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An Investigation of a Culturally Responsive Approach to Science Education in a Summer Program for Marginalized Youth

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by

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DEDICATION

To my Grandmother, Heddie, my Mother, Betty and my Sister, Lenora.

My master teachers and greatest heroines.

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My Grandmother often reminds me to hold to God's unchanging hand. I give all glory, honor, and praise to God, my Heavenly Father who began a good work in me and was faithful to carry it on to completion.

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ABSTRACT

The demographics of today's schools are becoming more and more ethnically and linguistically diverse, as culturally diverse students comprise approximately one third of school populations (Ladson-Billings, 2005). However, the educational experiences of students of Color demonstrate a history of marginalization and inequity (Williamson et al., 2007) as far too many students of Color have maintained poor educational achievement outcomes. The effects of such disproportionally high levels of low academic achievement are extensive and can be witnessed across subject content areas, particularly in math, science, and literacy. To improve the academic performance of students who are culturally, racially, ethnically, and linguistically diverse, improved methods of instruction and pedagogy that better facilitate learning among diverse student populations must be instituted (Ladson-Billings, 2005). Thus the need to provide summer science enrichment programs where students engage in scientific experimentation, investigation, and critical thinking are vital to helping students who have been traditionally marginalized achieve success in school science and enter the science career pipeline.

This mixed methods study examined the impact of a culturally responsive approach on student attitudes, interests in science education and STEM careers, and basic science content knowledge before and after participation in a science course within the Upward Bound Summer Program. Quantitative results indicated using a culturally

responsive approach to teach science in an informal learning space significantly increases student achievement. Students receiving culturally responsive science instruction exhibited statistically significant increases in their posttest science scores compared to pretest science scores. Likewise, students receiving culturally responsive science instruction had a significantly higher interest in science and STEM careers.

The qualitative data obtained in this study sought to gain a more in-depth understanding of the impact of a culturally responsive approach on students' attitudes, interests in science, and STEM careers. Findings suggest providing students the opportunity to "do" and learn science utilizing a culturally responsive approach was much more beneficial to their overall science knowledge, as it allowed students to experience, understand, and connect to and through their science learning. Likewise, culturally responsive science instruction helped students to foster a more positive interest in science and STEM careers as it provided students the opportunity to do science in a meaningful and relevant way. Moreover, results revealed students receiving culturally responsive science instruction were able to see themselves represented in the curriculum and recognized their own strengths; as a result they were more validated and affirmed in and transformed by, their learning.

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CHAPTER 1

INTRODUCTION

Whether or not you reach your goals in life depends entirely on how well you prepare for them and how badly you want them. You're eagles! Stretch your wings and fly to the sky. (Dr. Ronald McNair)

I am a product of opportunity and did not get this far without the prayers, help, love, support, encouragement, inspiration, and sacrifice of others. Individuals from all walks of life, in church, institutions and education, have provided me numerous opportunities to demonstrate my abilities. Essentially it was up to me to embrace, prepare for, and maximize those opportunities, but first, others had to give me a chance to succeed. As a African American female growing up in the deep rural south of South Carolina, where Chitlin Struts and dirt roads are just as common as morning traffic jams and city skylines, I can vividly recall my schooling experiences and how they altered my life and inspire the work I do today.

As I reflect on my K-12 learning experiences, I am reminded of leaky ceilings, moldy windows and the smell of mildewed floors, wore, tattered, and spineless textbooks, and above all the teachers who demonstrated tough love – Mrs. Bethea, Mrs. Thompson, and Mr. Wintrode. The rural elementary, middle, and high school I attended, was under- resourced, lacking things from updated textbooks to suitable structures and (curriculum) materials for teaching and learning. Although the recollection of limited

resources during my K-12 experience echoes in my mind, one thing that resonates louder are those teachers who pushed, challenged, and encouraged me.

During my elementary tenure, I was an outgoing and at times, talkative little girl. I oftentimes found casualty to talk in class and would have to surrender to a nearby corner or silent lunch. However, there was my third grade math teacher, Mrs. Bethea, a petite African American woman with a jheri curl, who "didn't take no stuff." There was no talking, laughing, playing, or chewing gum in Mrs. Bethea's math class. I struggled in math, for it was not a subject that came easy for me and I had to work and practice each day to get better. There were countless worksheets done, math drills performed, and flashcards made to help me get better; but no matter how hard I tried and how long I worked, I kept making "careless errors." It seemed "careless errors" was Mrs. Bethea's favorite two words, for on every math quiz, math test, and homework assignment, she would write those infamous two words, "careless errors." One day I finally made 100 percent on a math quiz. I remember feeling so excited because I felt I finally got it, however to my surprise, though smaller in size, Mrs. Bethea wrote, "beware of careless errors." This was a major breakthrough for me. You see all the time I was so caught up with and even frustrated by those two words that I missed the message and meaning of what Mrs. Bethea was trying to teach me. Those infamous words were more than mere words, they represented the importance of the struggle and why it is important to work hard and persevere. And even when you make it or think that you have, to always remember and beware of what you made it through to get to where you are.

I recall middle school madness just like it was yesterday. For me, the pressure to fit in with the cool kids, conform to the prescribed curriculum, and achieve academic

success was tremendous. I wanted to be cool and hang out with the popular kids. However, it was not cool to get to class early, sit on the front row, do your homework, or make good grades. When I started seventh grade, I found myself at a cross-road, I could be down with the cool kids and not do well academically, or I could achieve academically and be an outcast with the cool kids. Thankfully with the discipline of my mother and the "talkin to" from Mrs. Thompson, I chose wisely. Mrs. Thompson was an eighth grade science teacher. She and my mom went "way back" and we were all members of the same church. Mrs. Thompson was a big and tall African American woman with a voice comparable to Barry White. She seemed to possess somewhat magical powers because she always knew what I made on every test and quiz, when I got into trouble for talking in class, and where I was – there was no escaping her. One day she asked me what I wanted to be when I grew up. And though I do not recall exactly what I said, I hear her words resounding over and over in my mind, "you can be anything and do anything you put your mind to." You see until that moment, all of my focus was on doing well and getting good grades and I had not really given much time or thought to what I wanted to do after I graduated high school. Mrs. Thompson's words and mystic behavior was exactly the push I needed. Although at times a little strange, Mrs. Thompson had a unique way of moving me forward in the right direction. The fact that she always seemed to know how I did on tests and quizzes and if I was behaving or not, was her way of checking on me and sometimes telling on me. I look back on the middle school madness and I am thankfully for Mrs. Thompson's motherly spirit, tough love and compassion, and cleverness to rat me out to my mom when I needed it most. Mrs.

Thompson helped me to understand the importance of choice, how not to dissect a frog, and to believe in myself and the value of my abilities.

I clearly recall my high school experiences and all the disappointment, hurt, and frustration felt during that time. My two favorite subjects in high school and even today, are math and science. Unlike science, math was not something that came easy, but I was willing, able, and ready to master the challenge. My favorite science class during my high school tenure was biology. I loved the dissections, hands-on learning elements of the class, the teacher, and above all, the ability to connect what I was learning to me. However, the science curriculum did not reflect elements of culture, symbols of diversity, or relatable examples for someone like me – I felt disconnected and sometimes confused by the curriculum. To make matters worse, my favorite math teacher, Mr. Wintrode, said to me, "your math light bulb is not bright enough to take my Calculus class." As one would imagine, I was devastated and speechless. I stood in disbelief with a look of confusion and great sadness on my face, for he was my favorite teacher and I had grown to admire and respect him over my high school tenure. But then I remembered the teachings of Mrs. Bethea and the words of Mrs. Thompson, "you can be anything and do anything you put your mind to." Choosing wisely, I set out to prove him wrong, and I did! In May 2003 I graduated valedictorian, earning a B+ in my calculus class and a three on the AP calculus exam.

I began the introduction by sharing that I am a product of opportunity. For it has taken a village of individuals to support, nurture, and provide the opportunities I am privileged to today. However, what about those students who are equally talented and capable of the same merit as I am, but lack the opportunity? Here opportunity refers to

more than just mere academic success, but also access to systems and processes that can promote limitless aspirations. As an African American woman from a low-resourced K-12 schooling system, a first-generation college graduate from the rural South, and a female scientist, I advocate on behalf of those students who want better, deserve better, and need better. I embrace and carry with me all of these experiences, for these are the moments that have helped to shape, mold, and refine my interests and ignite the fire within to teach for, work with, and inspire science discovery among marginalized youth. The work I am inspired to do, stems from my own personal battles with oppression, marginalization, and inequity as well as amazing instances of opportunity. As a learner, scholar, and activist I seek to engage students who have been underrepresented and underserved in science through new discoveries and curiosity. I want students to know and understand that science can be an avenue for solutions to the inequitable circumstances in their lives and communities.

I draw upon these particular educational experiences as these are the moments that have shaped and inspired the work I do today. I want all students, especially students of Color and poor students, to understand that they are eagles and should stretch their wings and fly.

Problem Statement

In 2003, the National Center for Education Statistics reported that the average eighth grade student of Color performs at the same level of academic proficiency as the average fourth grade White student; and that there existed a four-year reading gap between African-American high-school students and their White counterparts. Fast-

forward to 2011, the National Center for Education Statistics reported that at grade 8, the average science scores for Black and Hispanic students were significantly lower than the score for White students. Likewise at grade 12, the average science scores for Black and Hispanic students compared to White students are again significantly lower.

Trends in International Mathematics and Science Study (2012) (TIMSS) an international assessment of mathematics and science at the fourth and eighth grades documents the current low performance of U.S. students on standardized math and science assessments; where East Asian countries such as Korea and Singapore are among the top-performers in science on TIMSS 2012 at grade four and Singapore had the highest average achievement at the eighth grade (Martin, Mullis, Foy, & Stanco, 2012). This level of performance of U.S. students appears to be consistent overtime. Studies such as the National Assessment of Educational Progress (NAEP) reveal the average performance of U.S. 17-year-olds on the 2008 reading and mathematics assessments was not measurably different from their performance in the early 1970s (USDOE, 2013). In addition to the overall low academic achievement trends for the U.S., students of Color and low-income students fare much worse than their middle class, White counterparts. In school year 2009-10 approximately 78 percent of public high school students graduated on time with a regular diploma. Among all public high school students, Asian/Pacific Islander had the highest graduation rate (93.5 percent), followed by Whites (83.0 percent), Hispanics (71.4 percent), American Indians/Alaska Natives (69.1 percent), and African Americans (66.1 percent) (USDOE, 2013). Moreover, students of Color, predominantly African American and Hispanic males, continue to be disproportionally

overrepresented in special education programs (Artiles & Trent, 1994; Ford & Harris, 1999; Gregory & Mosely, 2004).

Despite efforts to close the academic achievement gap for disadvantaged youth over the past forty years, considerable discrepancies remain. In 2009, the National Assessment of Educational Progress (NAEP) showed 49 percent of low-income fourth-grade students scored "below basic" levels in reading (the lowest proficiency level) compared to 20 percent of higher-income students. Similarly, such achievement gaps exist for mathematics, 30 percent of low-income students performed at the lowest proficiency level compared to only 9 percent of their higher-income peers. Due to the inequitable proportion of low-income minority students, similarly sized achievement gaps exist between White and Black students in the United States, White and Hispanic students, as well as among native speakers and English language learners (McCombs et al., 2011). These achievement gaps are especially disturbing as they support subsequent inequities in educational attainment, whereby students from the bottom quartile of the income distribution are more than twice as likely to drop out of high school as students from the top quartile of the distribution (National Center for Education Statistics, 2011). These low high school completion rates have significant consequences for both the student and society, as formal schooling is an important gateway to gainful means of employment (Belfield & Levin, 2007).

Considering the growing population of culturally and linguistically diverse students in U.S. schools, it is critically important that education policies, pedagogies, and initiatives effectively promote racial and ethnic minority students' educational achievement in Science, Technology, Engineering, and Mathematics (STEM) (Palmer,

Maramba, & Gasman, 2013). Academic achievement gaps among ethnically diverse students persist in science achievement and can also be observed in science course enrollments leading to careers in STEM fields (Chipman & Thomas, 1987; National Science Foundation, 2002). One outcome of these gaps is that women and people of Color are underrepresented in the science and engineering workforce. For example, White males (51%) dominated science and engineering occupations while Black men (3%) and Black women (2%) comprised only a small fraction of the science and engineering workforce (National Science Foundation, 2013). The 2013 National Science Foundation Women, Minorities, and Persons with Disabilities in Science and Engineering Report reveals persistent underrepresentation of these groups in science and engineering education as well as employment in the United States, as minority women constitute only 1 in 10 employed scientists and engineers. Although gains have been made over the past few decades in narrowing occupational gaps, women and minority scientists are often underutilized in the workforce than are their White, male counterparts (Oakes, 1990).

South Carolina Trends

Children of Color constitute a new diverse majority of those enrolled in the South's public schools and most of these students are also low income (Southern Education Foundation, 2010). Presently the South is home to 40 percent of the nation's low income students and has some of the lowest educational achievement and attainment levels in the country (Southern Education Foundation, 2010). There have been numerous calls and efforts made to provide states, school districts, and communities needed financial support to increase and enhance access to and opportunities in Science, Technology, Engineering, and Math (STEM) related disciplines for marginalized

populations (Caldwell & Siwatu, 2003; Tyson, Lee, Borman, & Hanson, 2007). As the challenge to better educate students of Color and poor students intensifies, the need to provide equitable science learning experiences for all students aimed at scientific literacy and STEM participation also becomes crucial. Research has shown that providing such experiences for Black and Hispanic students can have a positive impact. For example, Black and Hispanic students who took high level math and science courses were as likely as White students to pursue STEM degrees (Tyson et al., 2007). Such findings suggest that one factor impacting the racial disparities described here occur because fewer Black and Hispanic students are prepared for STEM in high school.

Several barriers related to STEM education exist for marginalized youth in South Carolina. First, academic achievement in science and subsequent matriculation into STEM career fields has been limited for students of Color and low-income youth. In 2011, the National Center for Education Statistics reported that 39% of South Carolina's eighth-grade students are below basic proficiency in science and 30% are below basic proficiency in math. Second, rates of participation in advanced placement courses exhibit significant White/Black disparities: of advanced placement test takers in Biology, 10.2% were Black and 82.1% were White; and in Calculus, 12.9% were Black and 81.3% were White (Southern Education Foundation, Inc., 2002). The underrepresentation of students of Color in advanced placement courses denies African American students the positive benefits of long-term outcomes for those who participate in advanced placement courses. Becker (as cited in Flowers, 2008) stated, "Education…has been viewed as the most significant investment an individual can make to accumulate higher levels of human capital" (p. 123). For high school students, advanced placement courses, generally

considered the gifted program at the high school level, enhance this investment. Without quality science education and equitable access to high-level science courses, students of Color will be less likely to pursue STEM-related jobs.

Summer Learning Loss

Although it is known by many names, “brain drain,” “summer slide,” summer learning loss is a real phenomenon that affects children nation-wide as research suggest low-income children and youth experience greater summer learning loss than their higher-income peers (Alexander, Olson, & Entwisle, 2007; Heyns, 1978; McCombs et al., 2011). Even more disturbing is that “summer learning loss is cumulative; overtime, the difference between the summer learning rates of low-income and higher-income students contributes substantially to the achievement gap” (McCombs et al., 2011, p. xiii). Commenting on the summer brain drain issue in a May 2012 interview with CNN, Ron Fairchild, President and CEO of Maryland-based Smarter Learning Group states, “summer after summer, low income kids lose roughly two months’ worth of learned skills which account for a huge and significant learning gap over the course of the elementary school years” (Schewe, 2006).

A recent study by Alexander et al. (2007) indicates that summer learning loss can be tied to economic status. This work reveals that during the school year lower income children’s academic skills in kindergarten through 4th grade improve at close to the same rate as those of their more advantaged peers; however over the summer, middle-and-upper income children’s skills continue to improve while lower income children’s do not. Emphasizing the importance and overall concern of summer learning loss, Karweit, Circuit, and Thompson (1994) comment that “many low income and minority students

lose some literacy and academic abilities during the summer months. Some students lose as much as three to four months of academic progress while children in high-income areas gain at least a month of progress during the summer." Likewise, Heyns in her 1978 book *Summer Learning and the Effects of Schooling* established that achievement gaps by family socioeconomic status and race/ethnicity widen more during the summer months than during the school year. Simply, summer learning loss disproportionately affects low-income students. Additional research by Hayes and Grether (1969) suggest that 80 percent of the difference between the performance scores of White and Black students can be explained by differential summer learning loss. Even President Obama in 2010 noted, "Students are losing a lot of what they learn during the school year during the summer" (McCombs et al., 2011). Therefore it is critically important that low-income and marginalized youth engage and participate in summer learning programs, as participation could mitigate learning loss and produce achievement gains (McCombs et al., 2011). I argue that summer learning programs deserve a front row seat in the educational reform arena, as it can be used as a conduit to alleviate summer learning loss and support success for underachieving populations.

Summer Learning Programs

For a long time, summer learning programs have taken a back seat to mainstream education reform efforts, as policymakers have devoted a great deal of time and money to improve the traditional school day and year. However, in many formal education settings, students of Color are experiencing inequitable opportunities to (high) quality science learning (Atwater, 2000). Research indicates that summer learning loss can be attributed to the lack of access to, and resources found in, quality summer enrichment

programs, which are too few in low-income neighborhoods (Cable News Network, 2012). More than half of the achievement gap between lower-and higher-income youth can be explained by unequal access to summer learning opportunities (National Summer Learning Association, 2009). Access to and opportunities in summer learning programs have the potential to prevent learning loss and propel students toward higher academic achievement (McCombs et al., 2011). According to McCombs et al. (2011) summer learning programs can effectively improve academic outcomes for students. Findings also suggest that extended learning opportunities, programs that extend learning into the out-of-school time hours, may be more advantageous for low-come, low-performing, ethnic minority or otherwise disadvantaged students.

A 2011 report from the Harvard Family Research Project suggests that year-round learning (including afterschool and summer learning programs) can help promote school success and reduce summer learning loss, especially for economically and otherwise disadvantaged youth. The report suggests that such programming initiatives can help close gaps in access to services and learning opportunities, provide developmentally appropriate activities and challenges, and strengthen student-centered learning. Furthermore, findings suggest that summer programming can also help deepen students' engagement and fill gaps in students' school-year learning.

The types of summer learning programs vary widely as each integrates and implements different curriculums and seeks to engage diverse student populations. In South Carolina alone there are a variety of summer programs (i.e. University of South Carolina, Carolina Master Scholars Adventure Series; Summer Inquiry Institute Camp; EdTech; etc.) These programs however, do not concentrate support and focus

recruitment on low-income, first-generation college students and individuals with disabilities like those that fall under Federal TRIO Programs (e.g. Upward Bound, Upward Bound Math & Science, Educational Talent Search, and Gear-Up). TRIO Programs are federal outreach programs designed to identify and provide services for individuals to progress through the academic pipeline from middle school to postbaccalaureate (U.S. Department of Education, 2013). All Upward Bound Programs must provide instruction in math, laboratory science, composition, literature, and foreign language. Upward Bound Math & Science is designed specifically for students who have a strong interest in pursuing a career in a science, math, or technology related field (U.S. Department of Education, 2013). It is important to note that programs such as TRIO Upward Bound, Educational Talent Search, and Gear Up not only provide summer learning opportunities, but also include year round academic learning components and provide services such as academic, financial, and personal counseling, exposure to academic programs and cultural events, tutorial services, mentoring programs, in addition to much more. Students participating in the programs previously mentioned have an opportunity to obtain access to services and opportunities that they may not otherwise receive.

In sum, summer learning programs have the potential to help children and youth improve their academic and other outcomes, as this is especially true for children from low-income families who may not have access to educational resources through the summer months as well as for low-achieving students who need additional time to master academic content (McCombs et al., 2011). Summer learning programs provide students an opportunity to learn and practice essential skills.

Culturally Responsive Science Pedagogy & Curriculum

Pedagogical approaches that have both relevance and meaning to the lives of their students have been shown to mitigate the underachievement of students of Color (Delpit, 1995; Garcia, 2001; Howard, 2001; Irvine, 1990; Ladson-Billings, 2009). Over three decades of literature suggests that culturally relevant teaching has the potential to reverse achievement trends of ethnically diverse students (Gay, 2010; Ladson-Billings, 2009; Lee & Fradd, 1998; Lee & Luykx, 2006; Moll & Gonzalez, 2004).

Gay (2000) shares:

> Although called by many different names, including culturally relevant, sensitive, centered, congruent, reflective, mediated, contextualized, synchronized, and responsive, the idea about why it is important to make classroom instruction more consistent with the cultural orientations of ethnically diverse students, and how this can be done, are virtually identical. (p. 29)

Gay (2010) defines culturally responsive teaching as “using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant and effective” (p. 31). Culturally responsive teaching is more than just a notion or a display of knowledge, instead it is embodiment of belief and recognition of racial, social, and cultural diversity in learning. Ladson-Billings (1992) explains that culturally responsive teachers develop social, emotional, intellectual, and political learning by utilizing students’ cultural capital to impart knowledge, skills, attitudes, and values. Simply, “they teach the whole child” (Gay, 2010, p. 32). In teaching the whole child, one must understand that differences do

not equate to deficits and that creating learning communities that value and embrace *all* students is not simply culturally responsive, but socially just.

Boutte, Kelly-Jackson, and Johnson, (2010) raised the question, "how does culturally relevant teaching look in an actual [science] classroom?" (p. 2). Boutte et al. (2010) posed the question because few explicit classroom examples on culturally relevant science pedagogy exist, as culturally relevant pedagogy is predominant in the literacy and language arts literature (Au & Jordan, 1981; Bell & Clark, 1998; Feger, 2006; Henry, 1996; Jimenez, 1997; Ladson-Billings, 1992).

Often embedded within the discourse of equity in science education is the assumption that science is objective, value- and culture-free, and rests on a universal knowledge base. However as Tan, Calabrese-Barton, Turner, and Gutierrez (2012) posit, "without consideration of the sociocultural and systemic factors that shape science and math education, all students are viewed as homogenous, promoting a reform agenda best described as one science [or math] fits all" (p. 8). Simply, sociocultural and critical perspectives highlight the economic and social realities that students deal with on a daily basis; as this requires an integrated view of how the daily contexts in which students live and learn matter, and critically inform opportunities for all students to learn science. Issues of equity, diversity, and social justice are critically important and there is an emerging body of literature that seeks to engage the science education community on such issues (Calabrese Barton, 2003; Basu, 2010; Johnson, 2011; Santos, 2008).

With an increasing number of ethnically, linguistically, and culturally diverse students in today's schools, it is imperative that science classrooms meet their educational needs. Therefore reform efforts aimed to reverse the underachievement of

students of Color requires "integrating disciplinary knowledge with knowledge of student diversity" (Lee & Luykx, 2006, p. 3). In the words of Justice Frankfurter in Dennis v. United States, 339 US 184 in 1949 – "there is no greater inequality than the equal treatment of unequals" (p. 3). It is important that science educators and researchers examine how culturally responsive pedagogy can play a role in increasing academic outcomes in science for culturally and linguistically diverse populations.

Purpose of the Study

Today's schools are becoming more and more ethnically and linguistically diverse, as culturally diverse students comprise approximately one third of school populations (Ladson-Billings, 2005). The enrollment number among these students has increased from 22 to 43 percent since 1972 (USDOE, 2006). Students of Color represent at least half of schools' population in the nation's largest 25 cities. African Americans, Asian Americans, and Hispanic students are projected to constitute nearly 57% of all US schools by 2050 (US Department of Commerce, 1996). However, the educational experiences of students of Color demonstrate a history of marginalization and inequity (Williamson et al., 2007) as far too many students of Color have maintained poor educational achievement outcomes. The effects of such disproportionally high levels of low academic achievement are extensive and can be witnessed across subject content areas, particularly in math, science, and literacy. To improve the academic performance of students who are culturally, racially, ethnically, and linguistically diverse, improved methods of instruction and pedagogy that better facilitate learning among diverse student populations must be instituted (Ladson-Billings, 2005). Methods such as culturally

responsive pedagogy utilize students' cultural funds of knowledge, experiences, and perspectives as a conduit to improve academic achievement among ethnically diverse students. Culturally responsive pedagogy is an inclusive, comprehensive, and transformative approach where prior experience, cultural background, and ethnic identity of both the teacher and student are mutually realized, valued, and shared (Gay, 2010). More than forty years ago, Abrahams and Troike (1972) argued that if racially diverse students are to be taught effectively, teachers "must learn wherein their cultural differences lie and…capitalize upon them as a resource, rather than…disregarding the differences… [and] thereby denigrating…the students" (p. 5).

Marginalized youth, particularly African American students are faced with inequitable opportunities to experience quality science in the nation's public schools (Atwater, 2000). Therefore the need to provide summer science enrichment programs where students spend time outside of the traditional classroom engaged in scientific experimentation, investigation, and critical thinking are vital to helping students who have been traditionally marginalized achieve success in formal science spaces and enter the science career pipeline. There have been numerous studies done to evaluate the effectiveness of summer science enrichment programs. Results reveal that summer science enrichment programs can improve students' social comfort and self-efficacy in science (Colyn, DeGraaf, & Certan, 2008; Fields, 2009; Gilmour & McDermott, 2008; Thurber, Scanlin, Scheuler, & Henderson, 2007). It is important to note that the summer science enrichment programs are not seen as substitutes for the regular schools, teachers, and counselors. Rather such programs are viewed more as opportunities for participants to gain hands-on experience doing science as scientists, in an engaging and culturally

relevant way. The literature is clear in that culturally responsive teaching helps students of diverse backgrounds achieve academic success (Au & Kawakami, 1994; Foster, 1995; Gay 2010; Ladson-Billings, 2009) however, it is not so clear how informal opportunities to learn science in a culturally responsive way impact marginalized youth. Thus there exists a gap in the literature that examines culturally responsive summer science enrichment programs and their impact on marginalized youth.

The purpose of this study was to understand the impact of a culturally responsive approach on student attitudes, interests, and overall science learning during a summer learning program. Specifically, this study sought to evaluate the impact of a culturally responsive approach on student attitudes, interests in science education and STEM career fields, and basic science content knowledge before and after their participation in a science course within the TRIO Upward Bound Summer Program. The following research questions guide this investigation:

R_1: What is the impact of a culturally responsive approach in a summer science program on student attitudes towards science education?

R_2: What is the impact of a culturally responsive approach in a summer science program on student interests in science education and STEM career fields?

R_3: What is the impact of a culturally responsive approach in a summer science program on student understandings of basic science content knowledge?

Significance

Limited understandings about the intersections of summer learning and culturally responsive science pedagogy and curriculum exist. This study aims to contribute new

understandings on pedagogical and curricular possibilities in these spaces. Given, the federal support of this particular summer learning program and the diverse student population it serves, obtaining a clearer understanding of the ways in which the science curriculum in this space impacts students is warranted. This work is also significant in the science education field for several reasons. First, summer science activities provide children and youth time to develop an interest in science which is critical to getting students into STEM careers (National Summer Learning Association, 2009); however little is known about the specific impact of science education curriculum in summer programs on students' basic science content knowledge. Second, research advocates for more culturally responsive curriculum to improve academic achievement amongst ethnically diverse populations (Esposito & Swain, 2009; Gay, 2000; Nieto, 1996); however there is limited research on the impact of substantive science learning activities using a culturally responsive framework (Berry, 2011; Boutte et al., 2010). This project's results have the potential to provide significant insight into the kinds of science education curriculum needed to increase academic outcomes for ethnically diverse populations.

