preparation for work outside of the classroom through the lens of their teachers. Outside of access of funds, which is a main issue, teachers need to first be open to learn about current and upcoming technologies that are on the horizon in STEM fields, if the expectation is for preparing students for the present and innovating for the future.

Limitations of the Study

A study of this magnitude has a number of limitations in methodology and scope, a few of which I will address. The first being that this research will contribute greatly to similar future studies as the survey data collection encountered meaningful limitations. Initially, this study was focused on collecting survey data and then individual and paired depth interview data of male students of color enrolled in a biological and physical sciences class of the college during January or February of the spring semester. (This college has four spring enrollment sections: 16-week session, 12-week session, and two 8-week sessions, three of which begin in January or February). However, within two and a half weeks of the survey administration, only one Black male student responded to the survey. Yet, this does not provide insight regarding how many male students of color were enrolled in these classes, and simply chose not to participate in the survey. This speaks to issues regarding how many male students of color were enrolled in these science classes during the study, whether there exists a level of mistrust of their professor, research study participation, or educational systems altogether. Quite possibly, behind this glaring piece of quantitative data lies a story of MSOCs and their science within the last 20 or more years that has yet to be fully uncovered.

Another limitation of the study was only conducting this study at one particular institution. As highlighted according to the college’s 2019-2020 publicly available enrollment
figures, only 1,600 of the 30,000 students enrolled identified as Black male. To increase the
possibility of reaching more students at this college, data collection could have included emailing
the entire student body the student survey recruitment letter. Or, the study could have included
other surrounding state or community colleges offering similar programs and diverse student
body populations. Having said this, the transformative approach for the CSC community may not
have been as meaningful.

As mentioned, one’s science identity is not static or unchanging. Without observing these
participants within their learning environments, a large part of the data collected is reliant upon
participants’ self-reporting and the recollections of their science learning experiences throughout
their lives as well as their perception of the relevance of their science learning experiences. To
gain better insight into the development of students’ science identity, prolonged in-person
observation or presence during instruction to fully gain insight into the learning environment as

Lastly, and a major part of this study, is the ISLDS instrument that makes connections
between science identity, science relevancy and identity-shaping factors. Socioeconomic status
was observed through parents’ level of education. However, many students were adults with jobs
and families of their own, making the effect of their parents’ education potentially null. While
questions regarding their financial aid and work status were asked, there was no comprehensive
or appropriate way to evaluate or scale survey participants’ current socioeconomic status.

Recommendations for Future Research

In order to move the findings of this study forward, there are three recommendations I
propose for future research connecting intersectionality to the science classroom environments.

The first is utilizing the ISLDS instrument within a new college context and with a
different student population. Sound statistical insight affirms conducting confirmatory factor analysis of survey instruments on a different sample of participants than were originally included in the exploratory factor analysis data. One suggestion I have is administering the ISLDS, specifically Part 1 on Science Identity, Part 2 on Science Relevancy, and the demographic items of gender, race/ethnicity, and SES from Part 3 to STEM students in an historically Black 4-year college/university and in a predominantly White 4-year university. A second suggestion in light of this recommendation is to administer the ISLDS to non-STEM students in a state college similar to CSC, or in the contexts described already. The findings from these different contexts would not only speak to the reliability of the instrument, but also address any differences in SIS or SRS due to intersectional identities and to students’ major or field of study. The comparative analysis of STEM and non-STEM college students may contribute more insight into science identity development and the condition of science relevancy in different school districts, communities, and geographical regions.

A second recommendation is to interview a wider breadth of students across intersecting identities with similar focus as Phase 2 and/or Phase 3. In interviewing the five MSOCs, I could not help but wonder whether the themes derived from their insight are common to other students as well. For example, would female students of color express the same connectedness technology, engineering, and mathematics as part of their science identity development? Would White male students have similar emphasis on the teacher, the classroom environment, and the foundations in science as these MSOCs did? This question can help to provide insight into the difference in gender and race/ethnicity in the SRS of the survey data.

Lastly, I continue to grapple with the low number of Black male students who both completed the survey and participated in the interview. Given all areas of my positionality, this
remains a core concern of mine and fellow colleagues at CSC. Therefore, a final recommendation is to further science identity research for Black male students across K-16, with particular emphasis on the middle and high school grades in both urban and suburban areas. While intersectionality may be a framework to continue to use, it may also be necessary to integrate stereotype threat or Patricia Hill Collins’ Domains of Power. Possible research questions include:

- How do Black boys and young men identify with science when taught by male vs. female science teachers?
- What does it mean for science to be relevant to middle school Black boys with varying socioeconomic levels?

My Final Reflections of Tension and Hope

Each of the young men I interviewed had unique lived experiences, and several of them had shared perspectives and cultural contexts and backgrounds. Neither of these individuals knew the other prior to this study, but as a result of this study, Orlando and Toni connected through social media because of their shared insights and interests expressed during Phase 3 data collection. Another participant, Miguel, answered all of the questions for the interview from his smartphone or laptop while riding to and from getting a Covid-19 test to confirm his negative status for raveling to New York in the upcoming weeks. Fernando interviewed with his camera off because his Wi-Fi access was inconsistent. Derrick was the first participant to email his interest in participating in the study and shared the new insight he was learning about himself because of the questions he answered. Unknown to me until the day of the interview, was the fact that I would be interviewing a neighbor, Orlando, who had moved in with his family less than a year before. I met him and his family months ago, shared mangoes with them from the
tree in our backyard, and chatted with him, his brother, or his parents as I walked the dog. In short, it was an unbelievable pleasure to have had them open up their lives to me for this necessary work. Reflecting upon what contributions they have made to this study makes reflect upon two thoughts I have had throughout the course of this study.

