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Good Science Teaching in an Urban Middle School Context : An Examination of the Relationship Between Science Teachers and Their Students

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GOOD SCIENCE TEACHING IN AN URBAN MIDDLE SCHOOL CONTEXT: AN EXAMINATION OF THE RELATIONSHIP BETWEEN SCIENCE TEACHERS AND THEIR STUDENTS

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ABSTRACT

GOOD SCIENCE TEACHING IN AN URBAN MIDDLE SCHOOL CONTEXT: AN EXAMINATION OF THE RELATIONSHIP BETWEEN SCIENCE TEACHERS AND THEIR STUDENTS

By William J. Brown

Good science teaching within an urban middle school context was examined in this qualitative methods study. This research also examined what middle school science teachers prioritized in an urban science classroom and uncovered ways in which culturally responsive teaching showcased itself among inservice teachers. Good science teaching and culturally responsive teaching strategies have been investigated, but its impact on urban middle school science classrooms with marginalized students is where the research is minute.

The data from the study revealed that the following culturally responsive teaching strategies are prioritized to have an impact on marginalized students in urban middle school classrooms: a) Belief System, b) Academic Success, c) Learning about students, d) Understanding students 'ways of knowing, and e) Providing a sense of equity. Core to these strategies was a belief system that all students are capable learners regardless of students' learning ability, disposition toward science, and motivational ability. Additional findings revealed that middle school science teachers focused on their students' academic identity in order to construct a students' science identity.

The frameworks used for the analysis and interpretation of this research study was through the theories of Dr. Gloria Ladson-Billings, Drs. Ana Marie Villegas & Tamara Lucas, and Dr. Angela Calabrese-Barton.

Keywords: academic identity, science identity, science competency, traditional instructional methods, urban education, urban school, fictive kinship, culture, rapport

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DEDICATION

In loving memory of my brother, Gernon Speller.

We Did It!!!

In loving memory to a dear and wonderful friend and professor who lived life with aplomb,

Dr. Michele Knobel

To Dr. Ana Marie Villegas and Dr. Tamara Lucas, thank you so much.

I kept fighting.

To my nephew, future Dr. Marquez Speller.

It's your turn now!!!

To my Wife and Best Friend, Diana Brewster and my wonderful children, Ava and Raegan,

I finished my climb.

Dr. William J. Brown

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Chapter 1 – Introduction

Urban school districts often find it challenging to staff their schools with effective teachers that can instruct, guide, and lead students in their educational development (Jacob, 2007). Teacher shortages are compounded by a lack of resources and the pressing needs of their diverse student populations, which are particularly acute in science classrooms (NGSS, 2013; Rotermund & Burke, 2021). Highly qualified middle school science teachers willing to teach in urban, high poverty schools are in even shorter supply as Black and Hispanic students have less access to lab facilities and equipment, and a limited curriculum (Ingersoll & Perda, 2010; Quinn & Cooc, 2015).

As a practicing middle school science teacher with over fifteen years of experience in New Jersey, I have seen first-hand the shortage of urban middle school science teachers in high poverty areas. Throughout my career, I have worked in school districts in areas Milner (2012) would describe as "urban intensive, urban emergent and urban characteristic" (p.559). As a direct result of this shortage, I have been asked to cover classes on a regular basis for classrooms without a science teacher for 6th, 7th, and 8th grade classrooms throughout the years. There is a direct line from those experiences to the questions posed by this dissertation. Without an adequate supply of science teachers, students in urban middle school classrooms will likely be hindered in their high school and college achievement, and ultimately have a lesser chance of a career with contributions to the fields of science, technology, and engineering (Fry et al., 2021; McGee, 2021).

For adolescents, one of the most important developmental processes is that of identity development, as they learn to both understand themselves and their relationship to the wider social world (Erikson, 1994). One aspect of this process is the development of an *academic*

identity, which is defined as "students' self-understanding related to their educational values, school belonging, regard and performance" (Pantoya et al., 2015, p. 61). For middle grades, the development of an academic identity is also essential as students enter a social environment in which the creation of an academic identity is based on the support of their teachers and the positive interactions that occur between them and their peers (Ryan & Patrick, 2001). Of greatest interest here are students' development of a *science identity,* which encompasses a students' interest in science, their persistence or tenacity in a science discipline, their intention to pursue a scientific career, and even their decision to enter a graduate science program (Stets et al., 2017). Middle school science teachers are essential to the development of students' science identities by creating pedagogical structures that allow them to learn and use science in their everyday lives.