Operational Definitions

- **Attitude**, as defined by Brandwein, Watson, & Blackwood (1958) represents the emotional orientation of an individual toward the topic at hand.
- **Culture**, as defined by Howard (2010) is a complex collection of values, norms, customs, ways of existing, ways of understanding and experiencing traditions that provide a blueprint for surviving, are passed from generation to generation and

serve as context for interpreting reality. To be clear, culture is not being used to refer or denote race and ethnicity, nor is it defined or used as a social construct.

- **Culturally relevant/responsive teaching** in this study is used interchangeable and refers to theoretical and pedagogical approaches to addressing student achievement through critical lenses that challenge school inequities (Ladson-Billings, 2009). "Culturally responsive pedagogy is situated in a framework that recognizes the rich and varied cultural wealth, knowledge, and skills that students from diverse groups bring to schools, and seeks to develop dynamic teaching practices, multicultural content, multiple means of assessment, and a philosophical view of teaching that is dedicated to nurturing student academic, social, emotional, cultural, psychological, and physiological well-being" (Howard, 2010, p. 67-68).
- **Extended learning programs** also referred to as extended learning opportunities (ELOs) include a broad range of programs that provide children with academic enrichment and/or supervised activities beyond the traditional school day and in some cases beyond the traditional school year. ELOs can include before-and after-school programs, Saturday academies, summer school, extended school year, and other innovative programs that enhance student learning.
- **Interest** refers to the state or desire of wanting to know and/or learn (more) about something or someone.
- **Marginalized** describes groups that have been excluded, or pushed outside of what has been defined as "mainstream," as such groups have not been allowed unconstrained access to mainstream resources. This study centers young people of

Color and low-income youth who have historically experienced discrimination and institutionalized inequity within U.S. public schools. For the purpose of this study, "youth" refers to people in high school between the ages of 14 and 18 years old.

- **STEM (Science, Technology, Engineering, and Mathematics) education** in this study refers to an approach to education which integrates science, technology, engineering, and mathematics through an instructional method which utilizes project-based problem-solving, discovery, and exploratory learning as it requires students to actively engage a situation to obtain a solution to a given problem (Fioriello, 2010).

Conclusion

In sum, if we are to effectively address science inequities and achievement gaps, we must employ new teaching strategies that allow students to bridge home knowledge with school knowledge. Culturally relevant pedagogy is an effective approach to help students of diverse backgrounds achieve academic success as it connects students' home knowledge with school scholarship (Ladson-Billings, 1995). Consequently, this study seeks to add to existing literature and fill a scholarly void offering insight on the impact of a culturally responsive approach to instruction on student attitudes, interests in science education and STEM career fields, and understandings of basic science content knowledge before and after their participation in a science course within a summer enrichment program.

CHAPTER 2

REVIEW OF RELATED LITERATURE

The purpose of this study was to understand the impact of a culturally responsive instructional approach and to examine the ways in which student attitudes, interests in science education and STEM careers, and understandings of basic science content knowledge is informed during participation in a summer learning experience. Consequently, this review of the literature: a) provides an overview of science education reform and approaches (or the lack thereof) to meeting the needs of diverse student populations; b) examines the literature on informal science education and the effectiveness of extended learning (summer) programs; c) reviews the research on culturally relevant pedagogy, including culturally relevant science curriculum and teaching; and d) examines the theoretical framework guiding this study.

Science Education Reform and its Impact on Diverse Student Populations

One of the most notable phrases associated with science education reform has been "science for all." Pivotal to several national reform documents and projects in the United States [American Association for the Advancement of Science (AAAS), 1989, 1993; National Research Council (NRC), 1996] this phrase emphasizes and promotes the concept of science for all Americans. However, with the growing diversity of today's K-12 students, coupled with consistent differential science performance among particular

demographic groups, the idea of “science for all” has yet to become reality. Simply, the science education community has fallen short of providing equitable science learning opportunities to *all* students – particularly marginalized youth of Color and poor students. Science education reform efforts have employed numerous approaches and teaching strategies (i.e. the learning cycle and inquiry-based instruction) to address the continued inequities and gaps in science achievement between students of Color and their White counterparts (Lee & Luykx, 2005; Moje, Collazo, Carillo, & Marx, 2001); however the persisting low performance of students of Color cause many to doubt and criticize such reform effectiveness. And while reform documents emphasize “science for all” as the essence of equity and excellence, regrettably measures do not provide a clear and coherent understanding of equity or strategies for accomplishing it (Lynch, 2000; Rodriguez, 1997). Thus, Lee & Luykx (2006) support a vision of reform aimed at the academic achievement of all students which necessitates integrating disciplinary knowledge with knowledge of students’ race/ethnicity, culture, language, and social class.

Science Education Reform

Science education reform has notably called for “science literacy for all,” “equity and excellence,” and “standards based reform” but what exactly do these phrases mean and require of us? It requires and acknowledges that those who work with diverse populations of K-12 students move beyond business as usual and catchy slogans, and work diligently to genuinely transform teaching and successfully engage *all* students. Conversely, although each of these phrases (“science literacy for all,” etc.) are widely desired outcomes of science education, not everyone agrees on a common definition

(DeBoer, 2000), and without clear and coherent understanding, such reform becomes a vague and daunting notion. The literature documents several reasons for the difficult transition between theory and practice of educational reform, as they include but are not limited to the following: insufficient school and classroom resources (Oakes, 1990), inadequate knowledge base of teachers (Anderson, 1991), and narrowly defined visions of science implementation in schools (Stanley & Brickhouse, 1995).

The past few decades have sought to institute change with the introduction and implementation of two important national policy efforts, as both have lead the way in science education reform – Project 2061: *Science for all Americans* (Rutherford & Ahlgren, 1990) and the *National Science Education Standards* (NSES) (National Research Council, 1996). Both the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science (AAAS, 1993) *Benchmarks for Science Literacy* address common areas (i.e. cooperative learning, equity, assessment and evaluation, constructivism, and learning styles) and overlap extensively in their recommendations (Biological Sciences Curriculum Study, 1994), however there are also distinct differences. The development of the *National Science Education Standards* (NRC, 1996) was guided by four principles: 1) science is for all students; 2) learning science is an active process; 3) school science reflects the intellectual and cultural traditions that characterize the practice of contemporary science, and; 4) improving science education is part of systemic education reform. Science is for all students is a statement of both equity and excellence as *NSES* maintains that all students regardless of sex, age, cultural or ethnic background, and ability level should have the opportunity to achieve scientific literacy. The *National Science Education*

Standards maintain a strong position to meeting the needs of students, stating "learning science is something students do, not something that is done to them" (NRC, 1996, p. 20). Furthermore the *Standards* challenge science teachers of all grade levels to display theoretical and practical knowledge and ability in science, learning, and science teaching. In other words, what students learn is greatly influenced by how they are taught, therefore science teachers should implement various instructional strategies and teaching practices to address *all* (diverse) student learning needs.

Unlike the *National Science Education Standards*, Project 2061: *Science for all Americans* is a long-term initiative focused on improving science education, facilitating all Americans becoming scientifically, mathematically, and technologically literate. Project 2061 articulates a coherent set of K-12 learning objectives that serve as a foundation for both state and national science education frameworks (AAAS, 2013). *Science for all Americans* defines scientific literacy, establishes and outlines benchmarks for science education, and develops a framework for teacher education. This project also seeks to encourage science teachers to actively engage students during the learning process, reduce use of rote memorization, and include cooperative learning opportunities and activities (Rutherford & Ahlgren, 1990). While the goal of both science reform initiatives were to provide a true standard for equity in science education, research reveals that educational reforms in diversity have disregarded difficult and challenging issues – ignoring the economic, cultural, and social background of students intended to support (Yerrick & Johnson, 2011).

More recently in July 2011, the National Research Council (NRC) released *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core*

Ideas, which identifies key scientific concepts and practices all students should learn by the end of high school. This *Framework* serves as the foundation for the new K-12 science education standards that will soon replace the *National Science Education Standards* and *Benchmarks for Science Literacy*. Over a two year process, led by twenty-six states the development of the new science standards – the *Next Generation Science Standards* (*NGSS*) is complete with implementation expected fall 2014. The *Next Generation Science Standards* seek to provide an important opportunity to improve not only science education but also student achievement. The *Framework* on which *NGSS* rests, reflects a new vision for science education with six guiding principles about the nature of learning science at its core: 1) children are born investigators, 2) focusing on core ideas and practices, 3) understanding develops overtime, 4) science and engineering require both knowledge and practice, 5) connecting to students' interests and experiences, and 6) promoting equity. The goal of *NGSS* is to create a context for learning, where students comprehend core knowledge and ideas and engage in scientific and engineering practices, therefore contributing to broader student understanding and deeper level scientific and engineering investigation in high school, college, and career (NGSS, 2014). It is also important to note that the *Next Generation Science Standards* are internationally benchmarked against countries (i.e. Singapore, China, South Korea, Japan, etc.) whose students have historically performed better than U.S. students in mathematics and science. With the debut of the *Next Generation Science Standards* tentatively slated for fall 2014, the science education community and those whose work center around equity and social justice, will be expecting to see that these new standards provide equitable

opportunities to learn science and engage in science and engineering practices to *all* students – particularly marginalized youth of Color and poor students.

Science education reformers often regard science as objective and culture-free while other education scholars have repeatedly argued it is not (Rodriguez, 2004). Aikenhead (1996) argued school "science curriculum, more often than not, provides students with a stereotype image of science: socially sterile, authoritarian, non-humanistic, positivistic, and absolute truth" (p. 10). Thus suggestively from this stereotype, the myth of culture-free science in school has its premise. Research suggests that devaluing student perspectives and culture of marginalized groups in science leads to withdrawal and continuous underrepresentation of such students in science (Brown, 2004). Recognition, acknowledgement, and inclusion of culture and diversity in science reform efforts is critically important to the academic success of marginalized students; for without inclusion, students of Color will continue to experience inequitable learning opportunities in science classrooms (Atwater, 2000) and the academic achievement gap among demographic groups will continue to plague our nation's schools .

Inquiry-based science instruction

Science education reform initiatives have called for a pedagogical shift from a teacher-centered, textbook-based instructional paradigm to a student-centered, inquiry-based model (NRC, 1996). In fact the *National Science Education Standards (NSES)* strongly promote inquiry, defining it as central to science learning (NRC, 1996, p.2). The *NSES* further suggest that inquiry-based instruction will be a powerful vehicle for students to learn and engage in scientific content. While *NSES* provide examples of inquiry-based instruction, suggest goals of inquiry teaching, and provide content for

inquiry learning; however it does not provide specifications and recommendations for how to conduct inquiry in the classroom, so that teachers can create modes of inquiry individually designed to meet the needs of their unique school settings. Moreover, there is no clear definition of inquiry as the term is used to describe both the *teaching* and *doing* of science (Colburn, 2000). The *National Science Education Standards* detail this dichotomy:

> …Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

Likewise, Anderson (2002) states “the reader is left to create his or her own images of what constitutes this form of teaching” (p. 3); similarly, Crawford (2007) reveals researchers, teachers, and teacher educators have widely different views of what constitutes inquiry in science. Colburn (2000) identifies three forms of inquiry-based instruction: structured inquiry, open inquiry, and guided inquiry. *Structured inquiry* provide students step-by-step procedures, including the questions to be investigated and the methods to collect data without disclosure of expected outcomes. *Open inquiry* places students in control of their decisions for each aspect of their inquiry – the problem to investigate, procedures, and interpretation; while *guided inquiry* is viewed as a semi-structured approach because students may or may not have control of the methods used to pursue answers and interpret results (Colburn, 2000). With variously different definitions and interpretations of inquiry and the term itself being complex, overused, and poorly

defined, it is no wonder that teachers struggle to effectively implement inquiry-based learning models in science for all students, especially with linguistically and ethnically diverse students. Regardless of definition, researchers continue to investigate the impact of inquiry-based models in science with students from diverse backgrounds.

The studies described in this section, though relatively few in number, vary widely in terms of research questions, methodology, and student outcomes. Guided by the *National Science Education Standard's* approach to inquiry-oriented instruction, Von Secker (2002) used hierarchical linear models to estimate the extent to which five inquiry-based teacher practices (eliciting student interest and engagement, using appropriate laboratory techniques, problem solving, conducting further study, and scientific writing) promote achievement of all students and reduce gaps in achievement among students with different demographic profiles (gender, race – ethnicity, and socioeconomic status). Findings suggest teacher practices that improve overall academic excellence simultaneously are as likely to contribute to greater inequities among more and less advantaged students as they are to close academic achievement gaps. Simply, instructional choices that teachers make do not affect all students equally. Even in the same class, teacher practices coupled with science achievement may be influenced by student demographic profiles.

In a quantitative investigation conducted by Cuevas, Lee, Hart, and Deaktor (2005), the authors examined the impact of an inquiry-based intervention on the ability to conduct inquiry by third and fourth graders from diverse backgrounds over the course of a school year. Study results revealed that the intervention enhanced the inquiry ability of all students regardless of grade, achievement, gender, ethnicity, socioeconomic status

(SES), home language, and English proficiency. Furthermore, low-achieving and low-SES students made considerable gains from the pre- to post-elicitation compared to their high-achieving and middle-SES counterparts. Likewise, students who exited from English for Speakers of Other Languages (ESOL) programs also exhibited considerable gains compared to non-ESOL students.

Research by Amaral, Garrison, and Klentschy (2002) examined the impact of a four-year intervention with elementary ELL students in a rural school district. Data collected measured student achievement in four content areas: science, writing, reading, and mathematics. Students in the district participated in kit- and inquiry-based science instruction that included the use of science notebooks. Results indicated that the achievement of English learners increased in relation to the number of years students participated in the project. Simply, the longer students were in the program, the higher their scores were in science, writing, reading, and mathematics.

Although incredibly few studies exist that examine diverse student achievement and inquiry-based science instruction, Kanter and Konstantopoulos (2010) investigated the impact of an inquiry-based science curriculum on minority student achievement, attitudes, and careers. Results suggest that students' science achievement improved with the project-based curriculum, however student attitudes toward science and plans to pursue science careers did not. Furthermore, findings indicate that the frequency of teachers' use of inquiry activities was not predicative of minority student science achievement. The authors state that "the social constructivism (and related conceptual change teaching) on which problem-based science (PBS) is based may not be sufficient

to help students from diverse backgrounds cross from their real-life worlds into the worlds of the science classroom and science in general" (p. 26).

It has been widely debated whether an inquiry-based teaching approach is the best method for helping students acquire knowledge due to the disadvantages with this approach – students arriving at incorrect solutions, use of inefficient strategies to find information, or students never discovering what it is they are trying to find out or why (Santrock, 2001). While, others argue and research data corroborates, that inquiry-based instruction without culturally relevant pedagogy may not be sufficient to support ethnically diverse students in learning science (Kanter & Konstantopoulos, 2010; Lee & Luykx, 2005; Meyer & Crawford, 2011; Moje et al., 2001; Patchen & Cox-Petersen, 2008). Although inquiry-based instruction has proven successful and promotes academic achievement, it lacks consideration of culture. It is important that teachers incorporate linguistic and cultural funds of knowledge students of diverse backgrounds bring to the classroom (Moll, 1992). Scholars argue that without this inclusion, students from ethnically and socially diverse backgrounds will continue to experience inequitable opportunities to quality science education (Atwater, 2000; Lee & Fradd, 1998; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

The studies examined here offer insights on the effectiveness of reform based measures such as inquiry-based models on diverse student populations. This work helps us better understand the challenges contemporary reform efforts have in meeting the academic needs of linguistically and culturally diverse students in learning science. Given these challenges, the extent to which students' everyday knowledge and language

intersect with scientific practices is in need of further understanding. Consequently, this study seeks to add to existing scholarship and fill such a gap.

Informal Science Education and the Effectiveness of Extended Learning Programs

Informal learning opportunities may provide ways for youth to increase and maintain their interest with science (Gibson & Chase, 2002). Informal science education is often an understudied area of science learning, as science educators are typically bound by traditional, content-focused science curricula, aimed to prepare students for the science "pipeline" (Aikenhead, 2006). There is no single definition of informal learning nor is there a standard list of domains where it can take place (McComas, 2006). Generally informal learning refers to "science learning that occurs outside the traditional, formal schooling realm…" (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003, p. 108). Typically, school field trips have been the primary way to support, engage, and connect abstract classroom learning with real-world science (Prather, 1989; Ramey-Gassert & Prather, 1994). Research supports that the most effective science instruction occurs when students and teachers have access to resources. Resources can include field trips but should also extend much farther. Likewise, the *National Science Education Standards* (NSES) support and encourage learning beyond the classroom stating that schools are part of the broader community "that contains organizations that influence science education, including colleges and universities, nature centers, parks and museums, businesses, laboratories, community organizations, and various media" (NRC, 1996, p. 8). One of the most definitive statements of support in the NSES is that "the

classroom is a limited environment. The school science program must extend beyond the walls of the school to the resources of the community" (NRC, 1996, p. 45).

Despite the small number of studies on out-of-school, summer science learning for K-12 marginalized youth, this section of the literature review seeks to provide evidential support of what has been done and its impact on student achievement. In her review of the literature on science learning beyond the classroom, Ramey-Gassert (1997) examined the importance of informal science learning experiences in the context of a variety of out-of-school science environments for (diverse) children as well as in-service and preservice teachers. She found that informal science education environments provide students unique and engaging science learning opportunities. Likewise, research suggests that informal settings have the potential to extend classroom (science) learning by providing students with a range of rich, motivating experiences (Harvard Family Research Project, 2011; McCombs et al., 2011; Ramey-Gassert, 1997).

While the nation's classrooms are increasingly diverse, science is not generally presented in such a way that is accessible or meaningful to all students, as most science instruction does not result in equitable achievement (Ferguson & Mehta, 2002; Kober, 2001). Despite efforts to close the academic achievement gap between disadvantaged and advantaged youth over the past forty years, considerable discrepancies (i.e. dropout rate, standardized test scores, etc.) remain.

Out-of-school, summer science programs

The academic persistence of students of Color has continuously been marked by dismal indicators of educational achievement such as high dropout rates and low standardized test scores. Davis, Ajzen, Saudners, and Williams (2002) state that African

Americans continue to drop out of high school at a higher disproportionate rate and earn lower (science) grades compared to their White counterparts. Likewise, achievement gaps among ethnically diverse students can also be observed in science course enrollments leading to careers in STEM fields. Research indicates that on average students lose skills over the summer, however not all students experience “average” losses as summer learning loss disproportionately affects low-income students. Therefore to address the academic achievement gap and mitigate (science) summer learning loss among marginalized and low-income students, access to high quality summer learning programs emphasizing and aimed to foster success in science among ethnically diverse populations is critical.

A general consensus among researchers, policymakers and practitioners reveal that the current wave of (summer) outreach programs working with K-12 students is directly attributable to the emergence of Upward Bound (UB) as part of the Economic Opportunity Act of 1964, as well as to the federal government funded GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs) program (Fields, 2001). With a mutual focus on first-generation, low-income students, both programs provide services to countless educationally and economically disadvantaged students nationwide. Student-centered outreach summer learning programs such as Upward Bound aim to counter negative school or community influences (lack of rigorous curriculum, poorly trained teachers, learning inequities, and lack of role models) by providing the missing components that help students aspire to, prepare for, and obtain college enrollment (Gullatt & Jan, 2003). Research on the academic enrichment provided by Upward Bound reveals that UB participants were more likely to remain in school and

earn more non-remedial high school credits in math compared to the control group (Gullatt & Jan, 2003).

To understand the influence of science summer camp on African American high school students in a Louisiana GEAR UP program, Bhattacharyya, Mead, and Nathaniel (2011) utilized a semi-structured survey before and after a weeklong science camp to determine changes in science attitudes and career choices. Study results revealed that students' attitudes toward science were positively changed after the camp, however the number of students wanting science as a career remained unchanged. Likewise, Munoz (2002) investigated a mathematics and science focused summer program for urban minority secondary school students. The goal of the program was to enhance students' ability to succeed in high school science and mathematics courses. Pre- and posttest results revealed significant gains in students' content knowledge of both mathematics and science subject areas.

To enhance diversity in the geosciences, Wechsler et al. (2005) through the Geoscience Diversity Enhancement Program (GDEP) provided a summer research opportunity for underrepresented high school and community college students and their faculty. Qualitative findings suggest that the program was successful in meeting project goals – 1) increase the number of underrepresented students who have a broad educational and research experience in the geosciences; 2) increase the awareness by community college and high school students about the geosciences, associated research careers, and the educational requirements for career development; 3) enhance the quantity and quality of geoscience research and teaching by faculty members from California State University Long Beach, community colleges, and high schools; and 4) enable a

smooth transition of underrepresented students from community colleges and local high schools into advanced undergraduate studies in the geosciences.

Martinez, Lindline, Petronis, and Pilotti (2012) conducted a study to evaluate the effectiveness of a science agricultural summer experience in recruiting underrepresented youth to natural resources management. The goal of this study was to determine if an in-residence, two-week summer science program for underrepresented minorities would increase interest in science, actual science knowledge, perceived science knowledge and also impact underrepresented youths' decision to attend college, major in a scientific discipline and pursue a career in science. Pre and post survey results indicated that students who participated in the two-week summer program improved in all areas measured – interest in science, actual science knowledge, perceived science knowledge, interest in majoring and pursuing a career in science. Findings also suggest that students were more confident and likely to do well in science after completing the summer science program. Furthermore, student participants exhibited a shift toward not only majoring in science once they graduated high school, but also seeking a career in science.

Seeking to increase diversity in science and health professions, Winkleby, Ned, Ahn, Koehler, and Kennedy (2009) present twenty-one years of follow up data from the Stanford Medical Youth Science Program (SMYSP). SMYSP is a five-week summer residential biomedical program for low-income high school students. The goal of the program is to enlarge the pool of underrepresented youth who succeed in college and the sciences. Results suggest that SMYSP positively influenced college success and career choices of students from all ethnic groups (African American, Asian, Latino, Native American, etc.). This study reported that overall, 84 percent of SMYSP participants have

graduated from 4-year colleges and 47 percent have continued on to medical or graduate programs. Significantly, this work highlights that “these college graduate rates are substantially higher than those for California and U.S. young adults from the same ethnic groups, with the largest differences evident for students from underrepresented minority groups” (p. 542).

In sum, literature on the out-of-school summer learning programs for marginalized youth exists, but it is intermittent. Despite continuous reform efforts to close academic achievement gaps between disadvantaged and advantaged youth, significant discrepancies remain. Research shows that students’ competences often decline during the summer and low-income students face greater learning loss compared to other students (Cooper, Charlton, Valentine, & Muhlenbruck, 2000). Therefore it becomes critically important that low-income and marginalized youth have access to and opportunities in high quality summer learning programs; such programs demonstrate potential to prevent summer learning losses that might occur and propel students toward higher academic achievement. Consequently, this study seeks to fill in these gaps in the literature through examination of student achievement and overall science learning during their participation in an Upward Bound summer (science) learning experience.

Culturally Responsive Science Teaching and Curriculum

On May 17, 1954 in the case of *Brown v. Board of Education* the U.S. Supreme Court unanimously ruled that “separate but equal” public schools for Blacks and Whites were unconstitutional. Yet more than 50 years later following the *Brown* decision, the American educational system has fallen short of providing an equitable science learning

experience for *all* students. Although considerable measures have been taken and substantial progress made, the cornerstone of science education reform emphasizing *Science for All Americans* has failed to deliver on its promise of improving academic achievement and providing scientific literacy to *all* the nation's students, particularly students of Color and low-income students. Regrettably, the promise of (science) education equality has yet to be achieved.

Although referred to by several different names, including culturally *relevant, sensitive, centered, congruent, reflective, mediated, contextualized, synchronized,* and *responsive*, the belief regarding the critical importance of classroom instruction being more consistent with the cultural orientation of students of Color, and how this can be achieved, are essentially identical (Gay, 2000). Culturally responsive teaching is based on the premise that culture is essential to student learning (Hughes et al., 2004). Culturally responsive pedagogy (CRP) is defined as using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively. It is based on the assumption that when academic knowledge and skills are situated within the lived experiences and frames of reference of students, they are more personally meaningful, have greater interest appeal, and are learned more easily and thoroughly (Gay, 2000). According to Ladson-Billings (2009), "It is an approach that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (p. 20). Culturally relevant pedagogy recognizes and acknowledges that the history of science and science teaching has been overgeneralized (Boutte et al., 2010). Conceptually, culturally relevant science resists the notion of a single correct answer and worldview and recognizes multiple and diverse

ways of knowing that students display in their everyday lives. It is important that science educators reconsider and revise their approach for teaching science, especially because many students consider science irrelevant and insignificant to their lives (Boutte, 1999; Boutte et al., 2010; Lee & Buxton, 2008).

Despite the small number of studies, findings suggest that culturally relevant pedagogy and curriculum materials may play an important role in promoting student achievement and attitudes toward learning science for culturally and linguistically diverse students (Aikenhead, 1997, 2001; Boutte et al., 2010; Kelly-Jackson & Jackson, 2011; Lee & Luykx, 2006). Boutte et al. (2010) provides insights and guidance for practitioners teaching science by describing tangible examples using a culturally relevant pedagogical framework. The authors conclude by stating that

> Culturally relevant teaching is a continuous quest, not a destination [and] it is hoped that teachers engage in culturally relevant pedagogy not solely to reduce the achievement gap or as a trend, but because it is an ethical and educational imperative that all students be effectively taught in light of pervasive and persistent educational trends. (p.15)

Likewise, Kelly-Jackson and Jackson (2011) build upon the culturally relevant pedagogy knowledge base by illustrating the tenets of culturally relevant pedagogy in the beliefs and teaching praxis of a middle school science teacher. In conclusion, the authors suggest that “one’s pedagogical stance is just as important as content competency in effectively teaching science to students of Color” (p. 412).

Furthermore, other studies describing science learning that draws upon culture, context, and pop culture offer promising results when cultural elements of students’ lives

are centered in science instruction and curriculum (Brown, 2011; Emdin, 2010, 2013; Mensah, 2010; Xu, Coats, & Davidson, 2012). The work of scholar Christopher Emdin (2010) promotes science curriculum and pedagogy that recognizes and affirms the cultural practices of urban youth through hip-hop. He offers hip-hop as a tool for teaching science in a “new and creative way” allowing teachers to connect science content delivery and instruction to urban students’ culture and interests. Emdin posits,

> In the instruction of science, particularly in urban settings where a majority of students express the extreme thoughtfulness and creativity that comes with being a part of hip-hop, the nature of instruction revolves around the cramming of facts, the omission of the contexts surrounding advances in science, and limited opportunities to utilizes one’s creativity to make sense of science. (p. 11)

Emdin’s reference speak to the importance of connecting students’ everyday lives and experiences, as well as their interests to and through the science classroom. Similarly, Emdin (2013) suggests using hip-hop as a bridge to teach STEM. He argues that teachers and educators should move beyond teaching straight science, technology, engineering, and mathematics, but utilize a more interdisciplinary approach such as STEAM (science, technology, engineering, arts, and mathematics). Using the STEAM approach, Emdin focuses on the art of rap and the culture of hip-hop as a key to engaging with and connecting science learning to young people of Color.