The first being is that there is still work to do in developing equitable pathways for these and other MSOCs in science professions and STEM fields. Various systems of power, oppression, and injustice continue to rear their ugly heads in different and sometimes hidden ways. As those who aim to dismantle these structures, particularly in education, requires vigilance and innovative thinking. Part of my mission in science education research is to sound the alarm and inform others in this work and practice to pay attention and enact forms of social justice in effective ways.

The second thought is that there is hope. Every day, marginalized learners persist and move past those power stop signs and create green lights for themselves and for others to emulate. Every day, teachers, school and district leaders, college professors, guidance counselors, and the like empower students of color to disregard or ignore obstacles that may have hindered them were it not for the support and vision of these meaningful others. Each of these young men and others like them are in fruitful science professions and contributing to the lives of their communities, states, countries, and the world in numerous ways. And every day, my young son has yet another curious STEM question or task he is investigating and exploring.

I hold both of these thoughts in tension at the same time. It can be a challenging and uncomfortable position to have, but the intersection of these two thoughts is what is needed to create relevant spaces for the voices and lived experiences of male students of color in science.
Hello Creek State College Students,

My name is Regina McCurdy, and I am a doctoral candidate from the School of Teacher Education at the University of Central Florida. I am writing to invite you to participate in my dissertation research study about your prior and current science learning perspectives, experiences, and background of college students enrolled in a biological science, mathematics, physical science, technology or engineering, or other STEM-related class. You are eligible to be in this study because you are currently enrolled in a biological science, mathematics, physical science, technology or engineering, or other STEM-related course at Creek State College. You must be 18 years of age or older to participate in this study. If you decide to participate in this portion of this study, you will be asked to complete an online survey that should take no longer than 20 minutes to complete on a computer, laptop, or mobile device.

While there is no compensation for participating in this survey study, it is possible that your instructor may provide extra credit for your completion of this survey. The amount of extra credit and the process of confirming your survey completion will be determined by the biological science, mathematics, physical science, technology or engineering, or other STEM-related instructor of the course through which you were notified of this research study. Remember, your decision to participate is solely voluntary and will in no way affect your grade, academic standing, or enrollment in this class or the college.

Please use the link below to access and complete the survey.

http://ucf.qualtrics.com/jfe/form/SV_eW0yeYWrrtJbaR

Thank you very much for your time.

Sincerely,

Regina

Regina McCurdy, Ed.S.
PhD Candidate, School of Teacher Education
College of Community Innovation and Education
University of Central Florida
APPENDIX B

SURVEY INFORMED CONSENT
You are being invited to take part in an online survey research as part of the dissertation study being conducted by Regina McCurdy, a doctoral candidate at the University of Central Florida. The purpose of this research is to explore aspects of your prior and current science learning perspectives, experiences, and background of college students enrolled in a biological science, mathematics, physical science, technology or engineering, or other STEM-related courses. This online survey is not a part of your academic coursework; therefore, it is solely your decision to participate. **You must be 18 years of age or older to take part in this research study.**

Confidentiality and Privacy as Participants in this Study

**Duration of Study:** The online survey via Qualtrics should take you no longer than 20 minutes to complete.

**Voluntary Participation:** Your participation in this study is voluntary. You are free to withdraw your consent and discontinue participation in this study at any time without prejudice or penalty. You do not have to answer any survey item that you do not wish to answer. Your decision to participate or not participate in this study will in no way affect your relationship with Creek State College, including continued enrollment, grades, employment, or your relationship with the individuals who may have an interest in this study.

**Name Identification:** Your survey responses will be collected through Qualtrics.com. No identifiable information about your IP address, the instructor, course, college, city, or state will be collected by the survey. Your STEM-related course instructor will not be able to view the survey questions of participant responses’ before, during, or after the survey administration. Anonymous data results may be shared with Dr. Malcolm B. Butler, faculty supervisor or Dr. Haiyan Bai, dissertation committee member and professor of quantitative methodology in the Department of Learning Sciences & Educational Research at the University of Central Florida.

At the end of the survey you will be asked if you would be willing to participate in a follow-up interview/focus group via Zoom. If you choose to provide contact information such as your email address, no identifying information will be included in any publications or presentations based upon the survey data, and your responses will remain confidential. All data will be password-protected in the principal researcher’s computer. If you choose to provide your email address are not selected to participate in the interview/focus group, your email address will be removed from the data and will not be saved/stored in any way by the researcher.

**Benefits:** You will receive no direct benefits from participating in this research study. However, your responses may help us learn more about how to better the science teaching and learning environments for science learners in K-12 and post-secondary institutions.

**Compensation:** There is no compensation for participating in the online survey. It is possible that your instructor may provide extra credit for your completion of this survey. The amount of extra credit and the process of confirmation of your survey completion will be determined by the science instructor of the course through which you were notified of this research study.
Risks: There are no foreseeable risks involved in participating in this study other than those encountered in day-to-day life.

Future Research: The anonymous data will be password-protected and stored by the principal investigator Regina McCurdy for a minimum of 5 years (per UCF policy).

You must be 18 years of age or older to take part in this research study.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, you may contact Regina McCurdy, Ed.S., PhD Candidate, School of Teacher Education, College of Community Innovation and Education, or Regina’s faculty supervisor Malcolm B. Butler, Ph.D.