Additionally, as the United States experiences racial and cultural shifts within its student population (Mordechay & Orfield, 2017), and to a much lesser extent, its teachers (Nguyen & Redding, 2018), it is worth asking about the practices of science teaching in these classrooms, especially among students who are marginalized (Ladson-Billings, 1994; National Center for Education Statistics, 2019; Villegas & Lucas, 2002a).

For some middle school science teachers, teaching science in a way that satisfies the needs of their students and the demands of the job present a problem. They perceive real tension in deciding how and in what dimensions the context of science should be taught to middle school students as science is domain-specific with its "rigid, fact-based curriculum" and Eurocentric focus. Thus, the meaning and ways of learning science become irrelevant to students (Davis et al., 2006) as they start to adopt a series of identities that counter the traditional instructional methods of the classroom. Teachers then view some of these personalities as a form of

opposition rather than understanding how external situations could affect their students academically (Emdin, 2016; Noguera, 2008).

When science teachers do not make space for students' ideas and experiences in the classroom, or when a science teacher deliberately ignores students' values, opinions, and stances regarding their experiences with science, students are more likely to see science as a form of oppositional learning (Emdin, 2016). Emdin (2011) notes that to successfully motivate students in science instruction, an alternate form of science teaching needs to be established that creates opportunities for marginalized students to develop both a scientific identity and scientific literacy. Matthews (2013) notes that continuous exposure to harmful and controlling school environments not only lead to a decline in motivation, efficacy, and interest in academics (pg. 144), but also to "negative reacting coping mechanisms" resulting from social pressures brought on by their peers. Thus, science learned in such a setting often has little relevance to the students, their lives, and their environment. This may result in an academic identity crisis in which students see themselves perceived as failures within the classroom by their teachers, which can lead to a self-reinforcing cycle of behaviors that are likely to be interpreted as destructive, confrontational, and dismissive (Noguera, 2008).

Science Identity and Science Learning

To be scientifically literate, students must "understand key concepts and principles of science; become familiar with the natural world and recognize both its diversity and unity; and use scientific knowledge and scientific ways of thinking for individuals and social purposes" (Coble & Koballa, 1996, p. 459). Additionally, they must use that scientific information and connect it with daily life (Fives et al., 2014). In other words, *all* students should understand their environment and obtain scientific understanding of their world through scientific observation

through the usage of scientific knowledge. However, given the definition, students also need to be familiar with the natural world by using key concepts in science, its principles, and scientific ways of thinking to connect to society (Pearson et al., 2010) at large.

Additionally, to be scientifically literate, students should understand the "big ideas" in science when comparing concepts to the world and society. For example, Fries-Britt (2017) discussed that in a K-12 setting, African American male students became successful in science through engaging with peers academically and socially in a science environment. As peers shared and discussed the subject matter, they fostered relationships by assisting each other with their science assignments. In this context, African American males' science identity development correlated with peer interactions followed by moral support from the teacher.

Peer groups play an important role in shaping identity (Noguera, 2008; Rascoe & Atwater, 2005), and some students who express an interest in science may be subjected to ridicule among their peers (Graham & Anderson, 2008; Noguera, 2008). Thus, marginalized students may become even more disengaged in the science classroom if they feel caught in a dilemma as they contrast their interest in science with a science curriculum that emphasizes memorization, rote learning, worksheets, lower academic expectations, negativity by teachers, and social rejection from their peers (Atwater et al., 2010; Hill et al., 1995; Kanter & Konstantopoulos, 2010; Lee & Anderson, 1993; Tsui, 2007). Science instruction, because it is domain-specific, emphasizes a subject rooted in Eurocentric principles as opposed to a shared academic discourse in which the cultures and values of both the western world and the student population (Kim, 2015) are intertwined (Banner, 2016; Darling-Hammond et al., 2007). What takes place is that the science teachers who follow this *traditional* culture of science teach in the "form of rigid, fact-based disciplines, with prescribed knowledge, leaving little to no room for

students to explore or generate their knowledge and curiosity" (Strong, 2016, p. 382), and, as such, use their perspectives to reinforce it. This type of science teaching is devoid of students' culture, traditions, and lived experiences. Students then see science as a misunderstood and irrelevant subject to their lives.