Brown (2011) focuses on and explores the relationship between minority students’ language practices, identity and classroom learning. Through a thorough exploration of a series of research studies conducted over six years, Brown provides a basis for his argument that current conceptions of “Good Instruction” do not include an

adequate understanding of how language and identity impact [diverse] students' learning. Findings suggest when carefully prescribed, classroom pedagogy that utilizes and considers Discursive Identity has the potential to positively impact minority student's learning. Brown (2006) posits,

> The science education community must reconceptualize notions of underachievement and literacy development by incorporating a theoretical and pedagogical perspective that recognizes the role of students' discursive identity as an influential component of their performance in science classrooms. Without such recognition science education runs the risk of limiting opportunities for science learning along ethnic, gender, and racial lines. (p.121)

To help elementary learners engage in and understand basic principles of genetics, Mensah (2010) provides a hands-on learning, multicultural genetics approach to teach and engage young learners in science. Utilizing concepts of diversity in self, family, and others, elementary students were able to engage in a genetics lesson that increased their understanding of and connection to basic principles of inheritance and traits. Findings revealed this culturally relevant science lesson provided teachers and students the opportunity to learn more about each other and to engage in conversations about shared and unique traits. Through their own cultural frames of reference, students were able to make personal connections to their science learning that increased their understanding of basic genetics.

Moreover, to understand what influences and promote students' interests in science Xu et al. (2012) examined the perspectives of eight exemplary African American teachers. Results suggest that teachers being interested in what their students are

interested in, providing hands-on activities, involving the community, and allowing students to use forms of learning and expression (i.e. rap) with which they are comfortable encourages more interest in science. In one of the science classes, students wrote a rap song on the water cycle. This type of creative learning not only helped students gain a better understanding of the water cycle, but it also promoted students' interest in science.

In these studies, we find that situating science curriculum and learning from the everyday experiences, culture, language, and community of culturally and linguistically diverse students has potential to improve academic achievement, their engagement with, understanding of and interest in science. This study seeks to add to a growing body of literature on culturally responsive/relevant science by providing both quantitative and qualitative data to address the impact of a culturally responsive approach during a summer learning program on students' attitudes, interests in science and STEM careers, and basic science content knowledge.

Theoretical Framework

Two key theorists, Gloria Ladson-Billings (2009) and Geneva Gay (2002), have established the foundational tenets of this theory. In the following section, I discuss each of the theorists' definition of culturally relevant/responsive pedagogy. Included in the discussion are the theoretical tenets and examples of successful educational programs that exhibit and incorporate the tenets. Note that program examples serve two important purposes: (1) they provide evidential support that culturally responsive teaching has the potential to improve student achievement, (2) they served as models to help conceptualize a culturally responsive approach to the science program in this study.

Culturally Responsive Pedagogy

First, the work of Gay (2002) posits four pedagogical pillars of culturally responsive theory (i.e. teacher attitudes and expectations, cultural communication in the classroom, culturally diverse content in the curriculum, and culturally congruent instructional strategies) and six outcomes for learners (i.e. validating, comprehensive, multidimensional, empowering, transformative, and emancipatory).

Teacher Attitudes and Expectations

The first pillar of culturally responsive teaching is teacher attitudes and expectations (Gay, 2000). Good and Brophy (2000) defined teacher expectations as "inferences that teachers make about the future behavior or academic achievement of their students, based on what they know about these students now" (p. 74). In a comprehensive summary of the effects of teacher expectations and related classroom behaviors, Good and Brophy (2000) found that if teachers had high expectations of a student, the teacher's interaction with the student was more positive resulting in the student doing well; conversely, when teachers had low expectations of a student, the student performed less as well. The literature on pre-service teachers' predispositions reveal that White mainstream teachers tend to exhibit deficit level thinking and hold low expectations for their students (Irvine & Armento, 2001; Ladson-Billings, 1995). Furthermore, when teachers regard ethnically diverse students as a deficit they often have difficulty teaching in ways that are culturally responsive and academically challenging (Irvine & Armento, 2001).

High teacher expectations and positive attitudes is at the root of culturally responsive teaching. Culturally responsive pedagogy demands that teachers of ethnically

and linguistically diverse students set high expectations not only for some students, but for *all* students. Culturally responsive teachers resist hierarchical structures of schooling by maintaining high expectations for all students as they do not subscribe to the school of thought that some students will do well and others will fail – with CRP failure is not an option for any student. McIntyre, Rosebery, and Gonzalez (2001) noted the relationship of teacher expectations and student learning by stating "how teachers see their students directly influences how they treat them, what they expect of them, and subsequently what students learn. When children are view as less-formed adults, as persons with deficient language, as lacking the skills they "should" have, or as "culturally deprived," they learn less" (p. 118).

While McIntyre et al. (2001) observed the damaging effects of viewing students from a deficit perspective; a study of successful educators of African American students by Ladson-Billing (1994) notes the impact that high expectations yield on academic achievement. Ladson-Billings (2009) found that successful teachers set high expectations for their students as such was evident in the teachers' beliefs and their actions.

Cultural communication in the classroom

The second pillar of culturally responsive teaching is cultural communication in the classroom (Gay, 2000). The relationship among culture, communication, and education is one of great complexity and intimacy. Gay (2000) states that "language is incredibly powerful and diverse; it identifies and humanizes, and gives cultures, ideas, and thoughts the capacity to speak" (p. 76). Perspectives, worldviews, values, and norms are all manifestations of culture that provide an understanding for making sense of the

world. Simply, culture defines and refines the lens of how we view, think, and learn about the natural world. It is important to recognize "communication cannot exist without culture, culture cannot be known without communication, and teaching and learning are more effective for ethnically diverse students when classroom communication is culturally responsive" (Gay, 2000, p. 76).

Historically, classroom discourse has presented itself as a monologic script, where through by the teacher, reflection of the dominant cultural values are presented and shared (Gutierrez, Rymers, & Larson, 1995). A 1995 study by Gutierrez, Rymes, and Larson sought to understand and demonstrate the construction of power relations between the teacher and students. They identify the teacher's monologic script as one that inhibits dialogue and communication. And student's counterscripts as those who do not comply with the teacher's view of appropriate participation. The authors suggest that to bridge the gap between script and counterscript, the introduction of a "third space" is needed. The authors provide that third spaces are places where the two scripts intersect and create potential for authentic interaction to occur:

> In the face of a rigidly monologic teacher script, the relevance of students' counterscript to the processes or topics discussed in this classroom has little influence on the teacher's script. The only space where a true interaction or communication between teacher and student can occur in this classroom is in the middle ground, or "third space," in which a Baktinian social heteroglossia is possible. Conceiving the classroom as a place for social heteroglossia reveals the potential for the classroom to become a site where no cultural discourses are secondary. Acknowledging the inherent cognitive and sociocultural benefits that

> come from the multiple discourses is of particular importance, especially in classrooms populated largely by African American, Latino, and mixed race students. (p. 447)

Gutierrez et al. (1995) highlight the importance of these third spaces for the reason that they connect youth spaces with school learning spaces through social heteroglossia. Simply, these third spaces connect multiple discourses and perspectives that transform the learning environment through recognition and acknowledgment that members of the classroom community, particularly those of marginalization and oppression, hold varied expertise in the form of knowledge and should be shared. Therefore it is critically important to understand how alternative forms of knowing are marginalized or silenced; as such forms of knowing, could potentially reveal more than students are able to communicate and teachers able to discern. Boggs, Watson-Gegeo, and McMillen (1985) shares that "the attitudes and behavior patterns that have the most important effect upon children… [are] those involved in communication" (p. 301). This communication is "multidimensional and multipurposed, including verbal and nonverbal, formal and informal, direct and tacit, literal and symbolic discourse components" (Gay, 2000, p. 77).

Smith (1971) examined the routine tasks teachers perform, stating that "teaching is, above all, a linguistic activity" and "language is at the very heart of teaching" (p. 24). Teachers employ language in every aspect of daily interaction, whether it is communicating instruction(s), answering questions, explaining and/or justifying actions, or providing students praise or criticism. It is important to understand that not only does communication matter, but also how well one communicates. Likewise, Dandy (1994)

recognizes the power of communication in the classroom, sharing that "teachers have the power to shape the future, if they communicate with their students, but those who cannot communicate are powerless" (p, 10). The effects of such communication skill is critically important to improving the performance of ethically and linguistically diverse students (Gay, 2000). Gay (2000) positions that "communication is the quintessential way in which humans make meaningful connections with one another, whether as caring, sharing, loving, teaching, or learning" (p. 79).

Lee, in her 2007 book, *Culture, Literacy, and Learning: Taking Bloom in the Midst of the Whirlwind,* explains that "schools have long been the cauldron in which to wash away language that marks race, ethnicity, and working class status deemed by the powerful to be wanting" (p. 80) – to declare them deficient and abnormal, even nonexistent. Such ideals, attitudes, and actions are pedagogically unacceptable, especially when claims of providing the highest quality education possible for all students (i.e. science for all) are declared. It is important to understand that the inclusion of all, truly means all. In sum, communication is strongly culturally influenced. It is a developed skill that embodies an array of delivery methods open to various interpretations and instructional possibilities. Effective (cultural) communication in the classroom recognizes and understands that students bring to school diverse social, cultural, and linguistic heritages and treats each as a critical component of teaching and learning.

Culturally diverse content in the curriculum

The third pillar of culturally responsive teaching is ethnic and cultural diversity in curriculum content (Gay, 2000). Gay (2000) states, "the fundamental aim of culturally

responsive pedagogy is to empower ethnically diverse students through academic success, cultural affiliation, and personal efficacy" (p. 127). Thus knowledge in the form of curriculum content, is key to success; as this knowledge must be accessible to students and relevant to their daily lives and experiences outside of school. Curriculum content should be used as a conduit to help students bridge and affirm their existing and future attitudes, interests, knowledge and experiences. Content curriculum should reflect the experiences and contributions of different ethnic groups and individuals, taught in diverse ways, to meet the needs of today's ethnically, culturally, and linguistically diverse students.

Research over the past two decades reveal that textbooks are the basis of 70 to 95 percent of all classroom instruction (Apple, 1985; Gay, 2000; Tyson-Bernstein & Woodward, 1991; Wade, 1993). And while the introduction of multimedia instruction and technology have somewhat lowered these percentages, textbooks continue to be the most prominent tool used for classroom instruction (Gay, 2000). It is critically important that a culturally diverse curriculum is reflected within and among all content areas, however this work is limited to and will focus on culturally diverse curriculum on the performance of students of Color in science education. Although few studies detail science curriculum and instruction as culturally responsive, the relatively few that do, note that promoting science to ethnically, culturally, and linguistically diverse students involves understanding the nature and practice of science as it relates to students' language and cultural experiences (Boutte et al., 2010; Kelly-Jackson & Jackson, 2011; Lee & Fradd, 1998). Furthermore, the work of Lee and Luykx, 2006 and Moll and Gonzalez, 2004, suggest that ethnically diverse student achievement improves in

instances where scientific knowledge is embedded in their everyday lives and experiences as students are able to connect school knowledge with the funds of knowledge present in their home life and community.

A 1994 study by Matthews and Smith sought to understand the effects of culturally relevant instructional materials on the interests, attitudes, and performance of Native American 4^{th}-8^{th} grade students taught science. Over a ten-week period, teachers in the experimental group employed Native American cultural content to teach 25 hours of science instruction. Teachers in the control group taught the same number of hours, without the aid of specifically designed culturally relevant materials. Pretest and posttest data revealed that Native American students in grades 4-8 who were taught science using culturally relevant materials achieved significantly higher and displayed a significantly more positive attitude toward Native Americans and science compared to those students who were taught science without the culturally relevant materials. These results prompted authors to suggest that curriculum content on Native Americans should incorporate and deal explicitly with cultural characteristics and contributions of Native Americans and science.

In sum, more cultural content is needed in formal school curriculums, especially in science education and among more diverse student populations. It cannot be overstated that without equitable access to the content, practices, and discourses of science, students of Color may not have opportunities to develop rich understandings of science knowledge and practices that lead to careers in science, technology, engineering, and mathematics. In her conclusion on ethnic and cultural diversity in curriculum content, Gay (2000) states,

> …ethnically diverse students who feel invalidated in society and school are not likely to perform as well as they might on academic tasks, if for no other reason than that these prejudices interfere with their motivation to learn, time-on-task, and persistence in leaning engagements (p. 171-172).

Likewise, as Brickhouse and Potter (2001) position, learning is not only about what learners know, but also about how what they know is part of a larger system of practices.

Culturally congruent instructional strategies

The fourth and final pillar of culturally responsive teaching is cultural congruity in teaching and learning – that is, the process of instruction (Gay, 2000). Gay (2000) states instruction is the "engagement, the interaction, the dialectic discourse of students and teachers in the processes of teaching and learning" (p. 175). Effective teachers of culturally responsive teaching understand how ethnically, culturally, and linguistically diverse students learn. This understanding is key to the success of diverse students because the process of learning is influenced by one's culture. It is important to understand that culturally responsive teaching recognizes that not everyone from the same ethnic affiliation learn in the same manner, nor does it suggest or advocate segregating students by ethnic groups during instruction. Instead, culturally responsive teaching advocates the alignment of teaching styles with diverse learning styles as a way to bridge students' culture with learning.

Howe (1999) and Ormrod (1995) shares several culturally diverse instructional scaffolding principles of learning (as cited in Gay, 2000, p. 176). Some include:

- Students' existing knowledge is the best starting point for the introduction of new knowledge (principle of similarity).

- Prior success breeds subsequent effort and success (principle of efficacy).
- New knowledge is learned more easily and retained longer when it is connected to prior knowledge, frames of reference, or cognitive schematas (principle of congruity).
- Reducing the “strangeness” of new knowledge and the concomitant “threat of the unfamiliar” increases students’ engagement with and mastery of learning tasks (principle of familiarity).
- Organizational and structural factors surrounding how one goes about learning have more powerful effects on the mastery of new knowledge than the amount of prior knowledge one possesses per se (principle of transactionalism).
- Understanding how students’ knowledge is organized and interrelated – their cognitive structures – is essential to maximizing their classroom learning (principle of cognitive mapping).

These principles are critically important because they highlight not only concepts and ideas teachers should be aware of in providing instruction, but also shed light on the notion that teachers need to understand how students come to know what they know, so that they can provide congruent instruction via the student’s own learning scheme.

Students’ cultural beliefs and practices are oftentimes at odds with Western science; therefore, effective science instruction should seek to provide students the opportunity to bridge and connect their home cultures with the culture of science (Aikenhead & Jegede, 1999; Gao & Watkins, 2002; Lee & Luykx, 2006).

Gay (2000) posits that if the pedagogical pillars are in place then learners will experience six outcomes to culturally responsive teaching, expressing that it is validating and affirming, comprehensive, multidimensional, empowering, transformative, and emancipatory. CRP is validating and affirming as it teaches to and through the strengths of students through acknowledgement of one's cultural heritage. Culturally responsive teaching is comprehensive in that it teaches the whole child. Ladson-Billings (2009) explains that culturally responsive teachers develop intellectual, social, emotional, and political learning by utilizing cultural resources to impart knowledge, skills, values, and attitudes. Likewise, Hollins (1996) adds that education designed specifically for culturally and linguistically diverse students incorporates "culturally mediated cognition, culturally appropriate social situations for learning, and culturally valued knowledge in curriculum content" (p. 13).

CRP is multidimensional as it includes curriculum content, learning content, classroom climate, student-teacher relationships, instructional techniques, and performance assessments. It is empowering as it supports students to be better students and more successful learners. For students to be successful, they must first believe they can succeed, therefore culturally responsive teachers plan, support, and empower students to preserve toward high levels of academic achievement. Culturally responsive teaching is transformative in that it is very explicit about respecting cultures and experiences of historically marginalized US minorities, as it utilizes such as worthwhile resources for teaching and learning. Here students are taught to exercise pride in who they are and their ethnic identities. Banks (1991) argues that if education is to empower students of Color then it must be transformative; being transformative involves helping "students to

develop the knowledge, skills, and values needed to become social critics who can make reflective decisions and implement their decisions in effective personal, social, political, and economic action" (p. 131). And finally culturally responsive teaching is emancipatory – simply, it is liberating. CRP helps students realize there are multiple truths as no single truth is total and permanent. Crichlow, Goodwin, Shakes, and Swartz (1990) helps us understand why education grounded in multiculturalism is emancipatory by affirming it "utilizes an inclusive and representational framework of knowledge in which students and teachers have the capacity to produce ventilated narratives…. By collectively representing diverse cultures and groups as producers of knowledge, it facilitates a liberative student/teacher relationship that "opens up" the written text and oral discourse to analysis and reconstruction (p. 103). Table 2.1 provides an overview of the culturally responsive teaching student outcomes with explicit examples and definitions from Gay (2000).

Table 2.1. Culturally Responsive Teaching Student Outcomes and Definitions

Culturally Responsive Student Outcomes	Definition and/or Examples
Validating and Affirming	• It acknowledges the legitimacy of the cultural heritages of different ethnic groups, both as legacies that affect students' dispositions, attitudes, and approaches to learning and as worthy content to be taught in the formal curriculum. • It builds bridges of meaningfulness between home and school experiences as well as between academic abstractions and lived sociocultural realities. • It teaches student to know and praise their own and one another's cultural heritages.
Comprehensive	• It develops intellectual, social, emotional, and political learning by using cultural resources to teach knowledge, skills,

	values and attitudes – in other words, it teaches the whole child. • It is committed to helping students of Color maintain identity and connections with their ethnic groups and communities; develops a sense of community, camaraderie, and shared responsibility; and acquire an ethic of success. • Educational excellence includes academic success as well as cultural competence, critical social consciousness, political activism, and responsible community membership.
Multidimensional	• It encompasses curriculum content, learning context, classroom climate, student-teacher relationships, instructional techniques, classroom management, and performance assessments. • It requires tapping into a wide range of cultural knowledge, experiences, contributions, and perspectives. • It holds students accountable for knowing, thinking, questioning, analyzing, feeling, reflecting, sharing, and acting.
Empowering	• Empowering translates into academic competence, personal confidence, courage, and the will to act – in other words, student have to believe they can succeed in learning tasks and be willing to pursue success relentlessly until mastery is obtained. • It enables students to be better human beings and more successful learners. • It seeks to bolster students' morale, providing resources and personal assistance, developing an ethos of achievement, and celebrating individual and collective accomplishments.
Transformative	• It is very explicit about respecting cultures and experiences of historically marginalized US minorities (African American, Latino, and Asian American), and it uses these as worthwhile resources for teaching and learning. • It recognizes the existing strengths and accomplishments of these students and

	then enhances them further in the instructional process. • It helps students learn to analyze the effects of inequities on different ethnic individuals and groups, have zero tolerance for these, and become change agents committed to promoting greater equality, justice, and power balances among ethnic groups.
Emancipatory	• It is liberating in that it releases the intellect of students of Color from the constraining manacles of mainstream canons of knowledge and ways of knowing – in other words, there are multiple truths. • It lifts the veil of presumed absolute authority from conceptions of scholarly truth typically taught in schools. It helps students realize that no single version of “truth” is total and permanent. • It establishes that all students are winners, rather than some winning and others losing and for students to assume responsibility for helping one another achieve to the best of their ability – in other words, it establishes and strongly supports learning communities.

Note: Gay (2000, p. 31-38)

In sum, it is important to understand that culturally responsive teaching is multifaceted, where not only is there emphasis on student achievement but also teacher pedagogy and perceptions of self.

Culturally Relevant Pedagogy

In a seminal piece on the teaching practices of exemplary teachers of African American students, Ladson-Billings (2009) characterizes practices that she describes as “culturally relevant.” Ladson-Billings’ description of these teachers and their teaching

praxis is extensively rich. As such, it is not my attempt to invoke every aspect of culturally relevant teaching in this study. Rather, I draw from this description to provide a framework and point of reference when considering teaching strategies and evaluating the impact of the curriculum on science achievement for marginalized youth. The work of Ladson-Billings (1995, 2009) posits three pedagogical tenets of culturally relevant pedagogy with three outcomes for learners.

Conceptions of Self and Others

The first dimension of culturally relevant teaching is the teachers' conceptions of themselves and others (Ladson-Billings, 2009). According to Ladson-Billings, teachers who practice culturally relevant teaching can be identified by the way they see themselves, their students, and others – they expect excellence from all students and view their praxis as an art. Furthermore, teacher conceptions of self and others influence how teachers set their goals, expectations, and orientations toward their instruction (Ladson-Billings, 2009). Table 2.1 illustrates culturally relevant teaching conceptions of self and others, contrasted with the assimilationist perspective. Teachers who espouse culturally relevant practices see themselves as part of the community and teaching as giving back to the community, and encourages students to do the same. However, the assimilationist teacher see themselves as an individual who may or may not be a part of the community and encourages achievement as a means to escape the community. Moreover, culturally relevant teachers believe all students are capable of success, understand their pedagogy as evolving, and believe that instruction includes the mining of knowledge (Lee & Luykx, 2007).

Kelly-Jackson and Jackson (2011) illustrates how the theory of culturally relevant pedagogy is supported in the teaching beliefs of a middle school science teacher from a rural, low socioeconomic, and predominantly African American school. The authors posit that Sammie's (the teacher) high regard for herself and her students, belief that she was part of the community, and view that her teaching was a way to give back to the community, helped her students succeed. Similarly, in a study to identify and describe perceptions held by 49 pre-service teachers about African American students' ability to achieve in mathematics and science, Lewis, Pitts, and Collins (2002) found that nearly 70 percent of the pre-service teachers placed culpability of science achievement with students' culture and community and student dispositions. This finding speaks not only to conceptions of self and others, but also to the second dimension of culturally relevant teaching, social relations. In conclusion, the authors provide the following invaluable point:

> It is surprising that more than one in three teachers were unaware or unwilling to acknowledge even the possibility of low mathematics and science achievement of African American students. The failure of so many teachers to make this acknowledgement is problematic in that it actually puts them in a position of disempowerment. If there is no condition to address, then there are no efforts to address it. The result is that the poor performance of African American students is perpetuated due to inattention. (p. 40)

Table 2.2. Conceptions of Self and Others.

Culturally Relevant	Assimilationist
Teacher sees herself as an artist, teaching as an art.	Teacher sees herself as technician, teaching as a technical task.
Teacher see herself as part of the community and teaching as giving something back to the community, encourages students to do the same.	Teacher sees herself as an individual who may or may not be a part of the community; she encourages achievement as a means to escape community.
Teacher believes all students can succeed.	Teacher believes failure is inevitable for some.
Teacher helps students make connections between their community, national, and global identities.	Teacher homogenizes students into one "American" identity.
Teacher sees teaching as "pulling knowledge out" – like "mining."	Teacher sees teaching as "putting knowledge into" – like "banking."

Note: Ladson-Billings (2009, p. 38)

Social Relations

The second dimension of culturally relevant teaching is social relations (Ladson-Billings, 2009). Simply, culturally relevant teachers purposefully create social relations, and engage with and encourage a community of learners. Ladson-Billings (2009) maintains that, "encouraging a community of learners means helping the students work against the norm of competitive individualism" (p. 74). Teachers create a classroom environment that builds on the concept of community, where students care and strive for academic excellence for themselves, and also their fellow students – employing the ideology that the classroom is a team community of learners, where if one fails, all fail, and if one succeeds, all succeed. Table 2.2 illustrates culturally relevant teaching social relations, contrasted with the assimilationist perspective. Teachers who practice culturally relevant teaching encourages a community of learners and demonstrate connectedness with all students. However, the assimilationist teacher encourages

competitive achievement and only maintains a connection and interest with individual students.

Table 2.3. Social Relations.

Culturally Relevant	Assimilationist
Teacher-student relationship is fluid, humanely equitable, extends to interactions beyond the classroom and into the community.	Teacher-student relationship is fixed, tends to be hierarchical and limited to formal classroom roles.
Teacher demonstrates a connectedness with all students.	Teacher demonstrates connections with individual students.
Teacher encourages a "community of learners."	Teacher encourages competitive achievement.
Teacher encourages students to learn collaboratively. Students are expected to teach each other and be responsible for each other.	Teacher encourages students to learn individually, in isolation.

Note: Ladson-Billings (2009, p. 60)

Conceptions of Knowledge

The third and final dimension of culturally relevant teaching is conceptions of knowledge (Ladson-Billings, 2009). Ladson-Billings (2009) positions that knowledge is continuously recreated, recycled, and shared by both the teacher and student – knowledge is bi-directional and not static. Teachers of culturally relevant teaching practices strive to move students beyond rote memorization toward higher order and critical thinking competences through knowledge-building. Table 2.3 illustrates culturally relevant teaching conceptions of knowledge, contrasted with the assimilationist perspective. Teachers who practice culturally relevant teaching view knowledge critically to "recognize, understand, and critique current social inequalities" (Ladson-Billings, 1995, p. 476) and are passionate about the content area in which they teach. However, the

assimilationist teacher view knowledge as perfect and incapable of error, and is far removed and disengaged from the content area they teach. Knowledge is about doing, and the single correct answer approach is not one that culturally relevant teachers embrace (Ladson-Billings, 1995).

Table 2.4. Conceptions of Knowledge.

Culturally Relevant	**Assimilationist**
Knowledge is continuously recreated, recycled, and shared by teachers and students. It is not static or unchanging.	Knowledge is static and is passed in one direction, from teacher to student.
Knowledge is viewed critically.	Knowledge is viewed as infallible.
Teacher is passionate about content.	Teacher is detached, neutral about content.
Teacher helps students develop necessary skills.	Teacher expects students to demonstrate prerequisite skills
Teacher sees excellence as a complex standard that may involve some postulates but takes student diversity and individual differences into account.	Teacher sees excellence as a postulate that exists independently from student diversity or individual differences.

Note: Ladson-Billings (2009, p. 89)

The field of science education is short on studies that document and highlight the pedagogical tenets of both culturally responsive and culturally relevant teaching practices. We know what culturally relevant/responsive practices should look like conceptually (e.g., Aikenhead & Jegede, 1999; Lee & Fradd, 1998), however more information about its manifestations in practice is needed. Patchen and Cox-Petersen (2008) comment that, "it seems the culture of teaching science, and even more trenchantly perhaps, the culture of teaching teachers to teach science, must change before cultural relevance can be enacted in classrooms" (p. 1009).