IRB contact about your rights in this study or to report a complaint: If you have questions about your rights as a research participant, or have concerns about the conduct of this study, please contact Institutional Review Board (IRB), University of Central Florida, Office of Research, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901, or email irb@ucf.edu.
APPENDIX C

CONSTRUCT AND SURVEY ITEM ALIGNMENT
### Science Relevancy Construct

**Individual Dimension**

- Integration of various cultural backgrounds/perspectives
- Connection to students’ daily lives
- Importance to students, family, etc.
- See oneself in science - People who are mentioned (race/ethnicity, gender, culture)
- Skills
- Critical thinking
- Different & diverse perspectives are discussed, respected, and valued

**Survey Questions aligning to Individual Dimension**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Science in my secondary (middle and high) school science classrooms made connections to my everyday life.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>2. Science in my college science classes makes connections to my everyday life.</td>
<td>Yes/No</td>
</tr>
<tr>
<td>3. Scientists that are presented and discussed in my science classrooms usually have the same race/ethnicity and gender as I do. (Yes/No)</td>
<td></td>
</tr>
<tr>
<td>4. Which race/ethnicity of scientists is usually presented and discussed?</td>
<td></td>
</tr>
<tr>
<td>5. Which gender of scientists is usually presented and discussed?</td>
<td></td>
</tr>
<tr>
<td>6. Diverse perspectives and different ways of thinking about science were discussed, respected, and valued in my secondary science classrooms.</td>
<td></td>
</tr>
<tr>
<td>7. Diverse perspectives and different ways of thinking about science are discussed, respected, and valued in my college science classrooms.</td>
<td></td>
</tr>
</tbody>
</table>

**References**

Aronson & Laughter, 2016
Chamany, Allen, & Tanner, 2008
Cowie et al., 2010
Kang et al., 2018
Russell, 2014
Stuckey, 2013
Williams & Williams, 2011
Yalaki, 2016

**Societal Dimension**

- Integration of Social Issues or awareness
- Political
- Socio-scientific
- Contribution of science to the world
- Local community
- Real world issues/problems are addressed, discussed, meaningful
- Global problems
- Environmental issues

**Survey Questions aligning to Individual Dimension**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Science in my secondary (middle and high school) science classrooms included ways for me to use science to address (or solve) local or community-based societal (or global) problems/issues.</td>
<td></td>
</tr>
<tr>
<td>9. Science in my college science classes include ways for me to use science to solve local or community-based societal (or global) problems/issues.</td>
<td></td>
</tr>
<tr>
<td>10. Societal, political, and global problems/issues played a large role in my science classrooms.</td>
<td></td>
</tr>
<tr>
<td>11. Real-world issues and topics were addressed, discussed, and integrated into my secondary science classrooms.</td>
<td></td>
</tr>
<tr>
<td>12. Real-world issues and topics were addressed, discussed, and integrated into my college science classrooms.</td>
<td></td>
</tr>
</tbody>
</table>

**References**

Aronson & Laughter, 2016; Chamany, Allen, & Tanner, 2008; Kang et al., 2018; Stuckey et al., 2013
Williams & Williams, 2011; Yalaki, 2016

**Vocational Dimension**

**Survey Questions aligning to Vocational Dimension**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Science in my secondary (middle and high school) science classrooms included ways for me to use science to address (or solve) local or community-based societal (or global) problems/issues.</td>
<td></td>
</tr>
<tr>
<td>14. Science in my college science classes include ways for me to use science to solve local or community-based societal (or global) problems/issues.</td>
<td></td>
</tr>
<tr>
<td>15. Societal, political, and global problems/issues played a large role in my science classrooms.</td>
<td></td>
</tr>
<tr>
<td>16. Real-world issues and topics were addressed, discussed, and integrated into my secondary science classrooms.</td>
<td></td>
</tr>
<tr>
<td>17. Real-world issues and topics were addressed, discussed, and integrated into my college science classrooms.</td>
<td></td>
</tr>
</tbody>
</table>

References

Aronson & Laughter, 2016; Chamany, Allen, & Tanner, 2008; Kang et al., 2018; Stuckey et al., 2013
Williams & Williams, 2011; Yalaki, 2016
Preparation for future in science
- Science courses
- Science professions addressed, their responsibilities
- Useful

Gaining new knowledge

Access to resources, materials, learning opportunities

Throughout my secondary (middle and high) school years, I had adequate access to resources, materials, opportunities to be successful in science learning.
14. My secondary science classes incorporated information about the roles, responsibilities, and expectations of science professions.
15. My secondary science classes introduced me to a variety of science professions.
16. The academic and science coursework in my secondary science classes adequately prepared me to take college science classes.
17. My college science courses have been preparing me for a future profession in science or a science major.

Instructional Dimension

Survey Questions aligning to Instructional Dimension
(Scale: Strongly Agree—Strongly Disagree)
(Multiple Selection)

- Teaching and learning tasks
  - Variety
  - Technology
  - Social media
  - Interactive
  - Collaborative
  - Strategies
  - Activities
  - Meaningful
  - Different texts used
  - Use of scenarios
  - Prior knowledge

18. I prefer learning science through a variety of instructional strategies and resources.
19. Science teaching in my secondary science classrooms included a variety of useful ways to learn science.
20. Which of these ways of teaching were present and helpful for learning science in your secondary science secondary classrooms:
   - Use of digital tools
   - Use of lecture
   - Use of social media
   - Use of collaborative activities
   - Use of scenarios
   - Use of various texts
   - Use of notetaking
   - Use of group projects
   - Use of virtual simulations
   - Use of class discussions
   - Use of peer debates
   - Use of guest speakers
   - Use of field trips
   - Use of websites and videos

21. Science teaching in my college science courses has included a variety of ways to learn science.
22. Which of these ways of teaching have been present and helpful for learning science in your college science classrooms:
   - Use of digital tools
   - Use of lecture
   - Use of social media
   - Use of collaborative activities
   - Use of scenarios
   - Use of various texts
   - Use of notetaking
   - Use of group projects
   - Use of virtual simulations
   - Use of class discussions
   - Use of peer debates
   - Use of guest speakers
   - Use of field trips
   - Use of websites and videos

References
Kang et al., 2018; Stuckey et al., 2013; Williams & Williams, 2011

Science-Specific Dimension

Survey Questions aligning to Science-Specific Dimension
23. My science classes incorporated the knowledge about the history of science and the development of scientific principles, methods, and concepts.