The Role of Science Teachers

When science teachers instruct students whose cultures and ways of knowing about the world differ from their own, there is always the possibility of viewing their students' culture and upbringing through a deficit lens (Souto-Manning & Rabadi-Raol, 2018). Here, cultural barriers between the science teacher and the students are further intensified as the science instruction delivered in the classroom resembles traditional instructional methods that are domain-specific and neo-colonial in nature (Banner, 2016; Darling-Hammond et al., 2007). Traditional instructional methods are defined as pedagogical strategies that mirror the robust culture that promotes academic success for those who share that power (Villegas & Lucas, 2002b). In other words, teachers may use their cultural perspectives to reinforce their perceptions of science and science learning, by altering how it is introduced, and how it is obtained from the students. The students, then, become absent from the class as learning diminishes altogether (Davis et al., 2006).

Teacher perceptions of students learning is essential to student motivation and achievement, and teachers play a substantial role in helping students construct scientific identities within the classroom. Such teachers create "classroom environments that connect science to students' lived realities, and students engage in behaviors that develop the habits of mind of scientists" (Wright et al., 2016). They also listen actively, openly acknowledge, and value children's prior knowledge, learning interests, agendas, and ideas they accept from

students outside experiences. Such teachers conceptualize scientific teaching as a way of helping marginalized students examine science as it relates to their community and selves (Calabrese-Barton, 2002).

Such teaching is culturally responsive because it treats the student's lived experiences and culture as resources that can be leveraged for learning (Calabrese-Barton, 2003; Ladson-Billings, 1994). Culturally responsive science teaching may be defined as providing equitable learning experiences using students' cultural and linguistic backgrounds as resources for science instruction (Brown, 2004; Villegas & Lucas, 2002a).

Clearly, there is a pressing need to alter the school experiences of marginalized students through the practices of their teachers, who may be viewing such students as incapable of succeeding in education, (Gilbert, 1997; Haberman, 1991; Ladson-Billings, 1994; Ladson-Billings & Darling-Hammond, 2000). If teachers view marginalized students as high achieving, students will see themselves as such, supporting the development of their science and academic identities in the process. Good science teaching at urban middle schools by teachers of marginalized students is indeed possible (Ladson-Billings, 1995a), an outcome that this study seeks to better understand by investigating the thinking of the teachers who practice in this way.

Statement of the Research Problem

This study will focus on how science teachers instruct marginalized students as they engage them and help build their scientific identities through a culturally responsive lens. Culturally responsive science teaching is defined here as an equitable learning experience that requires students' cultural and linguistic backgrounds to be used as resources for science instruction (Brown, 2004).

Teacher Thinking and Decision Making

This study seeks to explore teacher thinking and decision-making as well. Teacher thinking is of the utmost importance as teachers alter their instruction, based on their student population, school district, and administration. As such, the thinking of teachers needs to be contextual, interactive, and speculative (Lampert & Clark, 1986) for both themselves and their students. For contextual knowledge, teachers "make decisions that are situation-specific" meaning that based on the student population and science content taught within the classroom, modifications might be necessary to ensure student success (p.29). For interactive learning, teachers not only ask questions to their students, but they create an atmosphere for students to learn by predicting possible outcomes for students, detecting issues that might take place during instruction, and determining whether students might be interested in the content altogether (Lampert & Clark, 1986; Westerman, 1991). For speculative knowledge, depending on the teacher, their students, and their experiences, both in and outside of the classroom, the teacher decides to either accept or reject the norms of the classroom and decide on their own, what works best for their student population. This includes altering the curriculum and making changes when necessary if the content is not engaging or if the students are unable to relate to it.

This study also explores teachers' thinking in the hope of discovering what pedagogical practices and the decisions behind them are essential for creating, in marginalized students, a scientific identity and what pedagogical practices help develop their scientific literacy.

Purpose of the Study

This study will focus on how science teachers instruct marginalized students as they engage them and help build their scientific identities through a culturally responsive lens. Therefore, my overall research question is: *How do middle school science teachers in an urban*

context think about their relationship with good science teaching and their students? The following sub-questions will also be addressed in my study:

1. What do middle school science teachers prioritize in an urban science classroom?
2. How does culturally responsive teaching occur in an urban middle school science classroom?

Ladson-Billings (1994) noted that the primary goal of culturally relevant teaching was to "empower students intellectually, socially, emotionally, and politically through the use of cultural referents to impart knowledge, skills, and attitudes" (p.18). However, a corresponding vision of "good science teaching," across multiple educational settings with marginalized students is more difficult to find portrayed in the literature. Culturally relevant science teaching in one school could vary in one area compared to another (Villegas & Lucas, 2002b). As such, one critical aspect of a culturally responsive science teacher is that they should have the ability to get students to connect to their science classroom by accepting them for who they are as individuals and reminding them that they have an innate ability to be successful rather than sacrifice their personality and character to achieve academic excellence (Emdin, 2016).