Ladson-Billings (2009) posits three student outcomes to culturally relevant teaching, proposing that it produces students who are academically successful, demonstrate cultural competence, and exhibit sociopolitical consciousness. First, culturally relevant teaching emphasizes academic success for all students. Academic success refers to teachers having and maintaining high expectations for all students and learning is not at the expense of losing one's cultural identity. In a 45 classroom-based research study, Morrison, Robbins, and Rose (2008) synthesized the literature on culturally relevant pedagogy with the goal of operationalizing culturally relevant teaching as defined by Ladson-Billings (2009). Findings revealed that only 14 of the 45 studies included some aspects of the three tenets of culturally relevant pedagogy, while none of the studies incorporated all identified subcomponents of the three tenets of culturally relevant pedagogy. Despite this, Morrison et al. (2008) detail that teachers provide support for academic success by modeling, scaffolding, and clarification of challenging curriculum; utilizing student strengths as instructional starting points, investing in and owning responsibility for student success, establishing and nurturing cooperative learning environments, and maintaining high behavioral expectations.

Second, culturally relevant teaching supports students in the formation of a positive cultural identity – cultural competence. Cultural competence is accomplished through teachers helping students to develop positive ethnic and cultural identities (Morrison et al., 2008). Cultural competence is encouraged by teachers in ways such as reshaping the prescribed curriculum, building on student prior knowledge and experiences, and encouraging and building relationships between home, school, and communities (Lee, 2009; Morrison et al., 2008). And finally, culturally relevant teaching

guides students in developing critical consciousness. Critical consciousness refers to the students' ability to identify, understand, and critically critique societal issues and inequities. Morrison et al. (2008) provide that teachers can help students cultivate critical consciousness through critical literacy – using text and literature as a catalyst for critical perspective and dialogue, engaging students in social just work, making explicit the power dynamics of mainstream society, and sharing power in the classroom. Table 2.5 highlights culturally relevant teaching student outcomes with explicit examples and definitions from Ladson-Billings (2009).

Table 2.5. Culturally Relevant Teaching Student Outcomes and Definitions

Culturally Relevant Student Outcomes	Definition and/or Examples
Critical Consciousness	• It assists students in the formation of a positive cultural identity by helping students to recognize, understand, and critique current social inequities. • It makes explicit the dynamics of mainstream society to those students outside the mainstream, while simultaneously validating the unique cultures and heritages of students. • It gives students power in the classroom – students and teachers power share. In other words, students have a voice and choice regarding classroom policies, curriculum issues, assessment options, etc.
Cultural Competence	• It guides students in developing a critical consciousness that they can use to critique or interrupt current and historical social inequities. • It develops a dynamic or synergistic relationship between home/community culture and school culture by building on students' funds of knowledge.

	• It helps students develop positive ethnic and cultural identities by reshaping the prescribed curriculum to be more reflective and inclusive of students and their families, communities, and cultures.
Academic Success	• It emphasizes academic success for all students as the teacher must have and maintaining high expectations and use students' strengths as instructional starting points – in other words, meet students where they are in their learning. • It offers and supports modeling, scaffolding, and clarification of a rigorous and challenging curriculum. It encourages students to collaborate with and model for each other, and clearly outlines learning goals and expectations. • It creates and nurtures cooperative learning environments as well as maintain high behavioral expectations. Cooperative learning environments should promote students' motivation to work and include learning activities aimed at creating a sense of belonging.

Note: Ladson-Billings, 2009

The study's research design and analysis is informed by the literature as it utilizes both culturally responsive and culturally relevant theoretical frameworks. This work seeks to gain an understanding of student attitudes, interests in science and STEM careers and basic science content knowledge by specifically operationalizing the student outcomes of both theoretical perspectives. There is a growing body of knowledge that supports culturally responsive and culturally relevant science teaching in formal learning settings; however there are limited resources on culturally responsive and culturally relevant science teaching in informal science learning spaces. This study seeks to contribute to this body of knowledge. As both the teacher and researcher, I

conceptualized a study that would provide the opportunity for me to engage in and interact with students in a critical, yet reflective way so as to gain a holistic understanding of their science learning experiences during a summer learning program.

Conclusion

In this literature review, research related to science education reform and its impact on diverse student populations, informal science education and the effectiveness of extended learning programs, culturally relevant and responsive pedagogy, and culturally relevant and responsive practices were examined. The theoretical framework of this chapter reviews the seminal work of scholars like Gay (2000) and Ladson-Billings (2009) regarding culturally relevant/responsive pedagogy while examining the theories that led to their development and how it is implemented in classrooms. Research reviewed in this chapter demonstrates the benefits that students of Color gain through culturally responsive instruction and practices. A culturally responsive framework will be utilized as the theoretical tool for this study because it provides the opportunity to focus on aspects of culture and student's science learning experiences. It is important to note that this study does not focus on nor detail the work, role and pedagogical practices of instruction provided by the teacher. Simply, the focus and intent of this work is culturally responsive/relevant student outcomes.

CHAPTER 3

METHODOLOGY

As an educator I must not avoid or negate values and personal commitment. These values require action. Knowledge comes from doing.
(Unknown Author)

This study investigated the impact of a culturally responsive approach to student engagement and overall science learning during a summer learning program. Specifically, this study examined the impact of a culturally responsive approach on student attitudes, interests in science education and STEM career fields, and basic science content knowledge before and after participation in a science course within the Upward Bound Summer Program. The investigation drew upon two distinct methodologies, quantitative and qualitative, as the collective strength of both methods provide a better understanding of the research problem than either form of data alone (Creswell, 2015). Likewise, this study utilized a critical action research and case study approach whereby the teacher-researcher employed a mixed methods design.

Methodological Approach

There is a plethora of terms coined to describe and define (critical) action research (Feldman, 2002; Kemmis 2001; McCutcheon & Jung, 1990; McKernan, 1988). Feldman (2002) posits, “action research happens when people research their own practice in order to improve it and to come to a better understanding of their practice situations” (p. 242). Similarly, McKernan (1988) describes it as “a form of self-reflective problem solving,

which enables practitioners to better understand and solve pressing problems in social settings" (p. 6). McCutcheon and Jung (1990) concurs, but inserts an emphasis on collaboration:

> Systemic inquiry that is collective, collaborative, self-reflective, critical, and undertaken by the participants of the inquiry. The goals of such research are the understanding of practice and the articulation of a rationale or philosophy of practice in order to improve practice. (p. 148)

A critical action research design is more open and fluid (Reason & Bradbury, 2001) and enabled me to serve as both teacher and researcher thus situating the study within my own practice with a critical and emancipatory vision.

This research study also utilized a case study methodological approach. The term case study has been used to denote variously different things in different disciplines (Glesne, 2006). Stake (1995) describes case study research as a bounded integrated system with working parts. Likewise DeMarrais & Lapan (2004) posits, "case study research can involve the close examination of people, topics, issues, or programs and seek to answer focused questions by producing in-depth descriptions and interpretations over a relatively short period of time" (p. 218). A case study approach is not privileged to generalizability because discovering the uniqueness of the phenomenon – a culturally responsive science approach on student learning during a summer learning program, is the main focus and purpose.

To understand the phenomenon of a culturally responsive approach to summer science learning, I posed the following research questions:

R_1: What is the impact of a culturally responsive approach in a summer science program on student attitudes towards science education?

R_2: What is the impact of a culturally responsive approach in a summer science program on student interests in science education and STEM career fields?

R_3: What is the impact of a culturally responsive approach in a summer science program on student understandings of basic science content knowledge?

This study examined statistical trends in students' attitudes toward, and interest in, science and STEM careers and compared them to the attitudes held by students who did not receive my instruction and curriculum. Journals and focus group interviews were used to ascertain *how* and/or *what* specifically (dis) engaged students' interests in and attitudes toward science. The focus group interviews also captured the overall impact of a culturally responsive approach on student attitudes toward and interests in science education and STEM careers.

Additionally, this study collected and explored quantitative data (pre-and post-science content assessments and pre-and post- Culturally Responsive Science Assessments) in order to describe changes in student content knowledge, while also exploring qualitative data that examined changes in students' attitudes toward science and interests in science and STEM career fields. Utilizing a mixed method approach, statistical data trends (pre- and post-science content assessments and pre-and post- Culturally Responsive Science Assessments) were combined with student narratives and personal experiences (science journals and focus group interviews).

In this chapter, I describe the methods, instrumentation and procedures used in the study. A comprehensive explanation of the procedural framework for collecting, analyzing and integrating quantitative and qualitative data was outlined according to the "mixed methods paradigm" (Creswell, 2003; 2015).

Pilot Study

In summer 2013, I conducted a pilot study with an Upward Bound Program. The purpose of the pilot study was to gain a greater understanding of the impact of a culturally responsive Science, Technology, Engineering, and Mathematics (STEM) education curriculum in a summer learning program on marginalized youth's attitudes, interests, and basic STEM content knowledge; and to gain insights regarding measurement procedures, particularly identification of unclear or ambiguous pre and posttest survey items and focus group questions. Participants included sixteen 9^{th} – 12^{th} grade high school students from local school districts. The pilot study utilized an action research approach resulting in my role as both teacher and researcher. Action research was applied because I was interested in studying my own class of students and my own teaching practices. Utilizing an action research approach provided the opportunity to evaluate and revise curriculum content as well as survey instrument items that would later be used in the dissertation.

The primary research questions for this study were:

R_1: What is the impact (if any) of the STEM curriculum on student attitudes toward STEM education?

R_2: What is the impact (if any) of the STEM curriculum on student interests in STEM education and STEM career fields?

R_3: What is the impact (if any) of the STEM curriculum on student understandings of basic STEM content knowledge?

To answer the research questions for the pilot study I utilized a mixed methods design for data collection and analysis that included two focus group interviews (before and after the summer course), pre- and post-STEM attitude and interest assessments, Draw-A-Scientist Test (DAST), and Draw-An-Engineer Test (DAET). Below I present research findings for each abovementioned research question and conclude with a summary of lessons learned.

Research question one. To address this question, a 40-item Likert-scale STEM attitude and interest assessment was developed. The purpose of the STEM attitude and interest assessment was to develop a clear and comprehensive instrument to capture student attitudes and interests relating to STEM education. The data from the pilot study informed the current study in several ways. First, due to frequent student questions concerning items on the pre and posttest assessment, it was evident a number of items may have been ambiguous and confusing thus impeding student answer selections. For example, each question on the assessment was written with its reverse code as this created a constant exchange between responses confusing students. This indicated the need for additional revision and testing and the assessment was amended and revised

resulting in only a single reverse code for each category of questions. Survey results indicated no statistical significance among the four STEM attitude and interest categories – 1) science positive attitude and engineering positive attitude, 2) science negative attitude and engineering negative attitude, 3) science positive interest and engineering positive interest, and 4) science negative interest and engineering negative interest.

Research question two. To address this question, focus group interviews were used simultaneously with the STEM attitude and interest assessment so as to provide an opportunity for students to discuss topics in more detail and depth and to address specifically, how the STEM curriculum influenced students' interests in STEM careers. The data gathered here had several implications. First, upon conducting the initial focus group interview with sixteen student participants, I learned one, the number of focus group participants was too large; and two, the initial lack of richness and depth in student responses to interview questions was due to my linearly-crafted interview protocols that attempted to capture but compartmentalize their understanding – that is, knowledge and comprehension of a scientist and then knowledge and comprehension of an engineer. Upon revising the interview protocol for the final interview with seven student participants, a more holistic understanding of how students come to understand and define the work of scientists and engineers became evident. Students recalled and shared with enthusiasm specific instances of their classroom summer learning experiences (i.e. Beyoncé Bungee, bridge building competition, dissection exercises, etc.) and how each of the lessons and/or activities involved different or similar processes (i.e. types of questions asked, type of work performed, work descriptions, etc.). Utilizing a more semi-structured interview strategy for the second focus group interview with a smaller group of

participants proved beneficial. Focus group findings indicated a number of student misconceptions where many students' ideas and explanations of who an engineer and/or scientist is and what they do was largely based on television and animation depictions. Findings confirm that student misconceptions are deeply- rooted, as participants maintained and held firm to their initial conceptions of a scientist and engineer even after discovering their ideas were false or incorrect. Furthermore, findings indicated diverse career interests (i.e. crime scene investigation, sports medicine, and poet) among participants as students maintained their career choices from the initial interview to the final interview. Results suggest that perhaps this time period was too short to see a change in career choice and that students need more direct exposure to various STEM related career fields.

Research question three. To address this question, I used the DAST and DAET instruments as well as student final course grades. Data gathered here provided great insight on student's conceptions of an engineer and scientist, but was not a beneficial measure of content knowledge. Overall, final course grades increased from the beginning of the summer to the end, however this increase was not shown to be statistically significant. In the end the methods of data collection here were insufficient to address the research question.

In sum, the pilot study informed my selection and development of the research questions and assessment items, allowing me to adapt and adjust ambiguous assessment questions and improve instructions; craft interview protocols in a more semi-structured manner and remain mindful of focus group size. Likewise, the findings and results of this pilot study informed my understanding of student career choices, allowing me to

orchestrate more face-to-face engagement opportunities for students to be exposed to science and STEM related careers with professionals of Color, and to develop additional, more rigorous and resourceful measures to assess student understandings of science content knowledge.

Research Context and Participants

Upward Bound Summer Program

In response to the War on Poverty, President Johnson signed the Economic Opportunity Act of 1964. This legislation gave birth to the Office of Economic Opportunity and special programs for students from disadvantaged backgrounds, creating with it the establishment of programs such Upward Bound, Talent Search, and Student Support Services – collectively these three became known as TRIO (McElroy & Armesto, 1998). To date, other TRIO programs include Educational Opportunity Centers (EOC), the Ronald E. McNair Post-Baccalaureate Achievement Program and Upward Bound Math/Science. TRIO programs provide services to students from low-income families as well as to those from families in which neither parent holds a bachelor's degree (first-generation college). The goal of Upward Bound is to increase the rate at which participants complete secondary education and enroll in and graduate from institutions of postsecondary education (U.S. Department of Education, 2013). Upward Bound Programs provide academic instruction in mathematics, laboratory sciences, literature, composition, and foreign languages as well as a host of other services (including but not limited to) are provided – i.e. tutoring, counseling, mentoring, cultural enrichment, etc.

This study took place within a TRIO Upward Bound Summer Program serving 9th – 12th grade students at a college in South Carolina. The local Upward Bound Program

participant demographics were majority Black or African American. Nationally, the largest percentage of Upward Bound participants in 2000–2001 were Black or African American (45%) followed by White (25%), Hispanic or Latino (19%), and Asian (5%). According to the U.S. Department of Education 2000/2001 Upward Bound Program Profile Report, the most commonly cited reasons for the need for services for Upward Bound participants were those related to low grades, low achievement scores, and low aspirations (about 30%). As the second most commonly reported reason for needing services was lack of opportunity, support, and guidance to take challenging college preparatory courses (about 20%). The purpose of utilizing a culturally responsive approach is to actively engage students in science learning investigations and activities. Students were challenged to apply research methods and modes of inquiry to a variety of scientific disciplines (i.e. Biological Sciences, Genetics, etc.) in an authentic and integrated way, as a real scientist would do. Moreover, the lessons used in the Upward Bound Program is inclusive of the South Carolina Academic Science Standards and draws upon a culturally responsive/relevant framework. The context of the study and the uniqueness of the lessons made this an optimal research site for the study.

Participants

Students were recruited and selected to participate in the TRIO Upward Bound Summer Program based on socioeconomic measures and parental education background status. Table 3.1 shows participant demographics for both experimental (students in my class) and comparison groups (students not in my class). All participants were local high school students, rising 10^{th} – 12^{th} grade. The initial sample size for both groups marginally declined from the start of the summer program to the end of the program as some students were dismissed and sent home early as a result of various circumstances

(i.e., family emergency, sports camps, disciplinary action, etc.). Thus data presented is inclusive of complete, both pre and posttest results of students who completed the entire summer program. Likewise, the demographics reported and shown below are for students who remained the entire duration of the summer program. The study sample (experimental group) consisted of eleven rising 10^{th} – 12^{th} grade students; the comparison group consisted of nineteen rising 10^{th} – 12^{th} grade students.

Table 3.1. Participant demographics for both experimental and comparison groups.

	n	Gender		Ethnicity		Rising Grade Level			FRL
		Male	Female	African/African American	Multiracial	10^{th}	11^{th}	12^{th}	
Experimental Group	11	3	8	10	1	2	5	4	100%
Comparison Group	19	6	13	17	2	10	7	2	100%

Note. FRL = Free and Reduced Lunch Status

Prior to the start of the study, students participated in Upward Bound orientation. Here students were provided a brief overview of the program, course expectations, and other program related details. Students were not told the research questions or the protocol for randomizing students assigned to their (science) classes. Students were told that they would be asked to complete a Culturally Responsive Science Assessment (pre and post) (Appendix B) and participate in two focus group interviews. Students were also told that their demographic data would be used anonymously in the study and that participation, non-participation or withdrawal will not affect their grades. Per IRB instructions, participating students were required to sign an assent form and take an informational letter home to their parents (Appendix A). It is important to note that the number of students participating in the initial orientation fluctuated slightly due to student absentees and/or late arrivals on the first day of the program.

Sampling Method

Participants in this study was recruited using purposive sampling in which participants were selected because of their participation in the Upward Bound Program. The researcher understands specific information about this group of students and deliberately wanted to recruit them (Berg, 2007). This type of sampling was suitable for this study as the target population was marginalized youth in an Upward Bound Summer Program. The Upward Bound Program staff randomly assigned students to all prospective classes – science, math, Spanish, English, and extracurriculars.

Data Collection Methods

A variety of instruments were utilized to gather data for this study, these included a survey aligned with culturally responsive pedagogy to capture student attitudes towards science education and interests in science education and STEM career fields, as well as pre- and post-science content assessments.

Culturally Responsive Science Assessment

All Upward Bound Program participants present for the first day of orientation were asked to voluntarily complete the Culturally Responsive Science Assessment on the first and last day of the summer program. The Culturally Responsive Science Assessment (Appendix B) was developed by myself, the teacher and researcher. Significant time and effort was taken by the researcher and other science education scholars at the researcher's institution to ensure assessment questions appropriately aligned with both the research questions and conceptual framework. The assessment was a 21-item Likert scale measure that consisted of seven questions for each of the following three categories: attitude toward science, interest in science, and interest in STEM careers. The Culturally Responsive Science Assessment had a high level of internal consistency as determined by Cronbach alphas of 0.760 (attitude toward science), 0.902 (interest in science), and 0.778 (interest in STEM careers). Each category was measured and assessed on a five point scale ranging from 5 – strongly disagree, 4 – disagree, 3 – undecided/uncertain, 2 – agree, to 1 – strongly agree. The Culturally Responsive Science Assessment was and continues to be a work in progress as it was developed and modified throughout the pilot investigation and the current study, being adapted from preexisting attitude and interest science assessments – Test of Science-Related Attitudes (TOSRA), Simpson Troost Attitude Questionnaire (STAQ-R), STEM Semantics Survey, Attitude toward Science in

School Assessment, Changes in Attitude about the Relevance of Science (CARS), Is Science Me? (Assessment Tools in Informal Science, 2015). Each of the before mentioned assessments were instrumental in the development of the Culturally Responsive Science Assessment because these assessments were well documented and validated psychometrics in the science evaluation literature (Germann, 1988; Blosser, 1984; Fraser, 1981). The purpose of the Culturally Responsive Science Assessment was to quantitatively assess students' attitudes towards and interests in science education and STEM career fields. The Culturally Responsive Science Assessment, a 21-item Likert-scale measure incorporated a 3 (interest in science, interest in STEM careers, and attitude toward science) x 7 (the total number of questions for each research question, i.e. interest in science, interest in STEM careers, attitude toward science) x 5 (strongly agree, agree, uncertain, disagree, strongly disagree) design.

Science Content Assessment

A science content assessment (Appendix C) was administered pre and post to participating Upward Bound students assigned to the experimental group (students in the researcher's class only). The purpose of the science content assessment was to assess students' understanding of basic science content knowledge. The science content assessment was constructed by myself, the teacher and researcher, as all assessment questions were obtained from the American Association for the Advancement of Science (AAAS) Assessment Test Bank (AAAS, 2015). The science content assessment consisted of fifteen multiple choice items, as questions was selected to measure student's science content knowledge of course material after receiving culturally responsive science instruction before and after the science course. Assessment questions measured student's content knowledge in three areas – the life sciences, physical science, and the

nature of science. Selected questions from the AAAS Assessment test bank were chosen because these items well aligned with curriculum and course content material. Figure 3.1 illustrates the specific AAAS Assessment items disciplines for both the pre and post-science content assessment as well as their respective science topic(s).

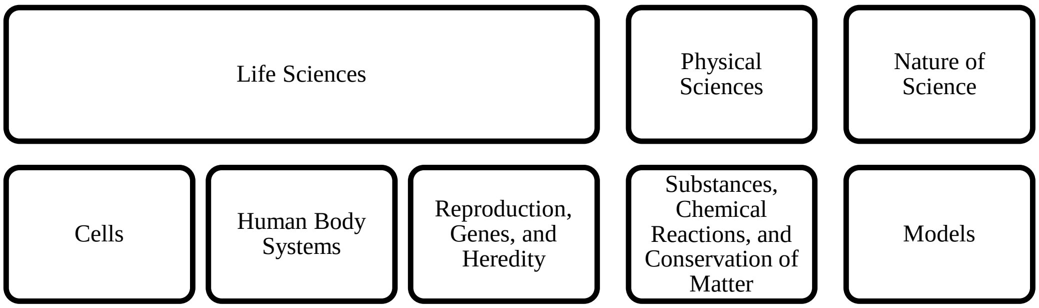

Figure 3.1. AAAS assessment items by science discipline and science topic(s).

Focus Group Interviews

Glesne (2006) positions that focus group research can have "emancipatory qualities if the topic is such that discussion gives voice to silenced experiences or augments personal reflection, growth, and knowledge development" (p. 104). Student participants took part in two focus group interviews, the first at the start of the summer program and the second at the end of the summer program. Focus group interviews were conducted in two sessions with a maximum number of six students per session as interviews ranged from 30 to 40 minutes each in length. To ensure the validity of the information received, the interviews were audio recorded and conducted by a third-party experienced research professional. The semi-structured focus group interviews were recorded and transcribed for coding and analysis.

The focus group interviews provided the opportunity to listen to the perspectives of students and how a culturally responsive approach to science education impacted their summer science learning. The goals of the focus group interviews were to capture actual

student testimony and garner understanding of how and/or what specifically (dis)engaged their attitudes toward and interests in science education and STEM careers. An underpinning assumption of focus group interviews is that individuals, in this instance the students, are valuable sources of information and are capable of expressing their own feelings and behaviors (Clarke, 1999). The focus group interviews provided the best opportunity to identify and understand science engagement and the overall impact of a culturally responsive approach to summer science learning as it granted the opportunity to honor students' voices and worldviews who have been traditionally marginalized in science. The following are example interview questions asked of the students – the interview protocol containing a more comprehensive list of questions is found in Appendix D:

First Interview

1. How do you define science?
    a. What does the word science mean to you?
2. How and when do you use science?
3. Think back over all the years that you have taken science courses, participated in science activities, and/or attended science related events. What is your favorite and most enjoyable memory?
4. Tell me about disappointments (i.e. lessons, activities, field trips, methods of instruction) you have had in science.
5. Who or what influences your decision to learn more about science?

Second Interview

1. In what way(s) was your summer science class different (in a positive way or negative) from your in school science classes?
2. What impact has your summer science class had on your interest in and attitude toward learning science?
3. What impact has your summer science class had your interest in science, technology, engineering, and math (STEM) career decisions?
    a. Think about what you want to be when you grow up. Who or what inspires your career interests and career goals?
4. Thinking back over all your experiences this summer with Ms. Garvin, what experience(s) meant the most in terms of your own learning and why?
5. In what way(s) do you believe your summer science class will help prepare you for the future?

Other Data Sources

Other data sources included program documents, student science journals, and artifacts. Participants' science journals were kept throughout the summer program by students for the documentation of their science learning experiences and were requested at the end of the summer program. Science journals were only provided to and collected from students in the experimental group as ten students provided journals. Science journal served dual purposes, 1) record and describe experimental observations, procedures, data and notes and 2) write critical reflections. On the first day of class students were provided a course syllabus detailing and describing the criteria for which their critical reflections should adhere. For example, to specifically target and address

students' attitudes and interests, the following writing prompts were suggested: 1) what concepts and/or events in the class, lab, field trip, and/or Lab out Loud session did you enjoy most and/or gain the most from as a young scientist and learner; 2) In what ways, if at all, has the class, lab, field trips, and/or Lab out Loud sessions challenged your understanding, thinking, and/or knowledge of science; and 3) I liked and/or enjoyed ___. These artifacts provide a more in-depth understanding of the research questions and what specifically (dis) engaged students' attitudes toward science and interests in science and STEM careers. Table 3.2 provides a summary of the data sources collected for analysis.

Table 3.2. Summary of Data Set

Data Source/Activity Type	Data Type	Quantity: How much? How many?
Pre/Post Culturally Responsive Science Assessment	Likert-Scale/Written Response	Two assessments – one at the beginning of the program and one at the end Total: 2 assessments
Pre/Post Science Content Assessments	Likert-Scale/Written Response	Two science content assessments – one at the beginning of the program and one at the end Total: 2 tests
Focus Group Interviews	Audio record	Two focus group interviews – one at the beginning of the program and one at the end Total: 2 interviews
Science Journals	Written Response	As many as I can collect from student participants (experimental group only)
Program Documents and Artifacts	Documents and Artifacts	As many of anything I could collect from program

Data Analysis

This study utilized a mixed methods triangulation design whereby the quantitative and qualitative components are concomitant (Creswell & Plano Clark, 2007). The triangulation design provided the opportunity to examine the same phenomenon, the impact of a culturally responsive approach during a summer program on student attitudes, interests in science and STEM careers, and overall science learning, from multiple perspectives. Figure 3.2 illustrates the triangulation design incorporated in this study by the researcher.

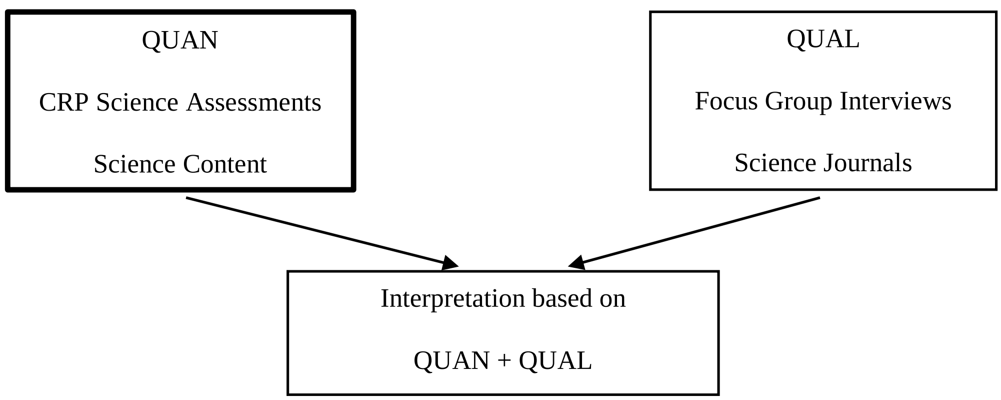

Figure 3.2. Triangulation of data sources.