24. My science classes focused on the development of scientific processes instead of scientific facts.

25. The various ways diverse cultures contributed to science was included in my secondary science classroom experiences.

26. The various ways diverse cultures contributed to science has been included in my college science class experiences.

27. My secondary science classroom experiences encouraged engaging in questioning, inquiry, and argumentation to make decisions about scientific evidence.

28. My college science classes encouraged me to engaging in questioning, inquiry, and argumentation to make decisions about scientific evidence.

References
Aronson & Laughter, 2016; Chamany, Allen, & Tanner, 2008; Kang et al., 2018; Russell, 2014

Science Identity Construct

RECOGNITION
- Students viewing/seeing/perceiving oneself as a “science person” or a “scientist” or “good at science”
- Others-parents, peers, classmates, instructors, viewing/seeing/perceiving one as a “science person” or a “scientist” or “good at science”
- Develops/becomes over time
- Interconnected to social/political/cultural contexts, norms, etc.
- Desire to be recognized as such or in a certain way
- Importance valued by student
- Affects how one acts/behaviors
- Connected to one’s group membership or desired group membership
- Not the sole determining factor of science identity
- Contributes to sense of belonging
- Can be shaped by school, classroom, learning community/context

1. I view myself as being a science person.
2. My family/parents view me as being a science person.
3. My friends view me as being a science person.
4. My peers/classmates view me as being a science person.
5. My teachers/instructors view me as being a science person.
6. I can see myself working in a science profession.

References
Avraamidou, 2019; Carlone & Johnson, 2007; Kim & Sinatra, 2018; Le et al., 2019; Stets et al., 2017; Vincent-Ruz & Schuun, 2018
Learning Environment/Community Context
- Can greatly affect students’ recognition as science person
- Site of participation/engagement or lack of
- Can provide access to or restrict access to science learning
- Can welcome/not welcome
- Can create a sense of belonging or not
- Artifacts, texts, posters in the classroom
- Inclusive or exclusive to learners
- Shaped by teacher, peers, objects, parents
- Greatly forms students’ experiences with science
- Greatly affects students’ recognition

(Scale: Strongly Agree—Strongly Disagree)

7. I felt like I could be myself in my prior science learning classrooms.
8. In prior science learning classrooms, I felt as though I could freely participate in science learning activities.
9. I feel like I can be myself in my current college science classroom.
10. I feel like I belong in science because of my experiences in my science learning classrooms.
11. My science learning environments have made me want to pursue science professionally.

References
Avraamidou, 2019; Carlone & Johnson, 2007; Kim & Sinatra, 2018; Le et al., 2019; Vincent-Ruz & Schuun, 2018

Interactions of Sociopolitical/Sociocultural Contexts
- Present in social aspects—norms, biases, beliefs, values, stereotypes
- Where multiple identities overlap and intersect
- Intersectionality becomes more evident
- Shapes identities in general

References
Avraamidou, 2019; Carlone & Johnson, 2007; Kim & Sinatra (2018); Le et al., 2019; Vincent-Ruz & Schuun, 2018

BELONGING
- A facet of the community and recognition
- Can support or discourage one’s recognition in the group/community
- Intertwined with interaction with others in the community

References
Avraamidou, 2019; Carlone & Johnson, 2007; Kim & Sinatra, 2018; Le et al., 2019
APPENDIX D

ISLDS INSTRUMENT
Identification of Science Learning Development Survey

Part 1: Science Identity

For Part 1 of the survey, reflect upon your identification with science in general and within the contexts of your science classroom experiences you have had up to this point in time.

Recognition (SCIR)

*Scale: Strongly Disagree—Strongly Agree*

1. I view myself as being a science person.
2. My family/parents view me as being a science person.
3. My friends view me as being a science person.
4. My peers/classmates view me as being a science person.
5. My teachers/instructors view me as being a science person.
6. I can see myself working in a science profession.

Belonging in Science Learning Community/Contexts (BLSCI)

*Scale: Strongly Disagree—Strongly Agree*

7. My science classroom environments made me want to learn more about science.
8. I felt like I could be myself in my science classrooms.
9. I felt like I could freely participate in the learning activities of my science classrooms.
10. I feel like I belong in science because of my science classrooms environments.
11. My science classroom environments made me want to pursue science professionally.

Part 2: Science Relevancy

For Part 2 of the survey, reflect upon the relevancy of the experiences you have had within your science classrooms up to this point in time.

Individual Dimension of Science Relevancy (IND)

*Scale: Strongly Disagree—Strongly Agree*

1. My science classroom experiences provided me with practical life skills.
2. My science classroom experiences made connections to my everyday life.
3. My science classroom experiences integrated knowledge I could use immediately.
4. My science classroom experiences included learning about scientists that looked like me.

Societal Dimension (SOC)

*Scale: Strongly Disagree—Strongly Agree*

5. My classroom learning experiences in science helped me use science to tackle local problems.
6. Science in my classroom learning experiences included ways for me to use science to address global issues.
7. Real-world problems were integrated into my learning experiences in science classrooms.
8. My science classroom experiences addressed the connections between science and society.
9. Science was presented as a way to solve social problems in my science classrooms.

**Vocational Dimension (VOC)**

*Scale: Strongly Disagree—Strongly Agree*

10. I had adequate access to resources for learning science.
11. My science experiences included access to quality science learning opportunities.
12. My science classes introduced me to a variety of science professions.
13. My science classes presented information about the responsibilities of science professionals.
14. My science classes adequately prepared me to take college science classes.
15. My science classes have prepared me for a future profession in science (or a science major).