In the following chapter, I explain the definition of urban education, followed by a description of the theoretical framework of Gloria Ladson-Billings, Ana Marie Villegas & Tamara Lucas, and Angela Calabrese-Barton that assisted in the creation of my lens for my literature review. In chapter 3, I describe my research methodology, and in chapter 4, I present my findings from the participants in my research and in chapter 5, I provide a comparative analysis across participants followed by a summary of the findings, the research's implications, and limitations in chapter 6.

Chapter 2 – Theoretical Framework and Literature Review

This chapter will consist of the following: (1) A description of, (2) A description of culturally responsive teaching from the work of Gloria Ladson-Billings, Ana Marie Villegas & Tamara Lucas, and Angela Calabrese-Barton and how their framework applies to the middle school context, (3) A description of scientific literacy in an urban middle school context, followed by (4) a description of scientific identity and (5) an explanation of science teaching in urban environments.

Urban Education

Urban Schools. The term urban school is most closely associated with the students and the school's location within the community (Milner, 2012). Racial demographics and socioeconomic data play a role as an urban school is defined as a school that encompasses an institution in an improvised community with high crime rates extreme exposure to health hazards (Reese et al., 2018), poverty, juvenile crime, teenage pregnancies, broken families, and drug abuse (Sinclair & Fraser, 2002), and limited to ill-prepared content area teachers (Jacob, 2007).

Milner (2012) further intensifies this definition of an urban school by including school districts that are experiencing challenges such as "lack of resources, qualification of teachers, and academic development of students (p. 560). Furthermore, the concepts of an urban school are further classified into three distinct clusters: environment, the density of the population surrounding the school, and geographic location, which set them apart from each other. Milner (2012) further describes urban schools as either an Urban Intensive, Urban Emergent, and Urban Characteristic. Milner's descriptions, shown in Table 1, offer a more detailed approach to defining the urban school housed in major cities, large cities, and rural and suburban areas.

Table 1

Evolving Description of Urban Education (Milner, 2012)

Urban Intensive	These schools are those that are concentrated in large, metropolitan cities across the United States, such as New York, Chicago, Los Angeles, and Atlanta.
Urban Emergent	The schools are those that are typically located in large cities but not as large as the major cities. They typically have some of the same characteristics and sometimes challenges as urban intensive schools and districts in terms of resources, qualification of teachers, and academic development of students. Examples of such cities are Nashville, Tennessee, Austin, Texas, Columbus, Ohio, and Charlotte, North Carolina.
Urban Characteristic	These schools are those that are not located in big cities but may be beginning to experience increases in challenges that are sometimes associated with urban contexts such as an increase in English language learners in a community. These schools may be located in what might be considered rural or even suburban areas.

This literature review on urban education is guided by the questions, "What takes place in urban schools and what does good teaching resemble in an urban middle school context?" This research was obtained through the ERIC database. The keywords used for my research were: Urban Education, Middle School, Junior High, 6th grade, 7th grade, and 8th grade.

Urban schools encounter issues such as violence, mobility, truancy, staff turnover, lack of parental involvement, student disengagement and dissonance between home and school environments (Beeks & Graves, 2016; Garcia-Reid et al., 2015; Lawless & Brown, 2015; Mora, 2011). Additionally, within urban school districts, an increase in bilingual students is also commonplace, with teachers struggling to motivate and encourage them for educational autonomy (Garcia-Reid et al., 2015; Kim et al., 2019; Oliveira et al., 2017).

This literature review on urban education highlights these issue that take place in urban schools, yet this review offers positive insight into the good teaching that takes place within the context of urban middle school education.

Discipline. The transition into middle school itself presents many challenges such as "behavioral and classroom expectations, the pressure to meet academic demands of middle school and accomplish such basic tasks as studying, taking notes, taking tests, eating in a large cafeteria, and having to make new friends" (Theriot & Dupper, 2010, p. 206) however, if those challenges are coupled with, metal detectors in schools, zero-tolerance policies that discriminate against marginalized students, discriminatory surveillance practices that prepare minority students for prison (Gastic, 2017; Peguero et al., 2021; Schroeder, 2016; Theriot & Dupper, 2010) For middle school students, especially Black and Latino students, they become more aware of their surroundings as they start to realize that they are more likely to receive harsher punishments in the middle school atmosphere for infractions such as class disturbances, insubordination, and misread social cues (Theriot & Dupper, 2010) interpreted by the teacher. Furthermore, the research also mentioned that African American students were disproportionately represented in these infractions (Welsh, 2019) compared to their white and Hispanic peers.