Culturally Responsive Science Assessments & Science Content Assessments

Student's scores on both the Culturally Responsive Science Assessment and the science content assessment were entered into the IBM SPSS 22 statistical software program and analyzed using a one-way repeated measure analysis of variance (ANOVA) and paired-samples t-test respectively. Only complete data sets (pre and post data for each student) were used for analysis.

Focus Group Interviews & Science Journals

To further engage the research questions and to gain a more in-depth understanding of the impact of a culturally responsive science approach on student

attitudes toward science, interests in science and STEM careers, focus group interviews and students' science journals were transcribed, coded and analyzed for patterns and themes. Focus group interviews, both pre and post were conducted only with students in the experimental group. Likewise, science journals were provided to and collected from only students in my class. Both data sources, focus group interviews and science journals underwent three rounds of rigorous coding to establish emerging themes and patterns. The first coding cycle utilized In Vivo codes. According to Saldana (2013) In Vivo coding seeks to honor the voices of participants and situate the analysis from their perspective. Utilizing initially an In Vivo coding scheme provided the opportunity to capture and understand through participants' voices their attitudes toward and interests in science and STEM careers. In Vivo coding also provided insight on the specific types of science learning experiences that resonated most and were largely meaningful to students. To address the study's research questions, focus group interviews and science journals were coded applying In Vivo codes and analyzed for words, terms, and/or phrases suggestive of one's attitude and interest. Attitude and interest are both difficult domains to assess and evaluate, however for the purpose of this study, attitude represents the emotional orientation of an individual toward the topic at hand (Brandwein, Watson, & Blackwood, 1958); and interest refers to the state or desire of wanting to know and/or learn about something or someone.

Second cycle coding included a combination of In Vivo coding and descriptive coding. Saldana (2013) describes descriptive coding as summative in nature as it includes a word or short phrase that details and explains the basic topic of a passage of qualitative data. To clarify, Tesch (1990) differentiates that "it is important that these [codes] are

identifications of the topic, not abbreviations of the content. The topic is what is talked or written about. The content is the substance of the message" (p. 119). Here, to address the research questions, interviews and journals were coded utilizing a combination coding scheme of both In Vivo and descriptive codes for words, terms, and/or phrases indicative of one's attitude and interest.

The third and final coding cycle utilized protocol coding. Protocol coding is appropriate for qualitative studies in disciplines with pre-established and field-tested coding systems "*if* the researcher's goals harmonize with the protocol's outcomes" (Saldana, 2013, p. 151). Guided by a culturally responsive/relevant theoretical framework, focus group interviews and science journals were coded using culturally responsive/relevant student outcome measures. Table 3.3 illustrates how student outcomes for culturally responsive teaching were grouped with student outcomes for culturally relevant teaching and used for analysis. Note that for the purpose of analysis and interpretation this was the schematic applied.

Table 3.3 Grouped culturally responsive/relevant student outcome measures

Culturally Relevant Student Outcome	Associated Culturally Responsive Outcome
Critical Consciousness	1. Empowering 2. Emancipatory 3. Transformative
Cultural Competence	1. Validating & Affirming 2. Comprehensive 3. Multidimensional 4. Empowering 5. Transformative 6. Emancipatory
Academic Success	1. Multidimensional 2. Empowering 3. Comprehensive

Utilizing the above schematic, focus group interviews and science journals were coded for words, terms, and/or phrases representative of the three student outcome measures for culturally relevant teaching – critical consciousness, cultural competence, and academic success. It is important to note in the above grouping for example, a code labeled critical consciousness also signifies empowering, emancipatory and transformative outcomes.

Researcher Role

Experiences and Biases

The proposed research project expands from my experiences as an African American female attending a predominantly White public school, a female pursuing an advanced degree in a male dominated field, a former elementary school science teacher, and currently a biology lab instructor. As I reflect on my life experiences and challenges, I realize that collectively these experiences have shaped my beliefs, attitudes, and values toward how African American students are (not) taught science. Through these experiences I have developed a sense of empowerment which guides and directs my path in seeking both quality and equity science education for all students. I use my empowerment to support and encourage students, parents, teachers, and communities to take action for themselves and for the future of all children.

I began teaching sixth grade science in 2008, at Cleveland Elementary School in Spartanburg, South Carolina school district seven. This was my first time in an actual classroom, having had little teaching experience. Unlike other elementary schools in Spartanburg school district seven, Cleveland Elementary was among the lowest performing, with student proficiencies well below grade level, limited parental involvement and support, and majority of students living in impoverished conditions and

unmaintained homes. However one thing I admired about both the students and staff at Cleveland Elementary was their relentless efforts to keep moving forward; for the motto at Cleveland is that every student is a scholar. It was at Cleveland Elementary that I clearly understood not all students are provided equitable learning opportunities, as I witnessed a large number of African American, low-income students, particularly African American males, not entering high school. This realization was, and is not acceptable, given that much of what these students needed, other students had – access to tutors, parental support, and school resources.

My interactions, conversations, and participation with students and teachers within these opportunities provided the initial impetus for this study. Based on personal experiences and my interactions with students and teachers of various walks of life, I realized I needed to undertake a more active role in educational reform; helping all students, particularly those of Color, come to understand and may be even appreciate the nature of science. I wondered if culturally responsive teaching was the answer. And that if students were presented with scientific examples and illustrations in which they could relate their own personal life experiences, would science cease to be boring and unpopular among marginalized youth. This study is an attempt to answer these wonderings.

Researcher as Mediator

Qualitative research "is an effort to understand situations in their uniqueness as part of a particular context and the interactions there. This understanding is an end in itself, so that it is not attempting to predict what may happen in the future necessarily, but to understand the nature of that setting – what it means for participants to be in that

setting, what their lives are like, what's going on for them, what their meanings are, what the world looks like in that particular setting…the analysis strives for depth of understanding" (Patton, 1985, p. 1). As the primary research instrument I seek to improve my own practice, knowledge and experience of culturally responsive science instruction and to gain a holistic understanding of its impact on students of Color through critical reflection and analysis. Utilizing a critical action research approach allows the opportunity to situate the study within my own practice and to engage with students in a critically reflective way. Moreover, I seek to engage the data to address the impact of a culturally responsive science approach in a summer program on students' attitudes toward, interests in science and STEM careers and understanding of basic science content knowledge. My goal is to share with the science community, K-12 educators, and society at large the findings of this work with the expectation of improving science teaching practices, through my own praxis and experiences.

Assumptions of the Study

The assumptions of this study include the following:

1. Students in the study will participate willingly and answer survey and interview questions truthfully and honestly.
2. Students in the study will conscientiously attempt to produce quality work.
3. The teacher-researcher will consciously, to the very best of her ability, avoid bias and not influence the validity of the student performances in pretest and posttest results by teaching to the test.
4. The use of multiple instruments – through triangulation – to measure the impact of a culturally responsive approach will provide a clear picture of

students' attitudes, interests in science education and STEM career fields, and understandings of basic science content knowledge.

Study Limitations

There are several notable limitations in this study: small sample size, instrument limitations, and my dual role as teacher and researcher. One, given the nature and setting of this study, a small sample size yields results not generalizable and representative of the entire population. However, results still offer valuable insight into the phenomenon being studied. The second limitation is due to instrument weaknesses as a result of a small sample size and item ambiguity. It is important to note that the Culturally Responsive Science Assessment was a continued work in progress as it was piloted and continuously modified for clarity and theoretical alignment. The third and final limitation is my dual role as teacher and researcher. The duality of roles may present possible issues of bias. However, due to the subjective nature of qualitative research, the teacher-researcher will introduce her bias (if any) in the interpretation of the results of the study. On a final note, the teacher-researcher will attempt to categorize and remove conjecture and bias, and recognize each throughout all phases of the research in order to diminish influence on research findings (Creswell, 2008).

CHAPTER 4

CURRICULUM

Every child deserves an effective teacher – one that is knowledgeable not only about their content area, but one that understands that a 'one size fits all' instructional approach does not work for all students.
(Beverly Weiser)

We are more than role models for our students; we are leaders and teachers of both an academic curriculum and a social curriculum
(Patricia Sequeira Belvel)

The purpose of this dissertation was to understand the impact of a culturally responsive approach on student attitudes, interests in science and STEM careers and overall science learning during a summer learning program. Because the intention of this study was to examine the impact of a culturally responsive approach on student attitudes, interests in science education and STEM career fields, and basic science content knowledge, it is important to provide a rich description and history of TRIO Programs, specifically the Upward Bound Program, the significance of the local site where the study takes place, and an overview of the science curriculum implemented in the study. Although the curriculum was not the focus of analysis for this dissertation, the description provided in this chapter serves as a foundation for understanding the particulars of the contexts in this study, the science curriculum used and how the curriculum aligned with culturally responsive/relevant theory.

A History of the Federal TRIO Programs

In August 1964 in response to the "War on Poverty," President Lyndon B. Johnson signed the Economic Opportunity Act. From the Economic Opportunity Act was born Special Programs for students from disadvantaged backgrounds, as they are more commonly known as the nation's TRIO programs (McElroy & Armesto, 1998). The Upward Bound Program was the first Federal TRIO Program created under the authority of the Economic Opportunity Act. Since 1968, TRIO programs have expanded and provides a wide range of services. Today, nine TRIO programs are included under the TRIO umbrella, seven of which provide direct services to students:

1. Educational Opportunity Centers (EOC) Program
2. Ronald E. McNair Postbaccalaureate Achievement (McNair) Program
3. Student Support Services (SSS) Program
4. Talent Search (TS) Program
5. Upward Bound (UB) Program
6. Upward Bound Math and Science (UBMS) Program
7. Veterans Upward Bound (VUB) Program

This study was situated within an Upward Bound Program. Upward Bound Programs operate with federal dollars and are independently ran, as long as the program meets the objectives and goals outlined by the grant. I provide below a brief overview of TRIO Upward Bound, the goal of the program, as well as the type of services provided to participants.

The Upward Bound Program

The Upward Bound Program provides fundamental support to participants in their preparation for college. Upward Bound serves high school students from low-income families as well as high school students from families in which neither parent holds a four-year degree. The goal of the Upward Bound Program is to increase the rate at which participants complete a secondary education and enroll in and graduate from institutions of postsecondary education (USDOE, 2013). According to the U.S. Department of Education’s list, UB program services include, but are not limited to the following:

- Instruction in mathematics, laboratory science, foreign language, composition, and literature;
- Academic tutoring, which may include instruction in reading, writing, study skills, mathematics, science, and other subjects;
- Assistance in secondary school course selection and postsecondary course selection;
- Assistance in preparing for college entrance examinations;
- Assistance in completing college admission applications;
- Guidance and assistance in secondary school reentry, alternative education programs for secondary school dropouts that lead to receipt of a regular secondary school diploma, entry into general educational development programs, or postsecondary education;
- Education or counseling services designed to improve the financial and economic literacy of students or the students’ parents;

- Exposure to cultural events and academic programs not usually available to disadvantaged youth;
- Information and activities designed to acquaint youth with the range of career options available to them;
- On-campus residential programs;
- Mentoring programs; and
- Work-study positions to expose participants to careers requiring a postsecondary degree (USDOE, 2013).

Local Site Significance

The local site for the Upward Bound Program in this study was a Historically Black College and University (HBCU). The Higher Education Act of 1965, as amended, defines an HBCU as:

> …any historically black college or university that was established prior to 1964, whose principle mission was, and is, the education of black Americans, and that is accredited by a nationally recognized accrediting agency or association determined by the Secretary [of Education] to be a reliable authority as to the quality of training offered or is, according to such an agency or association, making reasonable progress toward accreditation. (USDOE, 2015)

Historically Black Colleges and Universities remain a source of accomplishment and great pride for the African American community as HBCUs are the only institutions in the United States that were created for the sole purpose of educating Black society. Until the Civil Rights Movement, HBCUs were, with very few exceptions, the only

higher education option for many Blacks. Historically Black Colleges and Universities are public and private, religious and non-sectarian, two-year and four-year, selective and open, urban and rural (Kim & Conrad, 2006).

The local site for the Upward Bound Program in this study was St. Paul College. St. Paul College is a private, co-educational liberal arts institution. St. Paul's mission statement reads:

> St. Paul College will be a full opportunity college with high quality programs of teaching, research, and public service. These programs will provide our students and community with the knowledge, skills, understandings, and values required to empower them to be a power for good in society and to create a better world. We seek geographic, international, and racial diversity in our student body while continuing to facilitate the empowerment, enhancement, and full participation of African Americans in a global society and to maintain our historic affiliation with the Baptist Church. (Website, ND)

Given the history and mission of St. Paul College, programs and initiatives directed by Upward Bound align with, and are both culturally relevant and responsive to the needs of participants.

Culturally Responsive Science Curriculum

This study examined the impact of a culturally responsive approach. To explore the impact of this approach I developed and implemented a culturally responsive science curriculum aligned with South Carolina Science Academic Standards. Growing evidence supports curricular and teaching practices that situates learning from students' cultural experiences and links it to classroom learning as such practice produces positive learning

outcomes and promotes student academic achievement (Aikenhead, 2001; Gay, 2000; Ladson-Billings, 2009). Based on the theories set forth by Gay (2000) and Ladson-Billings (1994; 2009) the culturally responsive science curriculum employed in this study sought to integrate students' cultural and home knowledge around select science topics with goals of enhancing students' interests in science and STEM careers, and attitudes toward science as well as critical consciousness and cultural competence. Unlike traditional science classrooms and curricula, a culturally responsive science curriculum values the culture, knowledge, skills, experiences and beliefs students bring to school and actively engage and draw upon these understandings to make connections to science learning. It is important to remember that both culturally responsive and culturally relevant pedagogy is twofold and contain a set of both pedagogical tenets (things the teacher must do) and student outcomes (the pedagogical result, when pedagogical tenets are executed properly). Table 4.1 highlights the pedagogical tenets and student outcomes of both culturally responsive and culturally relevant pedagogy as defined by the respective theorist.

Table 4.1. Culturally responsive and culturally relevant pedagogical tenets and student outcomes.

Culturally Responsive Pedagogy	
Pedagogical Tenets	Student Outcomes
1. Teacher attitudes and expectations	1. Validating
2. Cultural communication in the classroom	2. Comprehensive
3. Culturally diverse content in the curriculum	3. Empowering
4. Culturally congruent instructional strategies	4. Transformative
	5. Emancipatory
	6. Multidimensional
Culturally Relevant Pedagogy	
Pedagogical Tenets	Student Outcomes

1. Conceptions of self and others 2. Social relations 3. Conceptions of knowledge	1. Develops sociopolitical consciousness 2. Develops cultural competence 3. Ensures academic success

Note: Culturally Responsive Pedagogy – Gay (2000); Culturally Relevant Pedagogy – Ladson-Billings, 1994.

The work to create culturally responsive science curriculum is context specific, student specific, dynamic, multidimensional and ultimately relevant and reflective of what one values, believes, and considers worth knowing. There is an entire field that looks at and identifies traditional Eurocentric curriculum, transforming and adapting it to and through the various cultural experiences and knowledge of different groups (Banks, 2006, 2008, 2009; Bigelow & Peterson, 1998; Gay & Banks, 1975; Howard, 2006). However, the purpose of this dissertation study was not to analyze or examine the curriculum, but to understand through improvement of my own practice, the impact of a culturally responsive science approach in a summer program on students' interests in science and STEM careers, attitudes toward science and overall science learning. Thus data and findings derived here are not generalizable and/or transferrable. Below I briefly provide an overview of the science curriculum utilized in this study and how it aligned with culturally responsive pedagogy.

Summer Science Curriculum

In conceptualizing and developing the science curriculum, there were four critical characteristics to ensure:

1. The curriculum incorporates teaching practices that are congruent with and responsive to the cultural context, and focus on student understanding and use of scientific knowledge and skills.
2. The curriculum incorporates culturally appropriate and relevant topics of significance and includes the expertise and experiences of local experts and professionals.
3. The curriculum connects science teaching and learning to culturally identified topics as well as to state academic science standards.
4. The curriculum engages in constant and continuous student assessment, whereby student understandings are highly valued and produce deeper level reasoning and the ability to apply scientific knowledge to real world conditions.

The science curriculum in this study contained several different components – science journals, Lab out Loud sessions and presentations, sickle cell genetics, and more. A detailed explanation of what each curricular component entailed is described below. Please note Table 4.2 at the end of this chapter provides a thorough description of each science curricular component (i.e., Lab out Loud, Rat Rap, etc.) and how it connects with and relates to the theory of culturally responsive teaching.

Lab out Loud (LOL)

Lab out Loud was a weekly learning initiative instituted to provide students the unique opportunity to engage in and interact with African Americans in STEM

related careers. African American professionals were invited to share their knowledge, skills, experiences, and expertise through presentation or activity, to students as a way to introduce and connect them to STEM careers. African American professional included a pediatric dentist, civil engineer, and biomedical scientist. The goal of Lab out Loud was to introduce, inform, and ignite students' interest in STEM related careers, especially careers least recognizable. Likewise, another critically important goal of Lab out Loud was to utilize African American professionals and community experts. This provided students the opportunity to meet, interact, and engage with STEM professionals of the same race, ethnicity, and culture – thus developing and shaping their critical consciousness through cultural competence. These representations of professional men and women of Color in STEM careers provided tangible examples from the community in which students live, of African American academic success in science, in hopes that students will see, self-identify (I am science) and envision their own educational success. Table 4.2 provides a description detailing Lab out Loud and how it connects with and relates to the theory of culturally responsive teaching.

Science Journals

Students were provided a composition notebook to detail, describe, and document their summer science learning experiences. Students used their science journals as a tool to record and assess their science learning experiences – e.g., Lab out Loud, university laboratory research, science lessons and investigations. Through writing prompts students shared personal accounts, intimate details and thought

provoking questions on various topics studied and discussed in class. Science journals provided students an excellent opportunity to think about their thinking, refocus their focus, ask questions, and critically reflect on what types of learning experiences proved most and/or least beneficial. The goal of the science journal was to help students develop a deeper and more critical understanding of their learning, enhance content specific thinking, and provide a platform where their voices could be seen, heard, believed, valued and shared. In chapter 5 I will further explore students' science journals to better understand student attitudes toward science, interest in science education and STEM careers. Table 4.2 provides a description detailing students' critical written reflections and how it connects with and relates to the theory of culturally responsive teaching.

Field Trips: University Laboratory Research

Research has shown the importance and overall value of field trips as they can be long remembered after a visit (Falk & Dierking, 1997), influence perspective career choices (Salmi, 2003), increase interest and engagement in science (Bonderup Dohn, 2011), and result in affective gains, such as a positive attitude toward science (Csikszentmihalyi & Hermanson, 1995). Over the course of the summer program students had the opportunity to participate in university laboratory research experiences. Here, students spent the entire day at the university conducting a series of experiments and investigations led by university research scientists and professors. University research projects included Genetic Roots, Human Genetic Disorders, and Biomedical Engineering. Each research

project provided students the opportunity to engage in hands-on, culturally responsive scientific inquiry. For example, Human Genetic Disorders provided students the opportunity to test different hemoglobin samples using agarose gel electrophoresis to detect sickle cell anemia among patient samples. The goal of the laboratory research experience was to expose students to career opportunities through hands-on, culturally relevant and real-world research. Table 4.2 provides a description detailing field trips in which students participated and how these experiences connect with and relate to the theory of culturally responsive teaching.

Rat Rap/Poetry Projects

Students had the opportunity to perform an animal (rat) dissection. The animal dissection provided students a kinesthetic way to learn real-life interconnections between organs and systems, and anatomy and physiology. Instead of utilizing a traditional method of assessment (i.e. lab practicum) students were given guidelines and a rubric for a rat rap and/or poetry project (Appendix V). Here students were asked to construct and create either a rap or a poem using rat anatomical terms and physiological functions. The goal of the rat rap/poetry project was to provide students an opportunity to demonstrate their knowledge and understanding of course material in a creatively relevant and innovative way. Likewise, the rat rap/poetry project also served as an alternative method of assessment, where a culturally responsive approach was employed to assess students' knowledge of structure, function, placement, and interconnections of rat organs and systems. Table 4.2 provides a description detailing the rat rap – poetry

project and how it connects with and relates to the theory of culturally responsive teaching.

Genetics: Sickle Cell Anemia

Sickle cell genetics was a unit that incorporated lessons involving the structure, function and relationship of DNA, nucleotides, base pairs, genes, and chromosomes. Here, lessons also included investigations, discussions and connections to genetic disorders, particularly Sickle Cell Anemia – this provided students the opportunity to connect classroom learning to their university research experience, but most importantly to their own lives and communities. Students candidly shared through classroom discussion or their science journals they were carriers for, or knew of individuals with Sickle Cell Anemia. The goal of the sickle cell genetics unit was to link science instruction to students' lives and communities using culturally significant and relevant science topics. Table 4.2 provides a description detailing Sickle Cell Anemia and how it connects with and relates to the theory of culturally responsive teaching.

Chemistry of Hair

The chemistry of hair was a unit inspired by my students. I found that an overwhelming number of African American students, both males and females enrolled in my science class did not find interest in or relevance to science in their daily lives. So I pulled out scissors and asked students to volunteer and/or donate a few strands of their hair. With their locks in hand, students explored the

chemistry of hair by utilizing their own hair as a starting point for chemical testing. Through culturally relevant instruction, learner-centered engagement and hands-on learning, students discovered first-hand the effects of chemical relaxers and properties of various acids and bases on different types of materials (i.e. human hair, pig kidney, aluminum foil, etc.). By comparing hair results with peers, students understood the significance of concentration and that not all relaxers (perms) are created equal. Simply, when a Black person puts a relaxer in their hair, it is not the same as when a White person gets a perm. Inclusively, the goal of the chemistry of hair unit was to help students connect and relate science, specifically genetics and chemistry to their everyday lives. Likewise, this unit was also intended to address state academic science standards by engaging students in culturally relevant and responsive topics. Table 4.2 provides a description detailing the chemistry of hair and how it connects with and relates to the theory of culturally responsive teaching.

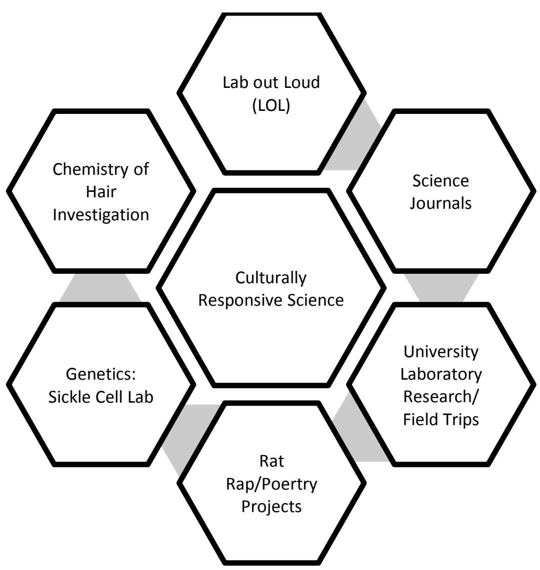

Figure 4.1. Curricular components of the culturally responsive science curriculum.

Table 4.2 explicitly defines and describes the characteristics and outcomes of culturally responsive science incorporated in the summer curriculum.

Table 4.2. Characteristics and outcomes of culturally responsive science in the summer curriculum*

Outcome	Definition of Outcome	Curriculum Alignment with Outcome
Validating & Affirming	• Acknowledges the legitimacy of the cultural heritages of different ethnic groups, both as legacies that affect students' dispositions, attitudes, and approaches to learning and as worthy content to be taught in the formal curriculum. • Bridges meaningfulness between home and school experiences and between science concepts and lived sociocultural realities; incorporate multicultural content, resources, and materials.	The science curriculum promoted social and cultural awareness. Each week students participated in Lab out Loud; a time of informal learning and discovery where students engaged in and interacted with African Americans in STEM through presentation or activity to celebrate and recognize their own and each other's cultural achievements. Likewise, the science curriculum introduced and connected students to various science concepts (e.g., Mendelian Genetics and chemistry) using culturally relevant funds of knowledge – e.g., Sickle Cell Anemia, the effects of chemical relaxers on (Black) hair.
Comprehensive	• Facilitates intellectual, social, and emotional learning by using cultural resources to impart knowledge, skills, values, and attitudes – teach and reach the whole child. • Hold students accountable for one another's learning as well as their own learning.	The science curriculum provided students intellectual (*curriculum promotes student centered, project and inquiry based hands-on ways to learn and engage science*), social (*all students engaged in university laboratory research as well as Lab out Loud sessions and presentations*) and emotional (*all students shared through critical reflection and journaling their science*

		learning experiences, positive and negative, good and bad) learning experiences by exposing them to various cultural opportunities and academic programs that many do not have access to through their regular school programs.
Multidimensional	• Encompasses curriculum content, learning context, classroom climate, student-teacher relationships, instructional techniques, classroom management, and performance assessments. • Hold students accountable for knowing, thinking, questioning, analyzing, reflecting, and sharing.	The science curriculum (lessons, investigations, and field trips) was designed to recognize and reflect the knowledge students bring to the classroom as well as promote collaborative learning and critical thinking. The science curriculum also utilized a wide variety of instructional strategies to connect to different learning styles – e.g., collaborative learning, experiments and simulations, critical reflections, as well as alternative methods of assessment (i.e., rat rap/poetry projects).
Empowering	• Empowering translates into academic competence and personal confidence. • Bolsters student morale, provides resources and personal assistance, develops an ethos of achievement, and celebrates individual and collective accomplishments.	A critical component of the science curriculum was Lab out Loud. Each week students engaged in and interacted with African Americans in STEM related careers to celebrate and recognize each other's cultural and educational accomplishments. These representations of successful African Americans in STEM provided tangible examples from the community in which students live, of African American academic success; tangible examples provide students an opportunity to realize, imagine and envision their own educational success.

Transformative	• Disrupts and transcends the cultural hegemony hidden in traditional science curriculum content and classroom instruction. • Develops social consciousness, intellectual critique, and political and personal efficacy in students so that they can combat prejudices, racism, and other forms of oppression and exploitation.	The overarching theme of the science curriculum was *I am science*. Each component of the science curriculum (e.g., Lab out Loud, science lessons and investigations, field trips) recognized the knowledge students bring to the classroom is just as important as what is being taught in the classroom. Lab out Loud provided students mirrors and windows to envision their own lives, success, and experiences as part of a larger cultural experience and to recognize that, you are/ we are/ I am science.
Emancipatory	• Guides students in understanding that no single version of "truth" is total and permanent.	The science curriculum provided students access to quality STEM educational learning experiences that provided the opportunity for them to develop critical thinking, collaboration and communication skills by examining their own lives and the lives of others. The science curriculum (e.g., Lab out Loud, science lessons and investigations) promoted social justice and equity in science as students were encouraged to become advocates for social change.

Notes: *Categories, outcomes and definitions derived from Gay (2000); Funds of knowledge is defined by researchers Luis Moll, Cathy Amanti, Deborah Neff, and Norma Gonzalez (1992) "to refer to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (p. 133).