**Instructional Dimension (INST)**

*Scale: Strongly Disagree—Strongly Agree*

16. The teaching in my science classrooms incorporated a variety of useful instructional strategies and resources.
17. The teaching in my science classrooms included a variety of useful ways to learn science.
18. The teaching in my science classrooms included helpful interactive ways to learn science.
19. My science classroom experiences incorporated collaborative ways of learning science.

**Science-Specific Dimension (SCI)**

*Scale: Strongly Disagree—Strongly Agree*

20. My science classes incorporated content about the history of science.
21. My science classes focused on the development of scientific processes instead of scientific facts.
22. My science classes included content about the variety of cultures that contributed to science.
23. My science classroom experiences encouraged participation in scientific inquiry.
24. My science classroom experiences encouraged critical thinking about scientific evidence.

---

**Part 3: Student Background and Demographic Information**

Part 3 of the survey contains items related to your general science and demographic background.

**Science Background and Interests**

1. At which age do you most vividly recall learning about or doing science?
   - 0-5
   - 6-11
   - 12-14
   - 15-18
   - 19-23
   - 24-30
   - 31 or older
2. Outside of the classroom, how did you most enjoy learning about science as a child (elementary age) (Please select one option)?
   - Family member(s)
   - Firsthand discoveries
   - Museums and zoos
   - Informational websites
   - Television shows
   - Written texts (books, magazines, and articles)
   - Other option not listed (Please describe the option in the space provided.)

3. Which of these activities did you (do you) participate in or attend outside of the classroom (not including field trips)? (Select as many activities that apply.)
   - Science-based competitions
   - Science camps
   - Science clubs
   - Science museums/centers/zoos/planetariums
   - Science research projects

4. Which of these instructional strategies have been helpful for your learning in science classrooms? (Select as many that apply):
   - Use of digital tools
   - Use of lecture
   - Use of social media
   - Use of collaborative activities
   - Use of scenarios
   - Use of various texts
   - Use of notetaking
   - Use of group projects
   - Use of virtual simulations
   - Use of class discussions
   - Use of peer debates
   - Use of guest speakers
   - Use of field trips
   - Use of websites and videos

5. Which of these instructional strategies have been the frequently used in your science classrooms? (Select as many that apply):
   - Use of digital tools
   - Use of lecture
   - Use of social media
   - Use of collaborative activities
   - Use of scenarios
6. As a child, did you want to pursue a science-related (or medical-related) profession when you grew up?
   - Yes
   - No (If not, what was the main job/profession that you wanted to pursue when you were a child? ___________________)

7. In elementary, middle, or high school, did you ever complete a science project (including science fair, independent research, or presentation) as part of your science class?
   - Yes
   - No

8. Did the scientists addressed in your science classrooms usually have the same race/ethnicity as you do? (Yes/No)
   - Yes
   - No (If No, which race/ethnicity of scientists is usually presented?
     - American Indian or Alaskan Native
     - Asian or Asian American
     - Black or African American
     - Native Hawaiian or Pacific Islander
     - White
     - Hispanic or Latino(a) or Spanish Origin
     - Multiracial/multi-ethnic

9. Did the scientists addressed in your science classrooms usually have the same gender as you do?
   - Yes
   - No (If No, which gender of scientists is usually presented and discussed?
     - Female
     - Male
     - Other

Family Background Information

10. Which best describes the level of education of your parents/guardians?
Both of my parents/guardians have at a bachelor's degree
One of my parents/guardians has a bachelor's degree
Neither of my parents/guardians has a bachelor's degree

11. Which best describes the occupations of your parents/guardians during your childhood/adolescent years?
   - Two of my parents/guardians had science-related occupations.
   - One of my parents/guardians had science-related occupations.
   - No parent/guardian had science-related occupations.
   - I do not know if one or more parents/guardians had science-related occupations.

12. Which best describes your family's/parents' role in your science learning?
   - Never supportive
   - Rarely supportive
   - Sometimes supportive
   - Often supportive

13. Have you ever had an individual who mentored you in science?
   - Yes
   - No

Student Demographic Information

14. Which of these options best identifies your biological sex?
   - Female
   - Male
   - Intersex

15. To which gender identify do you most identify?
   - Female
   - Male
   - Transgender Female
   - Transgender Male
   - Non-binary/non-conforming
   - Not listed (Please describe in the space provided)
   - Prefer not to respond

16. Which of these options best describes your race/ethnicity?
   - American Indian or Alaskan Native
   - Asian or Asian American
   - Black or African American
   - Native Hawaiian or Pacific Islander
17. What is your age? _________

18. Which term best describes the area in which you were raised for the majority of your childhood?
   o Rural
   o Suburban
   o Urban

**Academic and Career Information**

19. Which option best describes your current employment status?
   o I have a full-time job.
   o I have a part-time job.
   o I do not have a job.

20. Which option best describes your financial aid status?
   o I require financial aid to pay for all of my tuition and student fees.
   o I require financial aid to pay for part of my tuition and student fees.
   o I do not require financial aid to pay for my tuition and student fees.