Some of the discipline issues that marginalized students face are referrals that are based on teachers' perceptions of them being loud, aggressive, vocal, demonstrating masculine like behaviors (Evans & Esposito, 2010; Fordham, 1993) that are rooted in stereotypical imagery brought on by the media (Ladson-Billings, 1994).

As marginalized students transition from elementary to the middle grades (6th, 7th, 8th grade), they experience increased harassment and surveillance from teachers and school personnel (Peguero et al., 2021).

For example, Theriot and Dupper (2010) noted that as students transitioned from 5th grade to middle school (6th-grade students), they were more prone to subjective offensives by teachers and school personnel such as talking back to teachers and fighting. As such, marginalized students, upon entering middle school, are at a disadvantage from the very beginning as teachers and school personnel observe these students with discrimination, imprint stereotypical views on them before they have a chance to demonstrate their learning ability and are subjected to harsh discipline practices that could further lead to carceral situations as they become older.

Good Teaching in Urban Schools. Schools are similar to ecosystems, with each participating organism (teachers, administration, school personnel, etc.) contributing to the dynamic of student learning and development (Biag, 2016; Reed III, 2013). When teachers actively listen to, openly acknowledge, and value children's prior knowledge, learning interests, agendas, and ideas, they are accepting of their students' outside experiences (Wright et al., 2016) and create an environment that is welcoming and inviting to the students.

Teachers are significant as their approach to engaging with marginalized students requires an understanding of their culture and behaviors and an analysis of their own beliefs and behaviors as well (Bonner et al., 2018; Garcia-Reid et al., 2015) . Flint et al. (2019) demonstrated that teachers' perceptions and beliefs were essential for middle school students to learn mathematics. Initially, the teachers were skeptical at first, when their students were introduced to a support framework called HEAT, which incorporated the use of hands-on manipulatives,

learning by doing, and concept-based instruction. The program allowed the students to form "communities of practice that allowed for them to successfully learn mathematics and construct a math identity" (p.1041). The mathematically successful students in this research were African American, and the six teachers who participated in the program were White and female with teaching experiences ranging between 7 to 29 years.

Additional research from Flores-Koulish and Shiller (2020) further strengthens my argument. With the use of positive behavior supports (PBS) for African American and Latino middle school students, an analysis from the social studies and English teachers from the Baltimore (Black, White and Biracial teachers) school district uncovered how the teachers were able to incorporate "critical care, social justice, cultural relevance, and anti-racism" (p. 984) to engage their students in discourse following the death of Freddie Gray to predict various behavioral issues in their student population and increase classroom engagement.[1]

As the majority of the teaching workforce is White, female, and middle-class (National Center for Education Statistics, 2019), some are still unable to provide a quality education for marginalized students whose level of knowledge and skills are different from their own. Additionally, as the ethnicity of some of the teaching workforce is different from that of the students, they are still subjected to stereotypical prejudices and misconceptions by their teachers.

These examples further demonstrate that at the middle school level, teaching content for students to achieve educational autonomy in an urban setting could be conducted by teachers if they create pedagogical structures that incorporate the experiences and cultural orientations of the students. While teaching in an urban middle school requires classroom management and

[1] Freddie Gray was a 25-year-old black man who died of a spinal cord injury while in police custody in Baltimore, Maryland.

resilience, they also need to integrate pedagogical strategies that are engaging, fun, and relevant to the student's present body of knowledge (Iyer & Pitts, 2017). For students to be academically successful, the teacher needs to incorporate "the experiences and cultural orientations of students from diverse racial, ethnic and economic backgrounds into their teaching strategies" (Bonner et al., 2018, p. 699).

I now refer to the framework of culturally responsive teaching by Ladson-Billings (1994), Villegas & Lucas (2002), and Calabrese-Barton (2003) to create a series of themes that are the core attributes necessary to investigate the literature for good science teaching in an urban middle school context.

Culturally Responsive Teaching

Culturally responsive teaching is a practice that can be contrasted with the traditional curricular and instructional methods taking place within public school classrooms. Traditional curricular and instructional methods are defined here as pedagogical strategies that "mirror the culture of the powerful that promote the academic success for those that share that power" (Villegas & Lucas, 2002a, p. 30). Culturally responsive teaching is also defined here as a transformative process that focuses on disrupting the traditional model of education by centering on the students who do not share the culture of those in power and provide teachers with the tools necessary to help students "develop social consciousness, intellectual critique, and political and personal efficacy so they can combat prejudices, racism and other forms of oppression and exploitation" in the classroom and society (p.37). This pedagogical approach often runs counter to the traditional approaches to teaching because it focuses on the voices, sensibilities, and lived experiences of youth of color throughout the classroom (Ladson-Billings, 1994; Villegas & Lucas, 2002a). In the case of culturally responsive teaching in science education, trends exist for

successful students in middle school science classrooms. In the following sections, I will detail these trends of culturally responsive teaching based on the work from prominent researchers, Dr. Ladson-Billings, Drs. Villegas & Lucas, and Dr. Calabrese-Barton and how they apply in a middle school science context.