CHAPTER 5

RESULTS

In our multicultural society, culturally responsive teaching reflects democracy at its highest level. It means doing whatever it takes to ensure that every child is achieving and ever moving toward realizing his or her potential.
(Researcher Joyce Taylor Gibson)

This study examined the impact of a culturally responsive approach on student attitudes, interests in science and STEM careers, and basic science content knowledge before and after participation in a science course within the Upward Bound Summer Program. To present the study findings in the most efficient manner, the structure of this chapter is defined by the research questions and includes both quantitative and qualitative results respectively where appropriate, with a brief discussion following. Moreover, this chapter concludes with a section titled other relevant findings, and includes both quantitative and qualitative data that address the study's conceptual framework – culturally responsive pedagogy. A more in-depth discussion of the results as well as outlining implications for research, practice and policy are reserved for Chapter 6.

Research Question 1: What is the impact of a culturally responsive approach in a summer science program on student attitudes towards science education?

Quantitative Results

Student attitudes towards science was assessed using a Culturally Responsive Science Assessment (Appendix B) developed by myself, the teacher and researcher. The

assessment was a 21-item Likert scale measure that consisted of seven questions for each of the following three categories: attitude toward science, interest in science, and interest in STEM careers. The Culturally Responsive Science Assessment had a high level of internal consistency as determined by Cronbach alphas of 0.760 (attitude toward science), 0.902 (interest in science), and 0.778 (interest in STEM careers). Likewise, pre-test/pre-test t-test results indicated students in both the experimental and comparison group began at the same place in terms of their attitudes toward science, $p = 0.723$. Each category was measured and assessed on a five point scale ranging from 5 – strongly disagree, 4 – disagree, 3 – undecided/uncertain, 2 – agree, to 1 – strongly agree. Table 5.2 summarizes the descriptive statistics for both the experimental and comparison group. It is important to note, due to the numeric order associated with the Likert-scale used in this study, lower values (i.e., means) were desired. Based on the data in Table 5.1, students in the experimental group had a slightly more positive attitude toward science after receiving culturally responsive science instruction compared to the comparison group. Conversely, student scores on the assessment in the comparison group indicated a more negative attitude toward science.

Table 5.1. Descriptive statistics for experimental and comparison groups: Attitude toward science

	N	*M*		*SD*	
		Pre	Post	Pre	Post
Experimental Group	11	2.052	1.948	0.959	0.439
Comparison Group	19	2.173	2.330	0.743	0.727

To investigate if there was a significant difference overtime in the pre and posttest (within-subjects factors) and between the two groups, experimental and comparison (between-subjects factors) and to assess if there was an interaction between time and group, a one-way repeated measures analysis of variance (ANOVA) was performed. There were no outliers and the data was normally distributed at each time point as assessed by boxplot and Shapiro-Wilk's test ($p > 0.05$) respectively. The one-way repeated measures ANOVA results showed no statistical significance in student attitudes toward science from pre-test to posttest, Wilks' Lambda = 0.998, F (1, 28) = 0.048, p = 0.828; also, there was no statistical significance overtime and between the two groups, Wilks' Lambda = 0.961, F (1, 28) = 1.133, p = 0.296. Although quantitative results did not indicate statistical significance in student attitudes toward science within and between groups overtime, the following qualitative results provide insight into the type of science learning and instruction that positively impacts student attitudes toward science.

Qualitative Results

To further engage the research question and to gain a more in-depth understanding of the impact of a culturally responsive approach on student attitudes toward science, focus group interviews and students' science journals were coded and analyzed. The qualitative data sought to engage students in a candid, yet critical discussion and/or reflection of their science learning experiences in order to gain a holistic understanding of their attitudes toward science. It is important to note that focus group interviews, both pre and post were conducted only with students in the experimental group. Likewise, science journals were given to and collected from students only in my class. Qualitative data was coded and analyzed for reoccurring patterns and

themes associated with student perspectives on their formal and informal science learning experiences. Three predominant themes emerged from the data that provided some indication as to why there was a shift in attitudes over the course – 1) science learning experiences, 2) science disappointments, and 3) teacher attitudes and beliefs.

Science Learning Experiences

Science learning can occur in many different venues, both formal and informal (Bull et al., 2008). The National Science Foundation (NSF) employs the term informal learning to describe learning and engagement that occurs outside formal school settings. In the focus group interviews students openly shared their formal science learning experiences, how these experiences were different from their summer science experience, and their overall attitude toward science. All participants shared the significance and overall importance of "doing" science experiments and labs utilizing a hands-on learning approach. The "*doing*" of science is stressed as a large number of students recalled and concurred that "… when you're in school you just take notes and listen to lectures and read out the book and do busy work and packets" or "watch videos of other people doing stuff and you do nothing." One young lady shared that the summer science class was good for her because "I never dissected anything and we got to do like a rat dissection, so it was really fun." Student narratives detailed and described how their formal science classes have failed them by not providing access to and opportunities in being able to "*do*" science –

> The science teacher I had in 9th grade, she was bad, like she ain't teach nothing, and she gave out packets and had us work in groups. You can't do that, you gotta

[should] have hands-on, you gotta [should] have stuff to talk about and not just sit in front of class and ramble and give packets.

Providing students an opportunity to actually learn science, by doing science was significant because in their formal science classes, some students are simply denied or not provided the opportunity to learn science in a hands-on and meaningfully relevant way. Students shared that their summer science learning,

> …was different because we went like on field trips, and actually did more hands-on things, instead of just coming to class and doing PowerPoints and taking notes. And that's better than just reading and taking notes in class.

Students also shared science learning experiences the summer class provided that they were not given in their formal science classes. Table 5.2 highlight science learning experiences that students commonly shared as being most meaningful and beneficial to their learning from the summer, together with their exact comments.

Table 5.2. Meaningful summer science learning experiences

Science Learning Experiences	Student's Comments/Responses
Hands-on science (i.e., dissections, modeling, etc.)	• The dissection and labs was the best cause you don't really get that in school, and it was more hands-on, than what you do in school by yourself or with the teacher. • I like that I had a chance to dissect a pregnant rat that was very cool, like that was the coolest thing I ever did. I learned a lot and really enjoyed myself when we did it, like it was really good and I wouldn't mind doing that [dissection] again.
[Science] field trips	• The biology lab, because like some of the stuff we went over, I didn't know and I learned a lot. But this field trip that, um, I really took it in. I still remember some of the

	stuff that we did, and I think it'll help me next year if we do talk about it [genetics], so I will have like a head start. • Going to the university and doing the, ah, DNA lab was most exciting. I really enjoyed this most cause you get to be in that environment and doing, ah, the science to learn about yourself and your people. • I really liked the field trip to the college lab. Getting to see how a college lab looks was good because it looks way different than my school lab. I really enjoyed putting on and wearing the lab jacket with the safety glasses, it really made me feel like a real scientist. Going to the university science lab has me thinking that I would like to do something like this in the future, like I would look more into it.
Lab out Loud	• We actually had people come talk to us and you can ask questions instead of going to look online. And she let us write reflections about it. • Our Lab out Loud presentations really helped me love what I want to do in life. The presentations taught me that I should never settle for less and to always strive for the best. Having African Americans speak made me feel like my kind of people can strive for the best and be successful in life. They let me know how success can take you far. As I get older I would want to be just as happy and successful just like them.
Reflective and critical writing (i.e., science journaling)	• Ah, like reflections that Ms. Brittany had us writing, it actually gave us a chance to like express how we feel about science. And if we didn't agree with something or we didn't like something, she would tell us like write it down. And, ah, like in school, we don't really get to say how we feel about science [learning].
Rat Rap	• The rat rap was most fun and interesting even though I'm not a rapper and I can't rap. It was actually a new way for people to actually learn something in an easier way since this generation relates more to music than lectures. Making the rap was hard but it made

	me think more because it used a combination of English and science skills. If this was used in schools I think more people would actually pass because it's a better way to connect with your students on another level. • My most enjoyable science learning experience this summer was the rat rap because I didn't really know much about rats or their organs and writing the rap really helped me learn about them.

Additionally, some students shared they really enjoyed the chemistry of hair lab, this particular learning experience provided students knowledge of chemical reactions and the properties of acids and bases in a culturally responsive way; one student shared, "The hair lab was really cool. It was interesting to test the chemicals on our hair to see how it would react. I didn't know that White people get perms, I thought that was just for Black people."

These science learning experiences (e.g., dissections, field trips, Lab out Loud, reflective and critical writing, rat rap, chemistry of hair) resonated most with students, resulting in a positive impact on their attitude toward science as well as attitude to learn more about science, as one student commented - "At first like I ain't had good science teachers, so I didn't like science. But now like that I have Ms. Brittany, like I wanna learn more in her class."

Science learning experiences was a central theme in the data. Students openly shared without reservation learning experiences that have had an important impact, positive or negative, on their attitudes. A salient finding that emerged from the interview data, and concurs with the research literature, was that students of Color are not being provided appropriately sufficient science learning experiences in school (Atwater, 2000).

For a large number of students interviewed, formal science involve routine "lecturing, science packets, notes, and busy work" with a major focus on standardized state tests. Likewise, students receive very few opportunities, if any at all, to engage in scientific practices to learn science by "*doing*" science in a culturally responsive way. Unlike traditional science learning spaces, one student felt the summer science class was more interesting because,

> It wasn't at all focused on the big test – ASAP or any end of year tests. Here it's more, um what you'll get out of it than oh you gotta [must] learn this, just for this test or that test. No here we really learn and do hands-on experiments to learn.

Moreover, some students felt the summer science class allowed more time for in-depth discovery and exploration of science content that is not provided in formal education spaces,

> We got a better understanding of it [science] here during the summer class because you know when you're in school, you're moving so fast and there's only certain things that they [the teacher] tell you because they [the teacher] have to move on. You don't really get to work hands-on [in school], but here you do and you get a better understanding.

For a majority of students, learning science in a way that allows them to make connections to who they are and what they may have heard, seen, or experienced previously was important and resulted in a positive impact on their interest in science. One student shared,

> The DNA lab was one of my favorite science learning experiences cause I got to test my own DNA and look at it. We got to see and do things like you know on NCIS and Law and Order, and mix it up and test it.

Moreover, some students attributed a positive attitude toward science to being able to learn beyond the regular classroom by participating in culturally responsive lab based field trips –

> Going to the university and doing the, ah, DNA lab was exciting. I really enjoyed this most cause you get to be in that environment and doing, ah, the science to learn about yourself and your people.

Ultimately, a number of students said given what they know now about science they would share with others at home and in school what they have learned. This revelation and enthusiasm by students to share new knowledge with those around them was important as it speaks to the authenticity of students' attitudes toward [learning] science. Here findings suggest the importance of providing students different types of science learning experiences that extend beyond the traditional classroom (i.e. field trips) in order to foster positive attitudes towards science.

Science Disappointments

A second important theme relating to shifts in attitudes over the course was the notion of students' disappointments in science. I define disappointment to mean and/or refer to feelings of sadness or displeasure resulting from the nonfulfillment of one's hopes or expectations. Disappointments in science ranged from students being told or even promised a particular type of science learning experience, to students starting, but not completing a project and/or experiment. A number of students explicitly detailed and

described school experiences where they were promised a particular type of science learning experience, and it was never fulfilled. One student shared, “My teacher told us that we were gonna [going to] do an experiment this week or that week, but it never happened. We just sat in class and we talked and we didn’t really do anything.” Likewise, another student shared,

> I had a decent science teacher, but, um, he was disappointing because he told us that we was gonna [going to] get to do experiments and blow up stuff and we never did nothing, like nothing at all and I was really looking forward to it.

Moreover, a number of students recalled instances where they would start an experiment, but not see it through to completion –

> We were told that we would do much more experiments, like projects and to the point where like we’d start our project but never even finish it. We would be like what happened? And the teacher would say we messed it up.

Similarly another student shared, “Like in science class we would do an experiment but because she had like stuff that expired, the experiment wouldn’t go right and she would tell us that we would re-do it but we never did.” However one student shared, “Ms. Brittany kept talking about the dissection through the Saturday sessions and doing it and everything, so I was really looking forward to it.”

Teacher Attitudes and Beliefs

The teacher education literature is vast, and strongly supports the notion that teachers are major stakeholders to promote educational reform as their beliefs are significant factors to and for change (Crawford, 2007; Pajares, 1992; Richardson, 1996). For the purpose of this work, “Attitudes and beliefs are a subset of a group of constructs

that name, define, and describe the structure and content of mental states that are thought to drive a person's actions" (Richardson, 1996, p. 102). Teacher beliefs and attitudes are important as it influences how teachers make decisions (Pajares, 1992). Teacher attitudes and beliefs have an important impact on their students' attitudes toward learning, in this case science, as a teacher who exudes positive enthusiasm for science transfers those feelings to their students. However the opposite also holds true, as a teacher who displays negative apathy and a lack of interest in teaching and learning science transfers feelings of disinterest. One student shared in her science journal, "Ms. Brittany's attitude drawed [caused] me to pay more attention in class and I found myself becoming more engaged."

When students were asked to share ways in which their summer science class differed from their formal science classes, students often expressed thoughts that related to teacher attitudes and beliefs. One student shared:

> Ms. Brittany doesn't like just yell at us – say if somebody make her mad, she doesn't get an attitude and then just shut down the whole class period, you know, to do bookwork. Instead we always did something fun. And she [Ms. Brittany] always answers your questions. Like she gets down to the root, like she doesn't let anything slide, like even if she is about to say something she's like, what was that? And then she don't let you go on unless you explain it back to her. She's interested in what we have to say and how we learn and what we learn.

Based on the students' comment, it is clear that some formal science classrooms disengage students as teachers fail to properly and effectively communicate with

students, listen attentively to student questions, and speak in an appropriate tone and volume. Likewise, another student commented:

> Ms. Brittany doesn't like talk down to you like the other teachers, – the way they see it is it's all right cause they been teaching it for years. Ms. Brittany don't make you feel stupid and act like she know everything or say oh it's easy you should know that, I been going over it. She [Ms. Brittany] gets you to learn something from her because what she is teaching she finds a way to put on your level and get you up higher and raise you like to the level where you need to be. She [Ms. Brittany] actually encourages us. She don't talk negative and she don't give mean side comments.

It was interesting to hear students detail and describe instances from their formal science classes where the teacher demeaned and/or ridiculed them. Such inappropriate language and behavior from teachers negatively impacts student attitudes toward learning [science]. Through a culturally responsive analytical lens the belief and attitudes of the teacher cannot be understated as it is vitally important for teachers to work actively with students, respond to students with respect, and remain vigilant and responsive to students' needs. As previously stated, teacher attitudes and beliefs have an important impact on their students' attitudes toward learning, for a teacher who emanates a positive attitude transfers those feelings to their students – "I think Ms. Garvin's attitude is what helped us stay focused because Ms. Garvin never got mad, frustrated, stressed-out or anything and like that keeps a good vibe in class and it rubs off on everybody else."

Summary

Although the quantitative data did not indicate statistical significance overtime (from pre-test to posttest) and between the two groups (experimental and comparison), the qualitative results provide insight and gives voice to the data as it offers an explanation to address the types of experiences that impact student attitudes toward science. The data suggest that student attitudes towards science have been negatively impacted by their formal science experiences. Students shared that formal science learning consists of taking notes, listening to lectures, and "busy work" in the form of packets. Findings suggest that for this group of students, these instructional methods result in negative attitudes toward science. On the other hand, providing students with culturally relevant and meaningful science learning experiences in the form of hands-on learning, field trips, reflective writing and Lab out Loud produces positive learning outcomes and attitudes toward science. Results indicate students appreciated the summer science class because unlike their formal science class, the summer curriculum provided the unique opportunity to "*do*" and engage in science practices. Furthermore, the data highlights the importance of teachers keeping their word as well as the importance of teachers maintaining a positive attitude toward and respect for students. Findings also emphasize the importance of teacher-student expectations and the consequences that result when student's learning expectancies are not met. The disappointments students expressed seemingly had a negative impact and adverse effect of their attitudes toward science and students lost trust in their teachers as a result of perpetual patterns of broken promises. According to the data, if the teacher is positive, enthusiast, and supportive of

students, these feelings are transferred to the students and positively impacts their attitude toward science.

Research Question 2: What is the impact of a culturally responsive approach in a summer program on student interests in science education and STEM career fields?

Quantitative Results

Student interests in science education and STEM career fields was assessed using the Culturally Responsive Science Assessment. As previously stated, the assessment was a 21-item Likert scale measure that included seven questions specifically targeted to address each of the following three categories: attitude toward science, interest in science, and interest in STEM careers. Pre-test/pre-test t-test results indicated students in both the experimental and comparison group began at the same place in terms of their interest in science education, $p = 0.082$ and STEM career fields, $p = 0.463$. Each category was measured and assessed on the same five point scale as before, 5 – strongly disagree, 4 – disagree, 3 – undecided/uncertain, 2 – agree, to 1 – strongly agree. Tables 5.3 and 5.4 summarize the descriptive statistics for both experimental and comparison groups for interest in science and interest in STEM careers respectively. Again, due to the numeric order associated with the Likert-scale used in this study, lower values (i.e., means) were desired. According to the data in both Tables 5.3 and 5.4, students receiving culturally responsive science instruction had more of an interest in science, as well as an interest in STEM careers at the end of the summer program.

Table 5.3. Descriptive statistics for experimental and comparison groups: Interest in science

	N	*M*		*SD*	
		Pre	Post	Pre	Post
Experimental Group	11	1.961	1.740	0.729	0.549
Comparison Group	19	2.519	2.474	0.939	0.736

Table 5.4. Descriptive statistics for experimental and comparison groups: Interest in STEM careers

	N	*M*		*SD*	
		Pre	Post	Pre	Post
Experimental Group	11	2.753	2.156	0.808	0.562
Comparison Group	19	2.537	2.417	0.676	0.601

To investigate if there was a significant difference overtime in the pre and posttest (within-subjects factors) and between the two groups, experimental and comparison (between-subjects factors) and to assess if there was an interaction between time and group, a one-way repeated measures ANOVA was performed for both categories, interest in science and interest in STEM careers. For simplicity, results are reported first for interest in science, followed by interest in STEM careers.

For interest in science, there were no outliers and the data was normally distributed at each time point as assessed by boxplot and Shapiro-Wilk tests ($p > 0.05$), respectively. The one-way repeated measures ANOVA for students' interests in science did not indicate statistical significance from pre-test to posttest, Wilks' Lambda = 0.933, F (1, 28) = 2.006, p = 0.168. Likewise, there was no statistically significant interaction between time and group, Wilks' Lambda = 0.970, F (1, 28) = 0.876, p = 0.357. However there was a significant main group effect, F (1, 28) = 5.326, p = 0.029. This result

suggests that students' interest in science for the experimental group (*M* = 1.740, *SD* = 0.548) was significantly different from students in the comparison group (*M* = 2.473, *SD* = 0.736). Simply, students in the experimental group had more of an interest in science after receiving culturally responsive instruction than students in the comparison group.

For students' interests in STEM careers, there were no outliers and the data was normally distributed at each time point as assessed by boxplot and Shapiro-Wilk's test ($p > 0.05$) respectively. The one-way repeated measures ANOVA results for interest in STEM careers indicated statistical significance in time, from pre-test to posttest, Wilks' Lambda = 0.679, $F(1, 28) = 13.217$, $p = 0.001$. Likewise, there was also a statistically significant difference in the interaction of time and group, Wilks' Lambda = 0.827, $F(1, 28) = 5.871$, $p = 0.022$. Figure 5.1 illustrates the significant interaction that exists between time and group. This significant interaction suggest that change in score overtime is interacting with group.

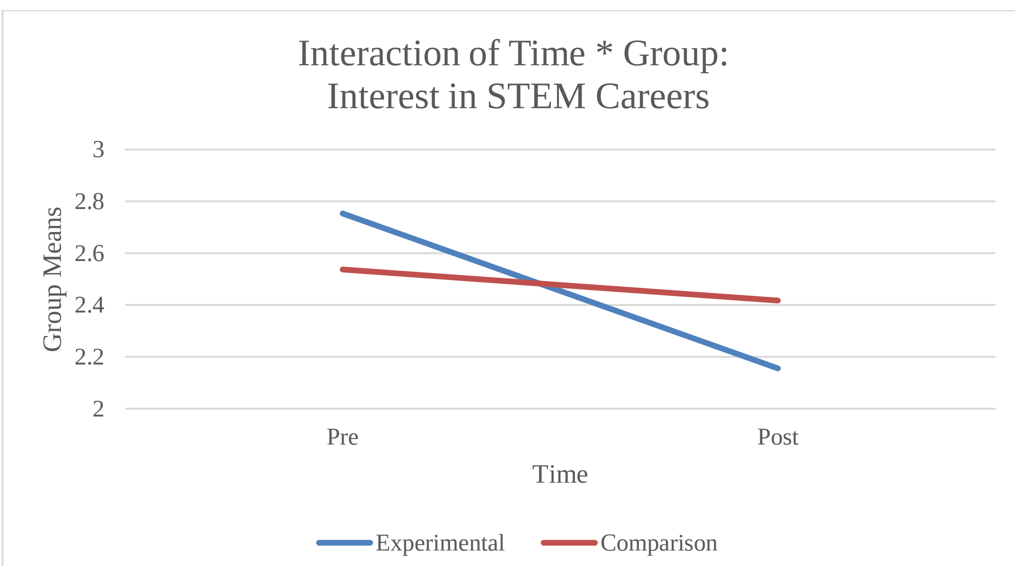

Figure 5.1. Interest in STEM careers – both time and the interaction of time and group were statistically significant, $p = 0.001$; $p = 0.022$ respectively.

Because results were statistically significant, post hoc comparisons (pairwise) were conducted to further investigate the level of significance for the interaction of time and group. There were no outliers in the data as assessed by inspection of a boxplot. Group scores for pre and posttest were normally distributed as assessed by Shapiro-Wilk's test ($p > 0.05$), and there was homogeneity of variances as assessed by Levene's test for equality of variances ($p = 0.987$). The pairwise comparison revealed a significant change overtime from pretest to posttest in the experimental group, $M = 0.597$, 95% CI [0.276, 0.919], $p = 0.001$; however change overtime for the comparison group was not significant, $M = 0.120$, 95% CI [-0.125, 0.364], $p = 0.325$. Results suggest students receiving culturally responsive science instruction exhibited significantly more interest in STEM careers compared to their peers who did not receive my instruction and curriculum.

Qualitative Results

Quantitative data indicated a significant main group effect where students in the experimental group had significantly more interest in science after receiving culturally responsive instruction. Likewise, results indicated a significant change overtime from pretest to post in the experimental group's interest in STEM careers. This result suggested that students receiving culturally responsive science instruction showed significantly more interest in STEM careers than those students in the comparison group. Therefore to gain a more in-depth understanding of the impact of a culturally responsive approach on students' interest in science and STEM careers, qualitative data in the form of focus group interviews and student's science journals were coded and analyzed. As the main sources of data, science journals and focus group interviews serve to provide a more

detailed perspective and explanation of the quantitative results through the voice of the participants. As previously mentioned, focus group interviews were conducted only with students in the experimental group. Similarly, science journals were provided to and collected from only students in my class.

The qualitative data was coded and analyzed for patterns and themes suggestive of students' interest in science and STEM careers. Two significant themes emerged from the data to address the research question: 1) guest speakers of Color and 2) knowledge for future aspirations. This section describes students' interests in science and STEM careers under the headings of guest speakers of Color and knowledge for future aspirations.

Guest Speakers of Color

Recall the quantitative data suggested students receiving culturally responsive science instruction had significantly more interest in STEM careers compared to their peers who did not receive my instruction and curriculum. Here the qualitative findings help to explain the quantitative data in regard to students' interest in STEM careers, and provide insight and depth revealing what specifically resonated most and resulted in the changes students exhibited regarding their interest in STEM careers. The most significant science learning experience that students shared receiving which resulted in the greatest and most profound impact on their interest in STEM careers was Lab out Loud. Lab out Loud was a critical component of the culturally responsive science curriculum as it provided students the opportunity to engage in and interact with African Americans in STEM related careers. Most students documented in their science journals the impact the Lab out Loud presentations and speakers had on their interest in science as well as STEM careers. One student shared:

> Till [until] now like we never had guests that came in that were African American. I see how far they have gotten and have done and I see [realize] that I have more opportunities like that for me to do stuff. We're coming up as a culture, basically. You know like a speaker came in and she was a scientist, ah, one was an engineer, and another a dentist and it was like it opened my eyes up to like what we are doing [learning] now and what I can be and what I can do [become].

Likewise, another student wrote,

> The Lab out Loud presentations helped me to see that people of Color can excel in science just as much as White and Asian people. Having African Americans share their careers with me made me feel like a rising successful African American. They showed me I could do it too.

Similarly, another student shared,

> The Lab out Loud sessions helped me understand the amount of work and focus that you need to be successful. Science isn't just about chemicals and labs, it also helps out in the medical field to make the world a better place. These sessions also taught me that trial and error is an important part of improving something. The African American speakers made me feel like there is actually more diversity in certain fields. Usually you always see a White man in these fields but this has proven that not all majors are taken over by White people and there are intelligent African Americans in the field of STEM.

The feelings, emotions, and reactions students shared about the Lab out Loud presentations was critically important and reveal the overall significance of students self-

identifying with STEM careers and science learning through professionals of Color. For a number of students, this was the first time they had seen and/or interacted with someone who was a biomedical scientist, pediatric dentist, or civil engineer of Color. Moreover, the empowerment students shared feeling was remarkable, as it was clear that some students may have felt and/or believed that STEM was not for students like them. After the Lab out Loud presentations, students reported feeling "great" saying they felt "encouraged" and "inspired" to follow their dreams, one student shared "if I keep my hopes high I can make it far." Here findings reveal a larger more profound truth about what students learned, gained, and experienced from speakers of Color sharing their stories, knowledge, and expertise. In addition to students sharing the positive impact the Lab out Loud presentations had on their interest in science and STEM careers, a significant number of students indicated thoughts and feelings suggestive of empowerment, transformation, validation and affirmation. Empowerment, transformation, validation and affirmation are just a few of the culturally responsive student outcomes. A more in-depth discussion of these outcomes are addressed below in the section titled other relevant findings.

Knowledge for Future Aspirations

A second important theme that emerged to address students' interest in science and STEM careers was knowledge for future aspirations. Knowledge for future aspirations refers to the belief held by students that the science instruction received, and the science learning experiences provided were all usefully relevant in their future science classes and/or careers. One student shared,

> What I have learned this summer will help prepare me for the future because now I am already two steps ahead. I'm sure that when I get to college I'll have to do a dissection. Without Ms. Brittany's class I never would have known how to do one. Now I'm prepared for that. Also, I'm prepared for the science class I'll take next school year.

A number of students shared beliefs of similar sentiment as another student wrote, "I will use what I have learned about DNA, chemical bonds, and chemistry in my next science class. This summer class has helped me understand and like science more."

Likewise another student said, "Everything we learned this summer made me want to keep learning science." Student responses highlight the importance and overall significance of learning science in a culturally responsive way. Providing students the opportunity to learn science utilizing a culturally responsive approach had a positive impact on their interests in science and STEM careers. Moreover, students shared beliefs suggesting what they learned during the summer program, expands beyond the summer program and will "*boost*" and/or provide them "*a head start*" in future science classes, careers, and in life. One student wrote, "What I learned this summer inspired me to become a civil engineer. In life I will strive to become a civil engineer and learning about rats, chemical reactions, and genetics will help me get there."