21. In which program are you currently enrolled?
   o Associate in Arts
   o Associate in Science
   o Bachelor’s degree
   o Certificate (technical/career)
   o Transient/Enrolled at another institution

22. Which program best describes your major area of focus?
   o Non-science major
   o Science major
   o Undecided
23. In which year of college are you?
   o 1st year/freshman
   o 2nd year/sophomore
   o 3rd year/junior
   o 4th year/senior
   o Other (Please describe your current student classification)

24. What is your approximate grade point average (GPA)?
   o 0-0.5
   o 0.6-1.1
   o 1.2-1.7
   o 1.7-2.2
   o 2.3-2.8
   o 2.9-3.4
   o 3.5-4.0
   o 4.0-4.5

25. In how many classes are you currently enrolled?
   o 1
   o 2
   o 3
   o 4
   o 5
   o 6

26. In how many science-related classes are you currently enrolled?
   o 1
   o 2
   o 3
   o 4
   o 5

27. What is your current letter grade in this science course?
   o A
   o B
   o C
   o D
   o F

28. Is this science course (through which you are completing this survey) the first college science course you have taken?
   o Yes
   o No
29. At this point, I have decided to pursue a science-related (including medical-related) profession after college.
   - Yes
   - No (If No, which profession have you decided to pursue after college?)
   - Undecided
APPENDIX E

INTERVIEW/FOCUS GROUP RECRUITMENT LETTER
Hello Creek State College Students,

My name is Regina McCurdy, and I am a doctoral candidate from the School of Teacher Education at the University of Central Florida. I am writing to invite you to participate in the interview/focus group portion of a dissertation research about your science learning perspectives, experiences, and background as a non-White male or male student of color. You are eligible to be in this study, because you provided your email address in the online survey research, you are currently enrolled in a STEM-related course at Creek State College, and because you identified as being both non-White and male. You must be 18 years of age or older to participate in this study.

If you decide to participate in this portion of this study, you will be asked to participate in an individual interview and a follow-up focus group interview with other participants via Zoom. Both the individual and focus group interview will be audio and video recorded through Zoom. The individual interview may last between 30-60 minutes. The focus group session will be conducted at a later date and may last between 45-60 minutes. You will be given the option of turning your camera on or off during the interview/focus group session. You also have the option of changing your name in Zoom to maintain your anonymity. You do not have to answer any interview/focus group questions that you do not wish to answer.

For participating in the individual interview, you will receive online access to a $10 Prepaid Visa Gift card as compensation of your time and availability at the conclusion of the interview. For participating in the focus group, you will receive online access to an additional $10 Prepaid Visa Gift card as compensation of your time and availability at the conclusion of the focus group session.

If you are interested in participating in this portion of the research, please use the link below to access and read the informed consent and select “yes” or “no” verifying your willingness to participate in this research study. Additionally, you will be asked to provide your email address and first name to confirm your willingness to participate and to begin scheduling the date/time of your individual interview. The document containing your email address and first name will be securely stored and password-protected on locally on my computer where only I can access it.

Thank you very much for your time.

Sincerely,

Regina

Regina McCurdy, Ed.S.
PhD Candidate, School of Teacher Education
College of Community Innovation and Education
University of Central Florida
APPENDIX F

INTERVIEW/FOCUS GROUP INFORMED CONSENT
Title of Project: Intersectionality as a Lens to Explore College Students' Science Identity, Science Relevancy Experiences, and their Decisions to Pursue Science

Principal Investigator: Regina P. McCurdy, Ed.S., Ph.D. Candidate (School of Teacher Education, UCF)

Faculty Supervisor: Malcolm B. Butler, Ph.D. (Director or School of Teacher Education, College of Community Innovation and Education UCF)

You are being invited to take part in an interview and/or focus group via Zoom as part of the dissertation study being conducted by Regina McCurdy, a doctoral candidate at the University of Central Florida. The purpose of this research is to explore aspects of your science learning perspectives, experiences, and background as male non-White (students of color) college students enrolled in a biological science, physical science, or other STEM-related course. This interview/focus group is not a part of your academic coursework; therefore, it is solely your decision to participate. You must be 18 years of age or older to take part in this research study.

Confidentiality and Privacy as Participants in this Study

Duration of Study: The interview may last between 30-60 minutes. The focus group session will be conducted at a later date and may last between 45-60 minutes. Additional interview of 15-30 minutes may be conducted as interview follow-up questions; however, you will have the option of responding in a Zoom session or via email.

Voluntary Participation: Your participation in this study is voluntary. You are free to withdraw your consent and discontinue participation in this study at any time without prejudice or penalty. You do not have to answer any interview questions that you do not wish to answer. Your decision to participate or not participate in this study will in no way affect your relationship with Creek State College, including continued enrollment, grades, employment, or your relationship with the individuals who may have an interest in this study.

Identifiable Information: Your interview and/or focus group sessions will be recorded via Zoom and stored in Zoom’s encrypted cloud portal to access transcriptions. After the researcher has confirmed the accurate transcription of the interview/focus group, the unpublished and passcode-protected recording will be permanently deleted from Zoom not to exceed 7 days after the interview/focus group session. You will be given the option of turning your camera on or off during the interview/focus group session. You also have the option of changing your name in Zoom to maintain your anonymity. The recorded transcription documents will use pseudonyms in place of your name and will be password-protected on the researcher’s computer. No identifying information will be included in any publications or presentations based upon these Zoom sessions, and your responses will remain confidential. If you choose to respond via email, your responses will be saved in a file in the researcher’s computer that is password protected. Additionally, the email containing your responses will be deleted from the researcher’s email folder. Anonymous data collected from Zoom sessions or email may be shared with the researcher’s dissertation committee members: Dr. Malcolm B. Butler, faculty supervisor/dissertation chair; Dr. Su Gao, dissertation co-chair; Dr. Sarah Bush or Dr. Haiyan Bai, dissertation committee members.

Access to Zoom Session: Upon consent of your participation in the individual interview, you will receive a Zoom link via email and a passcode required to access the session. Upon consent of your participation in the focus group session, each participant will receive a Zoom link via email and a passcode required to access the session.
**Compensation:** For participating in the individual interview, you will receive online access to a $10 Prepaid Visa Gift card as compensation of your time and availability at the conclusion of the interview. For participating in the focus group, you will receive online access to an additional $20 Prepaid Visa Gift card as compensation of your time and availability at the conclusion of the focus group session.