Ladson-Billings' Culturally Relevant Pedagogy. In urban schools, students of color sometimes resist the traditional curriculum due to their marginalization and disrespect in the classrooms. As such, student's voices, sensibilities, and lived experiences of youth of color in the US are often silenced (Ladson-Billings, 1994). I apply her framework for this study because while her focus relates to African American students' success specifically, I seek to know what CRP looks like in a diverse middle school science classroom. Below, I use Ladson-Billings' theory as a central part of my framework. The three tenets are described below.

Academic Success. Ladson-Billings contends that no matter the student's obstacle (racism, police brutality, social inequalities, etc.), they must have the necessary tools to succeed in school and education (Ladson-Billings, 1994) and life. Ladson-Billings focused on the academic achievement of African-American students and based her research on the premise that if teachers set high expectations, implement small goals, and scaffold their prior knowledge, teachers will be able to create opportunities for students to experience academic success (Milner IV, 2011). For example, a qualitative study by Brooms (2019), into the schooling experiences of young Black men who graduated from an all-boys charter school revealed that there school experiences, that led them to their academic success, were based on their school's culture and relationships. For culture, this included creating an atmosphere that was "inviting and uplifting" and a "great learning experience". For relationships, students attribute their success to the

teachers and their interests in them as a person, "provided them with positive feedback and encouraged them to succeed" (p.817).

Cultural Competence. Cultural competence is based on the teachers' ability to incorporate their students' skills and talents within the classroom. This translates into the teacher finding ways to honor the culture of their students, maintain their cultural integrity and use their abilities to help them become successful learners in school. Additionally, teachers also must be cognizant of their culture as well. Simply incorporating the students' culture into the classroom is not enough. Teachers need to be multicultural in the sense that acquiring "skills in additional cultures" is essential for both students and the teacher to work and exist in a "complex, diverse, and globally connected world" (Ladson-Billings, 2016, p. 36) in which they can improve their "socioeconomic status and make informed decisions about the life they wish to lead" (Ayers et al., 2008, p. 170). For example, Kumi-Yeboah et al. (2021) examined 25 teachers perceptions of their Black immigrant youth students. Findings demonstrated that teachers had "cordial relations" with their Black immigrant students as well as revealed that the teachers provided support with navigating a new school, offering guidance with classroom procedures and school policies, and provided social networking skills for help in interacting with classmates and peers. Research also revealed that the Black immigrant students also had to balance their multiple identities and their home and school cultures.

As the teacher assesses their students and their ways of knowing, they can also expand their knowledge themselves by understanding the broader aspects of their students' culture, their learning, and experiences (Ladson-Billings, 1994).

Additionally, teachers must balance both the lives of their students and the rules and regulations of the school as well. Students then should be listening to not only the teacher but

also each other as they share knowledge in such a way, the students become knowledgeable about a specific topic with the remaining students taking notes, asking relevant questions, and engaging in discourse from each other, so they can understand the society and power struggle around them. Here, culturally responsive teaching takes on a more fluid approach as students themselves become teachers and teachers become students, learning from each other and sharing their culture of origin, while developing multiple fluencies in at least one of more additional cultures (Ladson-Billings, 1995a). The classroom then, for students, is an opportunity to go beyond their personal cultures and interact, learn, and view education from a multicultural perspective.

Critical Consciousness. Under this tenet of culturally relevant pedagogy, the teachers can assist students by helping them navigate their culture within the curriculum while simultaneously understanding and responding to how the dominant culture of education oppresses and ostracizes them in an educational setting.[3] For example, students observed by Luter et al. (2017) in a low performance middle school in Buffalo, NY uncovered that the program Community as Classroom (CAC) initiative provided students with the ability to see how education, and schooling had a direct relation to their neighborhood. Using critical pedagogy to teach critical consciousness among the students, they were able to analyze their communities to understand the "root causes of their neighborhood and how they can bring about desirable change in their neighborhood" (p.3). The result of this initiative led to improved student attendance, on time arrival at school and reduced suspensions,

[3] Dominant culture would represent "the traditional" education methods that cater to a dominant racial identity. See Villegas and Lucas (2002).