Additionally, a number of students shared the importance and overall value of summer learning, expressing – "Over the summer most people like take a break from learning and everything and they go back to school and don't really prepare – it takes them a while to get back into the process of learning."

Here, a student expresses the importance of avoiding summer learning loss by attending a summer learning program. It was interesting to note that a number of students recognized both the impact and result of attending the summer science class as many described it as affording them an "*advantage*,"

> While I'm here with Ms. Brittany it's more like we do stuff that you wouldn't normally do in your [school] classroom because of the funds and the responsibility of the teacher. In my [school] science lab you would never dissect nothing. We wouldn't go on field trips, so like, I see this [summer class] as a bigger advantage because I had never been to a science lab till this year, like ever.

Although a majority of the students said the summer science class was advantageous to current and future learning, one student candidly shared that what she has learned does not have anything to do specifically with her future career, however "being in the summer science class makes me wanna learn more, cause it's interesting now." Through the voice of the participants, qualitative findings reveal and provide a rich description and holistic understanding to explain specifically what impacted students' interests in science and STEM careers.

Summary

The quantitative results suggest students receiving culturally responsive science instruction had significantly more interest in science as well as an interest in STEM careers. To holistically gain an understanding of the nature of the significance, students were interviewed about their summer science learning experiences and asked to document their science learning journey. Student responses and reflections insightfully informed the research question by addressing specific types of science learning

experiences that had the greatest overall impact on students' interests in science and STEM careers. Qualitative results revealed not all science learning experiences are created equal, as students respond best to culturally responsive speakers and knowledge for future aspirations. Providing students an opportunity to learn with and engage in science with speakers of Color proved beneficial and allowed students to experience, understand, and make connections to science interests. Teaching science utilizing a culturally responsive approach is not about conventional routine or doing what is familiar; but rather making the familiar strange and the strange familiar by investing time to know and understand your students, the cultures in which they embody, and the communities in which they live. Here, culturally responsive science instruction helped students to foster a more positive interest in science and STEM careers as it provided the opportunity to do and learn science in a meaningful and relevant way.

Research Question 3: What is the impact of a culturally responsive approach on student understandings of basic science content knowledge in a summer program?

Student understandings of basic science content was assessed using a pre/post science content assessment (Appendix C). The science content assessment was constructed by myself, the teacher and researcher, as all assessment questions were obtained from the American Association for the Advancement of Science (AAAS) Assessment Test Bank. The science content assessment consisted of fifteen multiple choice items as questions were selected to measure student's science content knowledge of course material after receiving culturally responsive science instruction before and

after participation in the science course. Assessment questions measured student's content knowledge in three areas – the life sciences, physical science, and the nature of science. It is important to note the pre/post science content assessment was only administered to students in the experimental group. Table 5.5 summarizes the descriptive statistics for student's pre-test and posttest results of a culturally responsive approach on student understandings of basic science content knowledge. Results indicate that after receiving culturally responsive science instruction, student's scores on the science content assessment were higher (*M* = 0.9755, *SD* = 0.0448) than before receiving culturally responsive science instruction (*M* = 0.5991, *SD* = 0.1637).

Table 5.5. Descriptive statistics for pre-test and posttest: Science content knowledge

	N	*M*		*SD*	
		Pre	Post	Pre	Post
Experimental Group	11	0.599	0.976	0.164	0.045

A paired-samples t-test was used to determine whether there was a statistically significant mean difference between students' pre-test and posttest scores before and after receiving culturally responsive science instruction. There were no outliers as assessed by boxplot inspection. The assumption of normality was not violated as assessed by Shapiro-Wilk's test ($p = 0.342$). Student scores on the post science content assessment was higher (*M* = 0.976, *SD* = 0.045) after receiving culturally responsive science instruction as opposed to before culturally responsive science instruction (*M* = 0.599, *SD* = 0.164), a statistically significant mean increase of 0.376, 95% CI [0.266, 0.487], t (10) = 7.610, $p < 0.001$. Quantitative results indicated a significant change from pretest to

posttest in student's science content assessment scores. This result suggests that after students received culturally responsive science instruction their science content assessment scores significantly increased overtime.

Other Relevant Findings

The theoretical perspective from which this study was framed was culturally responsive/relevant pedagogy. Although both culturally responsive and culturally relevant pedagogy is based on a two-part paradigm, tenets for the teacher and outcomes for students, this study focused specifically on student outcome measures. As stated in chapter three, both culturally responsive/relevant frameworks were merged for the purpose of this study as both frameworks serve as a lens to view this work. The student outcome measures for culturally responsive pedagogy was quantitatively assessed using the Culturally Responsive Science Assessment (Appendix B). The assessment was a 21-item Likert scale measure that aligned with culturally responsive pedagogy and consisted of three questions for each of the following six categories: validating and affirming, comprehensive, multidimensional, empowering, transformative, and emancipatory. The Culturally Responsive Science Assessment evaluated student outcome measures and revealed a moderate to high level of internal consistency as determined by Cronbach alphas of 0.500 (validating and affirming), 0.593 (comprehensive), 0.833 (multidimensional), 0.798 (empowering), 0.741 (transformative), and 0.713 (emancipatory). Each category was measured and assessed on a five point scale ranging from 5 – strongly agree, 4 – disagree, 3 – undecided/uncertain, 2 – agree, to 1 – strongly agree. Table 5.7 summarizes the descriptive statistics for both the experimental group

and comparison group. As previously stated, due to the numeric order associated with the Likert-scale used in this study, lower values (i.e., means) were desired. Based on the data in Table 5.6, students in the experimental group were more validated and affirmed, empowered, transformed, emancipated, comprehensive and multidimensional after receiving culturally responsive science instruction compared to their peers. Conversely, the data indicated that students in the comparison group became less validated and affirmed, empowered, transformed, emancipated, and comprehensive after receiving science instruction.

Table 5.6. Descriptive statistics for experimental and comparison groups' culturally responsive student outcome measures

Groups	N	Validating & Affirming				Comprehensive				Multidimensional			
		M		*SD*		*M*		*SD*		*M*		*SD*	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Experimental Group	11	2.727	2.121	0.828	0.583	2.212	1.879	0.820	0.4778	2.121	2.091	0.958	0.518
Comparison Group	19	2.719	2.842	0.448	0.905	2.211	2.351	0.621	0.698	2.526	2.386	0.849	0.803

Groups	N	Empowering				Transformative				Emancipatory			
		M		*SD*		*M*		*SD*		*M*		*SD*	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Experimental Group	11	2.273	2.152	0.929	0.689	2.121	1.697	0.807	0.433	2.121	1.909	0.958	0.560
Comparison Group	19	2.526	2.597	0.780	0.907	2.246	2.404	0.815	0.644	2.211	2.281	0.989	0.631

To investigate if there were any significant differences overtime in the pre and posttest (within-subjects factors) and between the two groups, experimental and comparison (between-subjects factors) and to assess if there were any interactions between time and group, a series of one-way repeated measures analysis of variance (ANOVA) were performed for each of the six student outcome measures – validating and affirming, comprehensive, multidimensional, empowering, transformative, and emancipatory. There were no outliers and the data was normally distributed at each time point as assessed by boxplot and Shapiro-Wilk's test ($p > 0.05$) respectively. There were a total of six measures assessed by repeated measures ANOVA – for efficiency, Table 5.7 highlights the results of the repeated measures ANOVA via Wilk's Lambda for each of the six outcome measures. The repeated measures ANOVA results did not indicate statistical significance for any of the six student outcome measures overtime, pre-test to posttest. However, there was a statistical significance in the interaction of time and group for two of the six student outcomes – validating and affirming, Wilks' Lambda = 0.828, F (1, 28) = 5.827, $p = 0.023$ and transformative, Wilks' Lambda = 0.817, F (1, 28) = 6.268, $p = 0.018$. The significant interactions suggest that change in score for validating and affirming and transformative was interacting with group.

Because results were statistically significant, post hoc comparisons (pairwise) were conducted to further investigate the level of significance for the interaction of time and group for validating and affirming and transformative outcomes. There were no outliers in the data as assessed by inspection of a boxplot. Group scores for pre and posttest were normally distributed as assessed by Shapiro-Wilks' test ($p > 0.05$), and there was homogeneity of variances as assessed by Levene's test for equality of variances for

both validating and affirming and transformative outcomes (p = 0.272, p = 0.834) respectively. For validating and affirming, post hoc results indicated a significant change overtime from pretest to posttest in the experimental group, M = 0.606, 95% CI [0.114, 1.098], p = 0.018; however change overtime for the comparison group was not significant, M = 0.123, 95% CI [-0.252, 0.497], p = 0.507. Likewise, transformative pairwise results indicated statistical significance overtime from pretest to posttest in the experimental group, M = 0.424, 95% CI [0.045, 0.803], p = 0.030; however change overtime for the comparison group was not significant, M = 0.158, 95% CI [-0.131, 0.446], p = 0.272. Results suggest students receiving culturally responsive science instruction were significantly more validated and affirmed and transformed compared to their peers. Simply, this result suggests that students were able to see themselves represented in the curriculum and recognize their own strengths; as a result they were more validated and affirmed in and transformed by, their learning.

It is important to mention, there was a moderately significant main group effect for one of the six student outcome measures – transformative, F (1, 28) = 2.988, p = 0.095. This result indicates that students in the experimental group (M = 1.697, SD = 0.433) felt more transformed in their learning after receiving culturally responsive science instruction compared to those in the comparison group (M = 2.404, SD = 0.644).

Table 5.7. One-way repeated measures ANOVA (Wilks' Lambda) results for the culturally responsive student outcome measures.

Culturally Responsive Outcome	Value	*F*	df	*p*
Time (n = 30)				
Validating and Affirming	0.916	2.562	1	0.121
Comprehensive	0.981	0.533	1	0.471
Multidimensional	0.982	0.524	1	0.475
Empowering	0.999	0.038	1	0.848
Transformative	0.955	1.312	1	0.262
Emancipatory	0.992	0.239	1	0.628
Time * Group (Interaction; n = 30)				
Validating and Affirming	0.828	5.827	1	0.023*
Comprehensive	0.897	3.212	1	0.084
Multidimensional	0.992	0.218	1	0.644
Empowering	0.981	0.528	1	0.473
Transformative	0.817	6.268	1	0.018*
Emancipatory	0.967	0.947	1	0.339
Group (n = 30)				
Validating and Affirming	-	2.515	1	0.124
Comprehensive	-	1.206	1	0.282
Multidimensional	-	1.542	1	0.225
Empowering	-	1.471	1	0.235
Transformative	-	2.988	1	0.095**
Emancipatory	-	0.718	1	0.404

df: degree of freedom; * $p < 0.05$; ** moderate significance ($p < 0.10$).

Summary

Quantitative results for culturally responsive student outcomes support the findings for research questions one, two, and three in several ways. First, the quantitative results for culturally responsive student outcomes speak to the authenticity of the data and provides evidence to support the significance of students' culture to learning science. The culturally responsive student outcome results provide depth and understanding to address *why* students in the experimental group had significantly more interest in science and STEM careers. Based on results, students in the experimental group felt more validated and affirmed and transformed by their science learning experiences. The science learning experiences that resonated most and resulted in the greatest impact on students' interests were highlighted in research questions one and two – Lab out Loud, culturally relevant lab-based field trips, the rat rap/poetry project and more. Results support that, for this group of students, in this particular summer science course, the aforementioned science learning experiences transformed, validated and affirmed students' interests in science and STEM careers.

Second, results corroborate the importance of culturally responsive and relevant teaching for ethnically diverse students and its positive impact on student academic achievement. The setting alone for this study highlights the diversity among participants and provided the optimum place for this work. Students shared in the qualitative portions of the data the importance of "doing" and learning science in a culturally meaningful and relevant way. Students in the experimental group were able to see themselves represented in the science content and curriculum and recognize their own strengths and abilities through Lab out Loud, critical reflection, and teacher-student interactions. As a result,

students were more validated and affirmed in and by their science learning and achieved academic success. Here findings reveal a larger more profound truth about what students learned, gained, and experienced from speakers of Color sharing their stories, knowledge, and expertise. In addition to students sharing the positive impact the Lab out Loud presentations had on their interest in science and STEM careers, a number of students described feeling empowered, validated and affirmed and transformed. Culturally responsive [science] teaching requires that a teacher look beyond self and sometimes their comfort zone to discover, locate and find those type of learning experiences that students need most. However to achieve this, the teacher must be aware of and familiar with the culture and community of their students.

CHAPTER 6

DISCUSSION OF RESULTS AND IMPLICATIONS

If not us, then who?
If not now, then when?

(John Lewis, U.S. Congressman)

The purpose of this study was to examine the impact of a culturally responsive approach during a summer learning program on students' attitudes, interests in science and STEM careers and basic science content knowledge. Applying critical action research and case study methodologies, I demonstrated that a culturally responsive/relevant approach to summer science learning increases and positively impacts students' attitudes, interests in science and STEM careers and science content knowledge. In this final chapter, I reiterate the study's findings, make explicit connections to the literature and provide implications for future practice and research.

Implications of a Culturally Responsive Approach on Student Attitudes

The study began by examining the impact of a culturally responsive approach in a summer learning program on students' attitudes toward science. Students' cultural beliefs and practices are oftentimes at odds with Western science; therefore, effective science instruction should seek to provide students the opportunity to bridge and connect their home cultures with the culture of science (Aikenhead & Jegede, 1999; Gao &

Watkins, 2002; Lee & Luykx, 2006). Culturally responsive/relevant teaching establishes a bridge between students' home and school experiences by acknowledging students' cultural heritage and ethnic backgrounds (Gay, 2000; Ladson-Billings, 2009). Culturally responsive/relevant teaching reaches and teaches the *whole* child as it demonstrates that academic achievement is just as important as maintaining one's cultural identity and heritage. Gay (2000) posited that culturally responsive pedagogy validates and affirms, liberates, empowers, and transforms ethnically diverse students by "simultaneously cultivating their cultural integrity, individual abilities, and academic success" (p. 46). Likewise, Ladson-Billings (1995) suggested that culturally relevant teaching meet three criteria: "an ability to develop students academically, willingness to nurture and support cultural competence, and the development of a sociopolitical or critical consciousness" (p. 483). Research supports and advocates the use of culturally responsive and relevant [science] teaching in formal educational environments; however few studies address the impact of this instructional approach in informal learning spaces. Utilizing a mixed methods approach both quantitative and qualitative data were obtained to gain a holistic understanding of the research phenomena. Quantitative results indicated that students in the experimental group had a more positive attitude toward science after receiving culturally responsive science instruction. Alternatively, students in the comparison group had a more negative attitude toward science. To further engage the research question and to gain a more in-depth understanding of what specifically contributed to students' attitudinal changes, qualitative data in the form of focus group interviews and students' science journals were analyzed. During the focus group interviews students engaged in candid conversations and critical dialogue regarding their science learning experiences.

Three predominant themes emerged from the data that lend support to address students' change in attitudes toward science – science learning experiences, science disappointments, and teacher attitudes and beliefs.

In the focus group interviews students explicitly described distinct differences between their formal science learning experiences and those provided during the summer science course. Students emphasized the importance and value of opportunities to engage in and learn science by "doing" science, utilizing a hands-on investigative learning approach. Focus group interviews detailed specific types of science learning experiences that resonated most and resulted in the greatest impact on students' attitudes toward science – rat dissection, rat rap/poetry project, Lab out Loud, science field trips, and more. For many students, formal science learning consists of "boring lectures, science packets, and busy work" as these type of science learning experiences are not meaningful or relevant to students. Qualitative results indicated that providing students an opportunity to learn science by doing science was important because in formal learning spaces, a number of students were denied or not provided the opportunity to learn science in a hands-on and meaningfully relevant way. The overall importance of learning science by "doing" science, cannot be overstated. The literature offers strong evidence that support science teaching utilizing laboratory, investigative and hands-on instruction to positively influence students' attitudes toward science and achievement (Freedman, 1997; Gardner, 1995; Gunsch, 1972). Therefore instruction that makes science more exciting and encourages students (e.g., dissections, laboratory based field trips, etc.) has a positive influence on students' attitude toward science and their academic achievement (Freedman, 1997). Findings are also consistent with the literature

in that situating science teaching and learning activities in conjunction with students' home knowledge, experiences, values, and cultural perspectives help students develop a positive attitude toward learning [science] (Wlodkowski & Ginsberg, 1995). Likewise, alternative forms of assessment (i.e. rat rap) may also prove beneficial for some students and help facilitate a more in-depth learning experience (Gay, 2000; Wlodkowski & Ginsberg, 1995). Here findings emphasize the importance of teachers incorporating culturally responsive and kinesthetic/hands-on science learning as such positively impacts, supports, and encourages students' attitudes toward science and academic achievement.

A second important theme that emerged from the data that provided insight to address students' change in attitudes toward science, was the concept of science disappointments. Students shared a number of situations and scenarios from their formal schooling experiences where they were promised a particular type of science learning (e.g., experiments, field trips) and it was not provided. Students also shared instances from their formal schooling where they would begin a project and/or experiment but were unable to complete the work. When students were asked why they did not complete their project(s), most said their teachers told them "*they [the student(s)] had messed it up*" – the teacher(s) failed to provide an explanation, justification or rationalization as to why. In *Diversity and Motivation*, Wlodkowski and Ginsberg (1995) document the notion of the blame cycle, detailing the act of blaming releases three highly desirable states of consciousness – 1) sense of control over the situation, 2) reduction of guilt, and 3) the idea and notion that we do not have to change. Although we do not know the teachers' accounts and do not wish to speculate or postulate the daily classroom decisions of these

individuals, student disappointments in science can be contextualized within the blame cycle as the teacher oftentimes blamed the student(s) for failed work and attempts. Science learning disappointments are important as it provides a foundation to understand some of the actions and events that have negatively affected, influenced and defined students' (formal) science learning experiences and attitudes toward science.

The third important theme that emerged from the data that provided insight to address students' attitudinal changes toward science was teacher attitudes and beliefs. The science teacher education literature extensively documents teacher attitudes toward science and science teaching as factors that significantly impact students' science achievement, attitude, interest in pursuing science education, and overall scientific literacy (Brittner & Pajares, 2006; Pasley, Weiss, Shimkus, & Smith, 2004; Turkmen, 2008). In the focus group interviews, students shared that teachers at school "yell and talk down" to them, is "negative" towards them and gives "mean side comments in class." Comparing their formal science learning experience and the summer science course, one student shared, "Ms. Brittany doesn't like just yell as us – say if somebody make her mad, she doesn't get an attitude and then just shut down the whole class period, you know, to do bookwork..." Similarly another student commented, "Ms. Brittany doesn't like talk down to you like the other teachers… [She] don't make you feel stupid and act like she know everything or say oh it's easy you should know that…" Wlodkowski and Ginsberg (1995) shares, "language is perhaps the strongest influence on whether or not a learner believes that what is happening in the classroom is relevant to his or her own beliefs, needs, and interests" (p. 114). Here students describe how their formal science teachers' language and classroom environments epitomize and impart

feelings of incompetence, helplessness, negativity, and a lack of enthusiasm and support. The behavior, attitudes and beliefs of the teachers, in this particular instance is problematic, as students, especially from traditionally marginalized and underrepresented groups should be encouraged, supported, and inspired in their science classrooms. The negative and unsupportive concerns students reported regarding formal science teaching and learning is reflective of their formal science learning experiences, and specifically highlights how poor attitudes and beliefs of the teacher, negatively impacted their (the students) attitudes toward science and resulted in the changes presented in this study.

Prior research suggest that teachers' negative attitudes and beliefs toward science and science teaching, which have been attributed to their negative K-12 science experiences (Appleton, 2006; Kelly 2000), may present major challenges in their teaching of science and/or ability to do so effectively (Kazempour, 2014). Therefore in order to prevent the continued perpetuation of a cycle of students that dislikes science and has a negative attitude toward science, in part due to their teachers' negative attitudes and beliefs and teaching practices (Siegel & Ranney, 2003), effort must be taken and properly invested in instructional strategies such as culturally responsive/relevant teaching, as it will help teachers to foster a positive attitude toward science that is reflected in their teaching of science.

Implications of a Culturally Responsive Approach on Student Interests

Culturally responsive/relevant teaching advocates the alignment of teaching styles with diverse learning styles as a way to bridge students' culture with learning (Gay, 2000, Ladson-Billings, 2009). Yet the literature is scant on the impact of a culturally

responsive/relevant teaching approach in an informal science learning environment, specifically as it relates to students' interest in science and STEM careers. Therefore to gain an understanding of the impact of a culturally responsive approach in a summer learning program on students' interests in science and STEM careers both quantitative and qualitative data were collected and analyzed. Quantitative findings indicated students receiving culturally responsive science instruction had more interest in science as well as an interest in STEM careers. To investigate if there were any significant differences overtime in the pre and posttest and between the two groups, experimental and comparison, and to assess if there was an interaction between time and group, a one-way repeated measures ANOVA was performed for interest in science and interest in STEM careers.

The one-way repeated measures ANOVA results for students' interest in science did not indicate statistical significance from pre-test to posttest. Likewise there was no statistically significant interaction between time and group. However, there was a significant main group effect ($p = 0.029$). The significant main group effect suggested that students' interest in science for the experimental group was significantly different from students in the comparison group. Simply, students in the experimental group had more interest in science after receiving the culturally responsive science curriculum than students not receiving my curriculum and instruction.

The one-way repeated measures ANOVA results for students' interest in STEM careers suggested statistical significance in time, from pre-test to posttest ($p = 0.001$). Likewise, there was also a significant difference in the interaction of time and group ($p = 0.022$). To further investigate the level of significance in students' interest in STEM

careers, post hoc comparisons were conducted for the interaction of time and group. Pairwise comparisons revealed a significant (p = 0.001) change overtime from pretest to posttest in the experimental group, however the change overtime for the comparison group was not significant (p = 0.325). Collectively these results suggest that students receiving culturally responsive science instruction in a summer learning program significantly increases students' interest in science and STEM careers. Quantitative results indicate and suggest that culturally responsive science instruction in a summer learning program significantly and positively impacts students' interest in science and STEM careers. However results do not specify or detail which aspects of the culturally responsive science curriculum had the greatest impact on students' interests and why. Thus to gain a more in-depth understanding of which aspects of the culturally responsive science curriculum engaged and impacted students' interest in science and STEM careers, qualitative data in the forms of focus group interviews and students' science journals were coded and analyzed. In their science journals and the focus group interviews students openly shared through critical reflection and dialogue their summer science learning experiences and which resonated most with them. Two important themes emerged from the data that provide insight to understand which aspects of the culturally responsive science curriculum had the greatest impact on students' interest in science and STEM careers – guest speakers of Color and knowledge for future aspirations.

The most significant science learning experience students shared receiving which resulted in the greatest and most profound impact on students' interest in STEM careers, was Lab out Loud. Lab out Loud was a critically important component of the culturally responsive science curriculum as it provided students the opportunity to engage in and

interact with African American professionals in STEM related careers from their community. One of the underlying goals of Lab out Loud was to provide students an opportunity to see themselves in the curriculum and to self-identify with science through professionals of Color so that they may envision their own academic success in science education and STEM careers. One student shared, “The Lab out Loud presentations helped me to see that people of Color can excel in science just as much as White and Asian people…They showed me I could do it too.” Likewise, another student commented, “Having African Americans share their careers with me, made me feel like we can do any career we choose to do as African American people…I can do anything I want to.” The literature offers strong evidence to support the importance and value of learners seeing, interacting, and engaging with people similar to themselves (in age, gender, ethnicity, culture, class, etc.) in and within their communities (in science) as this enhances and increases their self-confidence and abilities to self-identify (Bandura, 1982; Gay, 2000; Ladson-Billings, 2009; Lee & Luykx, 2005, 2006, 2007; Wlodkowski & Ginsberg, 1995). Wlodkowski and Ginsberg (1995) positions, “people that learners can identify with convey information more likely to be relevant to the perspectives and values of the learners themselves. This further increases the learners’ trust in using the strategies being seen or suggested” (p. 128). Moreover, teaching and learning activities contextualized within the learner’s experience and previous knowledge that is accessible through their current thinking and ways of knowing helps develop a positive attitude toward and interest in (science) learning (Wlodkowski & Ginsberg, 1995). Here findings corroborate what others in the literature have stated and adds to this body of evidence that

interest in STEM careers can be influenced in a summer learning program utilizing a culturally responsive instructional approach.

The second important theme that emerged from the data that provided insight to address students' interest in science and STEM careers was knowledge of future aspirations. To reiterate, knowledge for future aspirations refers to the belief held by students that the science instruction received, and the science learning experiences provided were all usefully relevant in their future science classes and/or careers. Many students shared the importance of their science learning experiences, expressing what they learned in the summer science course would "help prepare them for the future" and would provide a "*head start*" in the their upcoming science courses. Also, some students shared how they felt the summer science course prepared them for college level coursework, stating, "I'm sure that when I get to college I'll have to do a dissection. Without Ms. Brittany's class I never would have known how to do one…" Collectively results highlight the overall relevance, application, and importance of the curriculum to the student's lives as they were able to connect to and through their summer science learning experiences. Moreover results indicate that culturally responsive science instruction helped students to foster a more positive interest in science and STEM careers as it provided students the opportunity to engage in science learning experiences and scientific practices in meaningfully relevant ways.

Implications of a Culturally Responsive Approach on Student Content Knowledge

In formal learning spaces, research suggests that culturally responsive/relevant teaching increases academic achievement and learning outcomes for culturally,

ethnically, linguistically and diverse students (Au, 2007; Gay, 2000; Ladson-Billings, 2009; Lee & Luykx, 2006). However the research literature is scarce, and does not offer much to address the impact of a culturally responsive science approach in an informal learning environment. Thus to understand the impact of a culturally responsive approach on students' basic science content knowledge, quantitative data in the form of pre and post science content assessments were analyzed. Results indicated that after receiving culturally responsive science instruction, students' scores on the science content assessment were higher (M = 0.9755, SD = 0.0448) than before instruction (M = 0.5991, SD = 0.1637). To determine if the differences between means were significant, a paired-samples t-test was conducted. The paired samples t-test results indicated a significant change from pretest to posttest ($p < 0.001$). This result suggests and supports the research literature on culturally responsive/relevant teaching in that culturally responsive science instruction significantly increases student science academic achievement. This study adds to the culturally responsive/relevant body of literature that utilizing a culturally responsive instructional approach in an informal learning space may increase students' science achievement, especially students from ethnically and culturally diverse backgrounds.