**Benefits:** You will receive no direct benefits from participating in this research study. However, your responses may help us learn more about how to better the science teaching and learning environments for science learners in K-12 and post-secondary institutions.

**Risks:** There are no foreseeable risks involved in participating in this study other than those encountered in day-to-day life.

**Future Research:** The anonymous data will be password-protected and stored by the principal investigator Regina McCurdy for a minimum of 5 years (per UCF policy).

You must be 18 years of age or older to take part in this research study.

**Study contact for questions about the study or to report a problem:** If you have questions, concerns, or complaints, you may contact Regina McCurdy, Ed.S., PhD Candidate, School of Teacher Education, College of Community Innovation and Education.

**IRB contact about your rights in this study or to report a complaint:** If you have questions about your rights as a research participant, or have concerns about the conduct of this study, please contact Institutional Review Board (IRB), University of Central Florida, Office of Research, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901, or email irb@ucf.edu.
APPENDIX G

FOCUS GROUP QUESTION PROTOCOL
Research Question #3

How do male students of color describe the relevancy of their formal science learning to their lived experiences?

Interviewer: In the prior individual interviews, each of you shared your perspectives on your identities and your science learning experiences. For this focus group, I would like for you all to think more specifically about your science learning experiences and their relevancy to your life experiences.

1. How would you all describe classroom science learning that is relevant to students' lives? What descriptions, characteristics, phrases, or examples come to mind? (e.g. What are the traits, characteristics, or phrases of relevant science learning experiences?)

2. Given these descriptions, consider your own science learning experiences in classrooms throughout your schooling (K-college). In what ways have these science learning experiences been relevant to your lives? (What are some examples?)

3. In what ways have these science learning experiences not been relevant to your lives? (What are some examples?)

4. Now I have a task for you to complete. I would like for you to make a 3-slide presentation (with PowerPoint, Google slides, or a similar presentation tool).
   a. On the first slide, provide a title that you feel encompasses the essence or theme of your presentation. It may be helpful to complete this slide at the end.
   b. On the second slide, your job is to create a collage by finding and using images, pictures, visuals, or graphics to help you respond to this question: How have my science learning experiences been relevant to my identity(ideities)?
   c. On the third slide, your job is to create a collage by finding and using images, pictures, visuals, or graphics to help you respond to this question: If your past/current or future science instructors were to ask you, "What would science learning look like if it were relevant to students whose identities are like your own?" how would you respond? (Sweetman et al., 2010)
   d. Lastly, each of you will have the opportunity to share and explain your slide presentations.

5. Are there any other experiences you would like to share about the relevancy of science learning and your identity?
APPENDIX H

COHERENCE OF PHASE 3 CODES AND ISLDS DIMENSIONS
<table>
<thead>
<tr>
<th>Phase 3 Codebook List</th>
<th>Five Dimensions of Science Relevancy from ISLDS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Individual</td>
</tr>
<tr>
<td>Teacher traits/personality</td>
<td></td>
</tr>
<tr>
<td>Teacher Instructional Style</td>
<td></td>
</tr>
<tr>
<td>Student-Teacher Connection</td>
<td>x</td>
</tr>
<tr>
<td>Hands-on Learning/ Interactive</td>
<td>x</td>
</tr>
<tr>
<td>Future-Focused</td>
<td>x</td>
</tr>
<tr>
<td>Purposeful/practical</td>
<td>x</td>
</tr>
<tr>
<td>The learning experience/environment</td>
<td>x</td>
</tr>
<tr>
<td>Technology and art</td>
<td></td>
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<tr>
<td>Real-life/real-world examples &amp; problem-based learning</td>
<td>x</td>
</tr>
<tr>
<td>Access to materials and resources</td>
<td></td>
</tr>
<tr>
<td>Foundational concepts of science</td>
<td></td>
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<tr>
<td>Job and career preparation</td>
<td></td>
</tr>
<tr>
<td>Process of learning and concept attainment</td>
<td>x</td>
</tr>
<tr>
<td>Field trips</td>
<td>x</td>
</tr>
<tr>
<td>Sense of awe and wonder</td>
<td>x</td>
</tr>
<tr>
<td>Visual representations and media integration</td>
<td>x</td>
</tr>
<tr>
<td>Open-minded</td>
<td>x</td>
</tr>
<tr>
<td>Collaborative</td>
<td></td>
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<tr>
<td>--------------------------------</td>
<td>---</td>
</tr>
<tr>
<td>Use of concrete examples</td>
<td>x</td>
</tr>
<tr>
<td>Cultural differences</td>
<td></td>
</tr>
<tr>
<td>Accessible/inclusive of multiple modes of learning</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I

INDIVIDUAL INTERVIEW QUESTION PROTOCOL
Research Question #2: How do the lived experiences of male students of color shape their science identities and their decisions to pursue science professions?

Interviewer: Thank you for taking the time to participate in my research today. This purpose of this interview is to explore the identities that are meaningful to you, your past and currently science learning experiences and how your identities interact with your science learning experiences and the goals you have.

1. Tell me a little bit more about yourself. What led you to become a student at CSC?
   a. What short-term/long-term academic and/or professional goals do you have? Why are these goals important to you?
   b. What made you decide to enroll in your current science course(s)?

2. Take a minute to look at this identity web. Which of these identities would you use to identify yourself? You may select more than one term.
   a. Why did you select these terms?
   b. Are there any other terms that are missing that you would want to add or include? If so, why?
   c. How do these identities work together? (Can you give me an example?)
   d. Are there any situations or contexts in which certain identities you listed are more or less significant or noticeable than others? If so, can you explain or provide an example?
   e. If you had to be referenced, labeled, or addressed by only four of these identities, which four would you select and why?