For youth of color, developing a critical consciousness affects their *student agency* in a positive way. I define *student agency* here as a student's way of knowing and learning science that involves a critical awareness of the role science plays in their world and understanding how scientific ideas and ways of thinking can be used toward making a difference in their world (Calabrese-Barton & Tan, 2010).

For example, suppose African American males can engage in science and tap into their agency. In that case, students will be able to relate to the material due to the teacher's instructional opportunities for their success in the classroom. This also causes their attitude toward learning science to improve, and, stated earlier; these attitudes can lead students to decide and accept science courses that can lead them to science-related careers in higher educational settings. This, in turn helps students understand the world and allows them to be better prepared for the harsh realities of racism, discrimination, and systemic oppression. Boutte et al. (2010) provide an example of this as the teacher under examination, CKJ, discussed to the researchers how they were able incorporate powerful counter-narratives to science's Eurocentric focus by discussing scientists of the African diaspora and describing to their students that science is not the purview of White men. Here CKJ's explanation of African American scientists provide students with a foundation that science is not a one-sided, one race content area.

As students become aware of their society and its inequities, they are more readily able to acquire the educational skills and attitudes necessary to help them function in their environment and contribute to their communities (Ladson-Billings, 1995; Milner IV, 2011) at large.

Culturally relevant pedagogy then works as an essential bridge linking students' lived experiences to their academic experiences within their classroom. The teachers, in turn, have a deep investment in their students as they create an environment full of academic rigor, cultural

competence and cultivating a critical consciousness for their students to challenge the dominant culture in society. The theory does provide a successful lens for teachers to give students the ability to acquire fluency in learning content outside of their culture and allows them [students] to understand why they need to learn the content. What is deemed culturally appropriate for science teachers and for students of color, especially as it pertains to males is where it is lacking due to its broad scope. In other words, there is no specificity as to the pedagogical skills necessary to motivate African American males to succeed in science at the middle school level (Boutte et al., 2010).

Culturally relevant pedagogy then, is not a monolith. Rather, it is a framework that allows teachers the ability to incorporate a series of "identities and cultures" that are essential to assist in teaching the youth of the present (Ladson-Billings, 2014, p. 82). Table 2 describes the framework below:

Table 2

The Three Tenets of Culturally Relevant Pedagogy

1. Academic Success: Development of students by means of literacy, numeracy, technological, social, and political skills in order to be active participants in a democracy. (Ladson-Billings, 1995a) Students choose academic excellence (Ladson-Billings, 1995a)	• Students have the necessary tools to succeed in academia. • The teacher sets high expectations for students. • Teacher Implement Small Goals. • Teacher Scaffolds Prior Knowledge. • Teacher creates opportunities for students to experience academic success.
2. Cultural Competence: Teacher creates "bridges" for academic learning through instructional scaffolding. (Ladson-Billings, 1994) Students' real-life experiences are legitimized as they become of the official curriculum. (Ladson-Billings, 1994)	• Teacher incorporates students' skills and talents in the classroom • Teacher creates opportunities to honor the culture of their students. • Teacher maintains cultural integrity of the classroom. • Teacher uses students' talents and abilities to help them become successful learners in school. • Teacher understands students' ways of knowing. • Teacher allows students to share knowledge about a specific topic to their peers with the remaining students taking notes, asking relevant questions, and engaging in discourse.
3. Critical Consciousness Students are able to speak to the social and political reality of personal, community, national, and international civic life. (Ladson-Billings, 1995b)	• Teacher assists students to navigate their culture within the curriculum • Teacher understands that the dominant culture of education oppresses and ostracizes students in an educational setting • Students become self-conscious of the world that they live in and understand the realities of racism, discrimination, and systemic oppression.

Villegas & Lucas' Culturally Responsive Teaching. Villegas & Lucas (2002) respond to the question of what is considered successful teaching practice for diverse student populations by examining the "attitudes, knowledge and skills" (p.25) of successful teachers via classroom

observations, examining empirical and conceptual literature and examining the teaching practices of preservice teachers through discussions and observations. Their framework is a foundation for teacher educators to create a comprehensive curriculum to successfully examine preservice teachers' "assumptions of school, their relationship to society in the context of working with students of color and their pedagogy in regard to their instruction" (pg. 26). Under this framework, teacher educators understand that as they teach preservice teachers, preservice teachers then need to examine their misconceptions of diverse student populations and strengthen their teaching attributes to make the culture of the classroom conducive for all students.