Other Relevant Findings

To further engage the research questions and to gain a more in-depth understanding of the impact of a culturally responsive approach in an informal learning space, I analyzed each culturally responsive student outcome measure – validating and affirming, empowering, transformative, comprehensive, multidimensional, and

emancipatory. Results revealed students in the experimental group were more validated and affirmed, empowered, transformed, emancipated, comprehensive, and multidimensional after receiving culturally responsive science instruction. On the other hand, results suggested students in the comparison group were less validated and affirmed, empowered, transformed, emancipated, and comprehensive after receiving science instruction. To investigate any statistically significant differences overtime, within-subjects factors and between-subjects factors, a one-way repeated measures ANOVA was conducted for each culturally responsive student outcome measure. Analysis revealed a statistical significance in the interaction of time and group for two of the six culturally responsive student outcomes – validating and affirming ($p = 0.023$), and transformative ($p = 0.018$). To further examine the significance of the interaction of time and group, post hoc comparisons for validating and affirming, and transformative outcomes were performed. Post hoc results revealed a significant change for validating and affirming outcomes overtime, from pretest to posttest, in the experimental group ($p = 0.018$), however change overtime for the comparison group was not statistically significant ($p = 0.507$). Similarly, the transformative outcome post hoc results indicated statistical significance overtime in the experimental group ($p = 0.030$), however change overtime for the comparison group was not significant ($p = 0.272$). Results suggest students receiving culturally responsive science instruction were considerably more validated and affirmed and transformed by their science learning experiences compared their peers. Students in the experimental group were able to see themselves represented in, by and through the science curriculum, recognize their own strengths and abilities, and

transform through their science learning to achieve academic success and cultural competency.

Results indicate validating and affirming and transformative student outcome measures were statistically significant for students in the experimental group. Here I further engage the research findings and address aspects of the culturally responsive science curriculum that impact these significant changes.

Gay (2000) defines culturally responsive (science) teaching as using the cultural knowledge, prior experiences, and performance styles of culturally, ethnically, and linguistically diverse students to impart learning. Likewise Gay (2000) posits culturally responsive teaching is validating as it has the following characteristics: it acknowledges the legitimacy of the cultural heritages of different ethnic groups, both as legacies that affect students' dispositions, attitudes, and approaches to learning and as worthy content to be taught in the (science education) curriculum; it allows students to build bridges and connections between home and school experience as well as between lived sociocultural realities; and it incorporates multicultural information, resources, and materials in course content (p. 29). The culturally responsive science curriculum developed and implemented in this study contributed to students' validation and affirmation as they were able to see themselves as well as their cultural heritages represented in the science curriculum. A key component of the culturally responsive science curriculum that sought to validate and affirm students through social and cultural awareness was Lab out Loud. As previously shared, each week students participated in Lab out Loud as it was a time of informal learning and discovery where students engaged in and interacted with African Americans in STEM-related careers through presentation or activity to celebrate and

recognize their own cultural accomplishments and achievement. Students shared in their science journals the impact and overall significance the Lab out Loud presentations had on them, as some students were able to envision themselves and self-identify, perhaps for the first time, with science, “Having African Americans share their careers with me made me feel like a rising successful African American. They showed me I could do it too.” Similarly another student wrote, “Having African Americans share their careers with me made me feel proud and like I can accomplish anything I want to.” Student responses reflect both validating and affirming outcome measures as students express knowledge of and reverence for their own cultural heritages. Students articulate feelings and emotions of “I can do it too” as they have exemplars from their own communities of African American success in STEM.

According to Gay (2000) culturally responsive teaching as transformative means respecting the cultures and experiences of various groups and utilizing these as a resource for (science) teaching and learning. Transformative instruction recognizes, values, and appreciates the existing strengths and accomplishments of all students and develops them further into instruction. Likewise, Banks (1991) states that if education is to empower underrepresented and marginalized groups, it must be transformative. Transformative means helping “students to develop the knowledge, skills, and values needed to become social critics who can make reflective decisions and implement their decisions in effective personal, social, political, and economic action” (p. 131). Several components of the culturally responsive science curriculum sought to encourage and support transformation; however an important aspect of the curriculum that was explicitly aimed to address transformation was Lab out Loud. Here Lab out Loud provided students

mirrors and windows to envision their own lives, academic success, and educational experiences as part of a larger cultural context, to acknowledge their own cultural contributions to STEM and to self-identify with science. After the summer science course, students receiving the culturally responsive science curriculum were able to articulate and recognize that, we are/I am science.

This work adds to the body of evidence that culturally responsive science teaching positively impacts students' science academic achievement, attitudes, interests in science and interest in STEM careers, with the additional idea that culturally responsive science teaching produces significant outcomes by validating and affirming and transforming students. Students shared the important impact they believed Lab out Loud had on their learning as many were able to self-identify with science, perhaps for the first time. Similarly, students expressed beliefs and positions of cultural competence and socio-political consciousness as many were able to recognize and articulate the overrepresentation of Whites and underrepresentation of people of Color in STEM. There are a number of studies on culturally responsive pedagogy, however far too little systematically documents the impact on student learning and explains which types of culturally responsive practices most strongly impact students (Sleeter, 2012). This study's findings is an attempt to address such inquiries.

Implications for Practice and Research

I conclude this dissertation thinking and reflecting about the implications for directors and administrators of summer learning organizations and programs as we work to provide equitable access to and opportunities in STEM education through summer

science learning programs. In an effort to improve and increase students of ethnically, culturally, and socially diverse backgrounds, culturally responsive/relevant teaching practices are strongly advocated. A vast body of literature exist that support the use and effectiveness of culturally responsive/relevant teaching in formal educational spaces (Gay, 2000; Ladson-Billings, 2009; Lee & Buxton, 2008; Lee & Luykx, 2005, 2006, 2007; Patchen & Cox-Petersen, 2008). However few mixed method studies exist that have examined the impact of a culturally responsive approach in an informal science learning environment. This work adds to this body of evidence that culturally responsive/relevant (science) teaching positively impacts student's academic achievement, attitudes toward science, and interest in science and STEM careers, with the additional idea that culturally responsive science teaching is an effective instructional approach in an informal science learning space. Consequently, the following implications are considered.

Summer Science Learning Experiences

This study highlights the overall importance and value of summer science learning programs as they can help mitigate summer learning loss and positively impact students' interest in science and STEM careers, attitudes toward science and academic achievement in science. Summer science learning offers a promising way of thinking about where science learning can occur and calls attention to summer learning initiatives. Summer learning programs can fill gaps in students' school-year learning as well as help to deepen and engage students' interest in and attitudes toward science education.

Culturally Responsive/Relevant Teaching in Formal Education

This study highlights the importance of and the lack thereof culturally responsive/relevant teaching practices in formal educational spaces. The literature documents strong evidence that support the use, implementation and effectiveness of culturally responsive/relevant teaching in formal education spaces for culturally, ethnically, and linguistically diverse students (Gay, 2000; Ladson-Billings, 2009; Lee & Buxton, 2008; Lee & Luykx, 2005, 2006, 2007; Patchen & Cox-Petersen, 2008), however the results of this study reveal formal classroom teachers may not be utilizing this instructional approach effectively, if at all. The importance of culturally responsive/relevant teaching cannot be overstated as this instructional approach helps students of historically marginalized and underrepresented groups achieve academic success and positive learning outcomes. This study advocates the inclusion and implementation of more culturally responsive/relevant teaching in K-12 formal science learning classrooms as this could potentially increase students' interest in and attitudes toward science, improve students' science academic achievement, and facilitate a more in-depth learning experience through cultural connections.

Future Research

The purpose of this study was to understand the impact of a culturally responsive approach on student attitudes, interests, and overall science learning during a summer learning program. Specifically, this study examined the impact of a culturally responsive approach on student attitudes, interests in science education and STEM career fields, and basic science content knowledge before and after participation in a summer science

course. Future studies should explore the impact of culturally responsive teaching during and across multiple summer science/STEM learning programs with larger sample sizes. There are many TRIO Upward Bound Summer Programs and it would be useful to look across sites and within courses to examine and evaluate the impact of a culturally responsive instructional approach on students' attitudes, interests, and content knowledge. I believe TRIO Upward Bound Programs are an optimal context and site for future research as such programs include ethically, culturally, and linguistically diverse student groups and vary by location and geographical region. Future research investigating the impact of culturally responsiveness in other informal science learning venues (e.g., zoos, after school programs, etc.) would also prove beneficial as growing evidence supports that informal science programs can feed and stimulate the science-specific interest of students and positively influence academic achievement and even expand students' interest and inclination of future science careers (Bell, Lewenstein, Shouse, & Feder, 2009).

The limited number of studies focused on the impact of culturally responsive/relevant science teaching, especially in an informal learning environment with students traditionally marginalized and underrepresented in STEM careers, justifies future studies in this area.

Conclusion

A foundation for culturally responsive and culturally relevant science teaching builds on debates around who benefits from science. Oftentimes, the promotion for more science and/or STEM education is masked in national defense or global economic competition (Laughter & Adams, 2012), "rather than genuine ethical actions devoted to

increasing the scientific competencies of students of Color, students acquiring English, and other traditionally underserved urban students" (Tate, 2001, p. 1018). Therefore an important reason for culturally responsive science teaching is not just for a greater diversity of scientists, but because we need scientists to have a conscience (Laughter & Adams, 2012): "A key distinction between scientific inquiry and culturally responsive/relevant science is the degree of emphasis on sociopolitical and critical analysis" (Boutte et al., 2010, p. 4). To effectively answer the call, *science for all*, new pedagogies and practices to teach science must be implemented. Results from this study suggest that a culturally responsive/relevant approach to summer science learning increases and positively impacts students' attitudes, interests in science and STEM careers and science content knowledge. This work adds to the body of evidence that culturally responsive science teaching positively impacts students' science academic achievement, attitudes, interests in science and interest in STEM careers, with the additional idea that culturally responsive/relevant science teaching produces significant outcomes as it validates and affirms, as well as transforms students through their science learning experiences. I believe utilizing a culturally responsive/relevant science teaching approach we can improve students of Color science academic achievement, mitigate summer learning loss, and effectively work to close the (science) academic achievement gaps.

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Appendix A

Invitation to Participate and Assent Form

Dear St. Paul College Upward Bound Parents,

My name is Brittany Garvin. I am a doctoral candidate in the College of Education Department at the University of South Carolina. I am conducting a dissertation study as part of the requirements for my degree and I would like to invite your student(s) to participate. The purpose of this study is to gain an understanding of student attitudes, interests and overall science learning through their participation in a summer learning experience. This study seeks to evaluate the impact of a culturally responsive approach on student attitudes, interests in science education and STEM career fields, and basic science content knowledge before and after their participation in the TRIO Upward Bound Program.

If you decide (to allow your child) to participate, you (your child) will be asked to complete a pre- and posttest survey assessment during the first and last week of the program, as well as two focus group interviews. The focus group interviews will focus on and relate to student attitudes, interests in science education and STEM career fields as well as K-12 science education learning experiences.

The focus group interviews will take place at a convenient location on campus and should last approximately 50 minutes. Focus group interviews will be audio recorded so that I can accurately reflect on what is discussed. The recordings will only be reviewed by me and those responsible for transcription.

You will not be required to answer any questions with which you are uncomfortable. Participation is confidential. Data gathered during the study will be kept in a secure location in my private office at the University of South Carolina. The results of the study may be published or presented at professional meetings, but your identity will not be revealed.

Taking part in the study is your decision. You do not have to be in this study if you do not want to participate. You may also quit at any time if you decide to participate. Participation, non-participation or withdrawal will not affect your grades in any way. I will be happy to answer any questions you have about the study.

Thank you for your consideration. If you would like to participate, please sign the attached form and return it to Brittany Garvin.

With kind regards,

Assent Form

Study Title: An Investigation of a Culturally Responsive Approach to Science Education in a Summer Program for Marginalized Youth

Researcher: Brittany Garvin

I have read the information contained in the letter about the above titled study, which describes what I will be asked to do if I decide to participate. My parent/guardian has given me permission to participate. I have been told that the decision is up to me, and that I do not have to participate, even if my parent/guardian says that it is okay. I have been told that I can stop participating at any time I choose, and no one will be mad at me.

□ Yes – I want to participate in the study.

-OR-

□ No – I do <u>not</u> want to participate in the study.

____________________________________ _________________
Student's Signature Date

______
Age

Appendix B

Culturally Responsive Science Assessment

Student Background Information
Name: ____
Gender: ☐ Male ☐ Female
Rising Grade Level: ☐ 9th ☐10th ☐11th ☐12th
Ethnicity (Nationality): *Please check **all** that apply*.
☐ African /African American
☐ American Indian/Alaskan Native
☐ Hispanic/Latino (Mexican, Spanish, Cuban, etc.)
☐ White (not of Hispanic origin)
☐ Other: ____________________________

There are no correct answers for the following questions. You are simply being asked your opinion. Indicate your true feelings, not what you think may be an answer that is expected. Circle the appropriate answer according to the scale below. ***It is important that all questions are answered by circling only <u>one</u> answer:***

1. **Strongly Agree**
2. **Agree**
3. **Uncertain**
4. **Disagree**
5. **Strongly Disagree**

Interest in Science					
	Strongly	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**
1. I get excited when watching science/medical related shows on TV that feature people that look and talk like me.	1	2	3	4	5
2. I like to connect what I learn in science to my life, family, and community.	1	2	3	4	5
3. Science class is boring and a waste of time.	1	2	3	4	5
4. I look forward to science class because I know my science teacher(s) care about my future success.	1	2	3	4	5
5. I like to share what I learn about science with my family and friends.	1	2	3	4	5
6. I am excited when African American culture is represented in what I learn in science class.	1	2	3	4	5
7. I like that my cultural contributions to science are shared and taught in my science classes.	1	2	3	4	5

Interest in STEM Careers	Strongly agree	Agree	Undecided/ Uncertain	Disagree	Strongly Disagree
1. I know an African American scientist and/or engineer from my neighborhood.	1	2	3	4	5
2. I know of someone in my family who uses science, technology, engineering and/or math in their career.	1	2	3	4	5
3. I am interested in careers that use science.	1	2	3	4	5
4. Science helps me feel good about myself and future career success.	1	2	3	4	5
5. A career related to science, technology, engineering and/or math would be dull and boring.	1	2	3	4	5
6. I believe a career in science can help transform and change the world.	1	2	3	4	5
7. Knowing and reading about successful African Americans in science and engineering inspires my interest in science and engineering careers.	1	2	3	4	5

Attitude toward Science	Strongly	Agree	Undecided/ Uncertain	Disagree	Strongly Disagree
1. I believe that science is relevant to my life.	1	2	3	4	5
2. Knowing science and how it relates to me and my community will give me a career advantage.	1	2	3	4	5
3. I like science because it is explained and taught using language and examples in which I can relate.	1	2	3	4	5
4. I like to do my own science experiments rather than to find out information from my teacher.	1	2	3	4	5
5. I dislike science class.	1	2	3	4	5
6. I like science class because it acknowledges cultural diversity.	1	2	3	4	5
7. I like that my science teacher(s) relate science lessons to my life.	1	2	3	4	5

Remember, there are no correct answers for the following questions. You are simply being asked your opinion. Indicate your true feelings, not what you think may be an answer that is expected.

1. In **3-5 sentences**, describe a **<u>good</u>** science teacher (e.g., personal characteristics, lessons/activities, etc.)

   ____
   ____
   ____
   ____

2. What type of **<u>positive</u>** science experiences have you had **<u>in school</u>**?

   ____
   ____
   ____

3. What type of **<u>negative</u>** science experiences have you had **<u>in school</u>**?

   ____
   ____
   ____

4. In **3-5 sentences**, share what would inspire and/or empower you to like science more or consider a career in science.

   ____
   ____
   ____

5. What grade do you usually make in science? **(*Select only one*)**

   ☐ Mostly As (around 90-100)
   ☐ Mostly Bs (around 80-90)
   ☐ Mostly Cs (around 70-80)
   ☐ Mostly Ds (below 70)
   ☐ Not Sure

Appendix C

Science Content Assessment

2014 Summer Upward Bound Program: Science Content Assessment

1. Which of the following is TRUE about blood?

    A. Blood both carries oxygen to cells and carries carbon dioxide away from cells.
    B. Blood carries oxygen to cells but does not carry carbon dioxide away from cells.
    C. Blood carries carbon dioxide away from cells but does not carry oxygen to cells.
    D. Blood does not carry oxygen to cells and does not carry carbon dioxide away from cells.

2. Red blood cells carry oxygen. Which of the following types of cells use oxygen carried by red blood cells?

    A. Both cells of the lung and cells of the rest of the body
    B. Cells of the lung, but not cells of the rest of the body
    C. Cells of the rest of the body, but not cells of the lungs
    D. Neither cells of the rest of the body nor lung cells

3. How do the sizes of models compare to the sizes of the objects they represent?

    A. Models can be bigger than the objects they represent, but they cannot be smaller.
    B. Models can be smaller than the objects they represent, but they cannot be bigger.
    C. Models can be bigger or smaller than the objects they represent.
    D. Models have to be the same size as the objects they represent.

4. Why might a chemist decide to make a model of a DNA molecule?

    A. To show other people what DNA looks like, and to help herself think about DNA
    B. To show other people what DNA looks like, but not to help herself think about DNA
    C. To help herself think about DNA, but not to show other people what DNA looks like
    D. Neither to show other people what DNA looks like nor to help herself think about DNA

5. Which type of molecule contains genetic information that is passed from parents to offspring?

    A. Fat molecules
    B. DNA molecules
    C. Protein molecules
    D. Carbohydrate molecules

6. How many different types of nucleotides are used to make DNA molecules?

    A. One type
    B. Two types
    C. Four types
    D. Twenty types

7. In sexually reproducing organisms, such as humans, which of the following statements is TRUE about the chromosomes found in the cells of the children?

    A. All of the chromosomes in the cells of the children contain genetic information from just one of the parents.
    B. Half of the chromosomes in the cells of the children contain genetic information from one parent, and half of the chromosomes contain genetic information from the other parent.
    C. Some of the chromosomes in the cells of the children contain genetic information from each parent, but the number of chromosomes containing information from each parent cannot be predicted.
    D. Most of the chromosomes in the cells of the sons contain genetic information from the father, and most of the chromosomes in the cells of the daughters contain genetic information from the mother.

8. Which of the following are functions of protein molecules in an animal?

    A. Protein molecules help cells carry out many of their functions, and they are part of body structures such as hair and nails.
    B. Protein molecules are part of body structures such as hair and nails, but they do not help cells carry out many of their functions.
    C. Protein molecules help cells carry out many of their functions, but they are not part of body structures such as hair and nails.
    D. Protein molecules do not help cells carry out many of their functions, and they are not part of body structures such as hair and nails.

9. The eye color of children often resembles the eye color of their parents. Which of the following is genetically passed from parents to children?

   A. Particles of color are passed from parents to children.
   B. Cells that become the colored part of the eye are passed from parents to children.
   C. Molecules that contain the information that determines eye color are passed from parents to children.
   D. Nothing having anything to do with eye color is passed from parents to children.

10. Which of the following contain hereditary information?

   A. Chromosomes and genes
   B. Chromosomes but not genes
   C. Genes but not chromosomes
   D. Neither chromosomes nor genes

11. Which of the following contain genetic information?

   A. Chromosomes and DNA molecules
   B. Chromosomes but not DNA molecules
   C. DNA molecules but not chromosomes
   D. Neither chromosomes nor DNA molecules

12. A cat gets into a fight, and the tips of both of its ears get torn off. If the cat has kittens later, how will this affect the shapes of its kittens' ears?

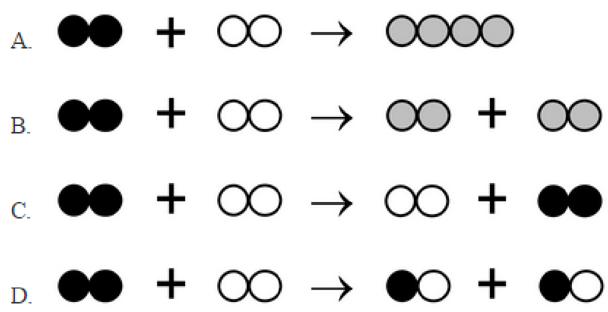
   A. All of the kittens' ears will be missing the tips.
   B. Some of the kittens' ears will be missing the tips.
   C. All of the kittens' ears will be slightly smaller.
   D. It will have no effect on the ears of any of the kittens.

13. Which of the following *always* results from a chemical reaction?

   A. Fire
   B. Bubbles
   C. A new substance that is a solid
   D. A new substance that can be a solid, liquid, or gas

14. Which of the following could represent a chemical reaction?

Atoms are represented by circles, and molecules are represented by circles that are connected to each other. The different colored circles represent different kinds of atoms.



15. Which of the following is an example of a chemical reaction?

A. A piece of wax melting and forming a liquid
B. A piece of chalk making white marks on a chalkboard
C. Bubbles of gas forming when a seashell is placed in vinegar
D. A powder dissolving in hot water to make hot chocolate

Appendix D

Focus Group Interview Protocols

<u>Pre</u> Focus Group Interview Protocol

Interviewer: <u>Constance Shepard</u>

Interviewees: <u>Upward Bound Students – □ Group 1 □ Group 2 ***(Check one)***</u>

Date of Interview: <u>Monday June 9, 2014</u>

Start – Time: ________

End – Time: ________

Welcome

Good morning and welcome to our session. Thanks for joining me today to talk about your science learning experiences. My name is Ms. Constance Shepard and I am from the University of South Carolina. The results of this interview will be used to assist Ms. Garvin with her dissertation research and to help her better understand the types of things that interest students in learning science. You all were selected to participate because each of you possess important knowledge about particular experiences that we hope to learn more about.

Guidelines

This is a focus group interview. There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we are just as interested in negative comments and experiences as positive comments and experiences.

You've probably noticed the microphone. We are tape recording the session because we do not want to miss any of your comments. Because we are tape recording, please be respectful of others – only one person should speak at a time.

Does anyone have any questions? …

Let's begin!

Warm Up Question

What are some things you hope to do and learn about this summer in science class?

Interview Questions

1. How do you define "science"?
    a. What does the word science mean to you?

(Probe for understanding)

2. How and when do you use science?

(Probe for understanding)

Check Time

3. Think back over all the years that you have taken science courses, participated in science activities, or attended science related events. What is your favorite and most enjoyable memory?

(Probe for understanding)

4. Tell me about disappointments (i.e. lessons, activities, field trips, methods of instruction) you have had in science.

(Probe for understanding)

Check Time

5. Who or what influences your decision to learn more about science?

(Probe for understanding)

Wrap Up Question

Think about what you want to do and become when you grow up. Who or what inspires your career interests and career goals?

<u>Post</u> Focus Group Interview Protocol

Interviewer: <u>Constance Shepard</u>

Interviewees: <u>Upward Bound Students – □ Group 1 □ Group 2 ***(Check one)***</u>

Date of Interview: <u>Monday June 30, 2014</u>

Start – Time: ________

End – Time: ________

Welcome

Good morning and welcome back to our final focus group interview session. Thanks for joining me today to talk about your summer science learning experiences. My name is Ms. Constance Shepard and I am from the University of South Carolina. The results of this interview will be used to assist Ms. Garvin with her dissertation research and to help her better understand the types of things that interest students in learning science. You all were selected to participate because each of you possess important knowledge about particular experiences that we hope to learn more about.

Guidelines

This is a focus group interview. There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we are just as interested in negative comments and experiences as positive comments and experiences.

You've probably noticed the microphone. We are tape recording the session because we do not want to miss any of your comments. Because we are tape recording, please be respectful of others – only one person should speak at a time.

Does anyone have any questions? …

Let's begin!

<u>Opening Question</u>

How was the Upward Bound Program this summer?

<u>Interview Questions</u>

1. In what way(s) was your summer science class different (in a positive way or negative) from your in school science classes?

(Probe for understanding)

2. What impact has your summer science class had on your interest in and attitude toward learning science?

(Probe for understanding)

Check Time

3. What impact has your summer science class had on your interest in science, technology, engineering, and math (STEM) careers?

    a. Think about what you want to do when you grow up. Who or what inspires your career interests and career goals?

(Probe for understanding)

4. Thinking back over all your experiences this summer with Ms. Garvin (i.e., field trips to USC, the hair and pig kidney lab, DNA and genetics lab, DNA modeling lab, Lab out Loud presentations, the sickle cell lab, the rat dissection and rat rap project) – what experience(s) meant the most, in terms of your own learning and why?

(Probe for understanding)

Check Time

5. In what way(s) do you believe your summer science class will help prepare you for the future (future careers, upcoming science classes, etc.)?

(Probe for understanding)

6. If you could change anything about your summer science experience, what would it be and why?

Appendix E

Rat Rap – Poetry Project Rubric

Rat Rap – Poetry Project Rubric

Assignment Details:

Your assignment is to make a song/rap/poem about the rat organs and their physiological functions below. You **do not** have to use all of the terms provided below, these are only provided to help get your juices flowing. Songs/raps/poems should include at **least 15** rat organs and functions. Use class notes and handouts to gather information (*if needed*). You may put your song/rap/poem to a tune of your choice or you may create your own beat. Your song/rap/poem can be a solo act or a group act up to no more than 3 members. The song/rap/poem must be **2-4 minutes**. Lyrics for your song/rap/poem **MUST** be turned in **PRIOR** to your performance (**1 submission per group**). You must write or type the lyrics legibly and neatly to turn in. You will be expected to present and/or perform your song/rap/poem to the class.

Grading Details:

Your peers, as well as I, will evaluate your song/rap presentation and provide a grade based on your performance. See **the rubric on the back of this page for grading guidelines.**

Rat Reflections

Each student is expected to turn in a single page written reflection based on their rat dissection and song/rap learning experience. In writing about your dissection and song/rap learning experience, students can use the following prompts:

- I learned ________
- I discovered ________
- I enjoyed _________
- I did not like _______
- Next time I will remember to _______

Diaphragm	Thoracic Cavity	Abdominal Cavity	Heart	Lungs
Kidney	Trachea	Left/Right Atrium	Stomach	Left/Right Ventricle
Liver	Aorta	Esophagus	Mesentery	Caecum
Small Intestine	Large Intestine	Spleen	Rectum	Anus
Pancreas	Urinary Bladder	Vas Deferens	Testes	Epididymis
Ovary	Vibrissae	Incisors	Pupil	Pinna / Tail

Song/Rap/Poem Grading Rubric

	4	3	2	1
Organs/Terminology Used	15 organelles are mentioned	Missing 5 of the organelles	Missing more than 5-10 organelles	Missing more than 10 organelles
Function of Organelles *Descriptions of each organelle. Analogy or other ways to help remember and accurately describe each reaction.*	The function of all organelles is clear.	Missing 5 of the functions	Missing more than 5-10 organelles	Missing more than 10 organelles
Creativity	The song/rap/poem contains many creative details and/or descriptions that contribute to the audience’s enjoyment. The composer(s) has really used their imagination.	The song/rap/poem contains a few creative details and/or descriptions that contribute to the audience’s enjoyment. The composer(s) has used their imagination.	The song/rap/poem contains a few creative details and/or descriptions, but they distract from the topic. The composer(s) has tried to use their imagination.	There is little evidence of creativity in the song/rap/poem. The composer(s) do not seem to have used much imagination.
Time	The song/rap/poem is 2 -4 minutes.	The song/rap/poem is 1-2 minutes.	The song/rap/poem is less than 1 minute.	The song/rap/poem does not meet the time requirement.