3. Think for a moment about your perceptions of science in general. If you could create an “identity” web about science, what terms or phrases would be on your “science web”? Consider:
   o how you perceive or think about science,
   o how you think the public or society perceives science,
   o what science does (or is used for),
   o who uses science,
   o who science is for, and
   o who does science
   a. Why did you select these terms or phrases?

4. Describe your science learning experiences as an elementary, middle, high school and college age student.
   a. What positive science experiences stand out to you?
b. What negative science experiences stand out to you?

c. How did you view yourself as a science learner then? Now? Why?

d. How do you think others (peers, classmates, teachers, family members, school leaders, etc.) viewed you as a science learner? Why? (How do you know?)?

e. How would you describe the identities of the other students in your science classes? (When considering the identity makeup of other classmates in your science classes, do they have similar or different identities than you?) How do you think their identities affect your science learning experiences?

f. How would you describe the identities of your science teachers and professors? How do you think their identities affected your science learning experiences?

5. Consider the four terms you labeled as part of your identity from the initial identity web. How do you think your science learning experiences in science classrooms or other science learning environments have interacted with your identities OR how have your identities interacted with your experiences as a science learner in science classrooms or other science learning environments? (e.g. How do you think the identities you named have interacted with, affected, or been affected by your science learning experiences in science classrooms or other science learning environments?)

6. Now consider the "science web" you developed. Do you think that any of these terms/phrases identify you in any way? If so, how? If not, why not?

a. In what ways, if any, do you think the "science web" contribute toward or address your short-term or long-term goals?

7. Are there any other pieces of information (or experiences) you would like to share about your identities, your science learning, your goals, or the interactions among these?
APPENDIX J

DISSERTATION DEFENSE ANNOUNCEMENT
Announcing the Final Examination of Ms. Regina P. McCurdy for the degree of Doctor of Philosophy

**Date:** June 28, 2021  
**Time:** 10:00 a.m. - 12:00pm  
**Room:** Virtual (via Zoom)

**Dissertation Title:** Male Students of Color in STEM through the Lens of Intersectionality: A Transformative Mixed-Method Exploration of Their Science Identities, Relevant Science Learning Experiences, and Decisions to Pursue Science Professions

This 3-phase mixed-methods study used intersectionality theory to explore the science identity and relevant science learning experiences of male students of color in STEM and their decisions to pursue science professions after college.

*Phase 1* used a researcher-developed survey to analyze differences in science identity scores (SIS) and science relevancy scores (SRS) of 702 diverse college students enrolled in STEM courses at a U.S. state college. While there were no significant differences in SIS and SRS scores regarding race/ethnicity and socioeconomic factors, statistical differences in SRS were present regarding gender. Female students had higher SRS than male students. *Phases 2 and 3* used interviews from five male students of color to explore how their lived experiences shaped their views of science, science learning, and professional decisions. The interactions among their a) future-focused mindsets, b) connectedness to technology, engineering, and math, and c) science experiences and ideas largely shaped their decisions to pursue STEM fields. Students described the teacher’s personality and the classroom environment as critical components of relevant formal science learning.

Implications include the need to confirm the survey’s SIS and SRS construct reliability with a different population of college students, the important role science teachers play in developing purposeful instruction that prepares male learners for science professions, and the intentional integration of real-world STEM in science curricula and teachers’ professional development.

**Outline of Studies:**

**Major:** Science Education

**Educational Career:**

- B.S., 1999, Florida State University
- M.A., 2007, Asbury Theological Seminary
- Ed.S., 2018, University of Central Florida

**Committee in Charge:**

- Dr. Malcolm B. Butler
- Dr. Su Gao
- Dr. Sarah B. Bush
- Dr. Haiyan Bai

Approved for distribution by Malcolm B. Butler, Committee Chair, on June 10, 2021.

The public is welcome to attend. Please contact Regina McCurdy for details regarding attendance.
APPENDIX K

UCF IRB HUMAN SUBJECTS APPROVAL LETTER
EXEMPTION DETERMINATION

December 21, 2020

Dear Regina McCurdy:

On 12/21/2020, the IRB determined the following submission to be human subjects research that is exempt from regulation:

<table>
<thead>
<tr>
<th>Type of Review:</th>
<th>Initial Study, Category 2</th>
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<tbody>
<tr>
<td>Title:</td>
<td>Intersectionality as a Lens to Explore College Students' Science Identity, Science Relevancy Experiences, and their Decisions to Pursue Science</td>
</tr>
<tr>
<td>Investigator:</td>
<td>Regina McCurdy</td>
</tr>
<tr>
<td>IRB ID:</td>
<td>STUDY00002298</td>
</tr>
<tr>
<td>Funding:</td>
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<tr>
<td>Grant ID:</td>
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<tr>
<td>Documents Reviewed:</td>
<td>• HRP-251- FORM - Faculty Advisor Scientific-Scholarly Review fillable form.pdf, Category: Faculty Research Approval;</td>
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<td></td>
<td>• 0-HRP-255- FORM_Request_Exemption_ReginaMcCurdy_Dissertation.docx, Category: IRB Protocol;</td>
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<tr>
<td></td>
<td>• Faculty Information Letter/Email, Category: Recruitment Materials;</td>
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<td></td>
<td>• Informed Consent-Interview_Focus_Group, Category: Consent Form;</td>
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<td>• ISLDS Survey Instrument, Category: Survey / Questionnaire;</td>
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<tr>
<td></td>
<td>• ReginaMcCurdy_IdentityWeb.pdf, Category: Interview / Focus Questions;</td>
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<tr>
<td></td>
<td>• Survey Recruitment Letter, Category: Recruitment Materials;</td>
</tr>
</tbody>
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This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please submit a modification request to the IRB. Guidance on submitting Modifications and Administrative Check-in are detailed in the
Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

[Signature]

Racine Jacques, Ph.D.
Designated Reviewer
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