The six components of this framework focus on how teacher educators continually have preservice teachers negotiate their "ways of thinking, behaving, and being" and how their reasoning is influenced by "race, social class, and language" (p.22). The first three components, shown in Table 3, shape the development of teachers as they teach a changing student population, and the last three strands focus specifically on teaching and learning diverse students in a culturally responsive context. For example, in a phenomenology qualitative study of preservice teachers, Skepple (2015) provided preservice teachers 2 phases to examine how their beliefs affected their approach to teaching culturally and linguistically diverse students. Phase one incorporated students completing a background questionnaire to examine characteristics that influenced their (preservice teachers) "cultural diversity knowledge base" (p.61). The second phase consisted of focus group interviews to identify culturally responsive experiences that the preservice teachers experienced, and to describe how those experiences affected their perceptions of culturally and linguistically diverse students.

While this research focused of culturally responsive teaching strategies in the southeast, the findings uncovered here could vary to additional regions within the United States, as well as the views and responses expressed by the preservice teachers.

Table 3

The Six Tenets for Preparing Culturally Responsive Teachers

Development of Teachers:	
Gaining Sociocultural Consciousness	Teacher educators shape, not only preservice teacher identities, but also help them shape the school and societal experiences for students as well.
Developing an Affirming Attitude Toward Students from Culturally Diverse Background	Teacher educators assist preservice teachers as they navigate multiple cultures of diverse students and develop methods for them to incorporate prior knowledge into students' learning.
Developing the Commitment and Skills to Act as Agents of Change	Teacher educators assist preservice teachers by helping them understand that teaching is not an isolated activity but seen as a construct in which they have the ability to accept and incorporate multiple methods of instruction that students are able to think, behave, and discuss content within the classroom.
Teaching and Learning:	
Embracing the Constructivist Foundations of Culturally Responsive Teaching	Teachers formulate the conceptions necessary to teach diverse students. These strands focus on the aspects of teaching and learning by creating "bridges" to incorporate diverse students' prior knowledge while incorporating new ideas and experiences from the classroom.
Learning About Students and their Communities	Teachers establish relationships and engage students learning by questioning, interpreting, and analyzing information in the context of problems or issues that are meaningful to them.
Cultivating the Practice of Culturally Responsive Teaching	Teachers create a classroom environment in which diverse students examine their environment to gain new ideas and construct knowledge about their local environment.

Teachers who practice culturally responsive teaching examine their personal biases about teaching students of color because they soon discover that their beliefs create an environment for students to be stereotyped, dismissed, or disregarded in the classroom. For example, in an analysis of preservice teachers of color by Plachowski (2019), she indicated that the participants had both positive and negative k-12 encounters that affected their initiative to become educators. Positive themes such as teachers knowing their students, being a warm demander, and exhibiting care to their student population were expressed whereas, their negative experiences consisted of some teachers exhibiting apathy toward them, experiencing poor academic supports, and experiencing overt racialized experiences. Overall, these experiences provided the drive necessary for these preservice teachers to pursue their teaching careers. Additionally, through these experiences, teachers were able to create authentic learning experiences that included their personal lives and a curriculum that houses prior knowledge for students. The curriculum also includes the knowledge of their community that causes teachers to develop a culture of learning that incorporates all students (Villegas & Lucas, 2002a).

Calabrese-Barton's Teaching Science for Social Justice. The framework of Calabrese-Barton (2002, 2003) pertains to urban science education and focuses on three tenets: a commitment to equity, social justice, and a sense of place. This framework guides science teacher educators as they work with youth in urban communities through science. Under this framework, the focus is on the students, but emphasizes their environment and how their environment shapes their view of science learning. For example, research by Calabrese-Barton (2003) of her students at Southside Shelter revealed that in the creation of a science community outside of their school, her participants revealed that "real science" to them (students) involved a form of science that is "useful to the community, will make a difference in their lives", (p.146)

have meaning, and have outcomes that affect more than just the participants involved, compared to the "fake science" which take place in school settings that involve science projects and grades. Another example to further strengthen the idea of "fake science" is through work of Fusco (2001). In her analysis of the same community-based science project mentioned above, the students of the after-school program (aged 12- 16) created what is called a *practicing culture of science learning* in which students focused on science by articulating the "goals and activities" involved in creating a community garden to neighborhood members. Overall, this practicing culture of science learning is based on "participants concerns, interests, and experiences in and outside of the science classroom, involves an ongoing process of researching and enacting ideas, and is situated within the broader community (p.872). Here, fake science is considered "knowledge and content…that does not support students' development" for both themselves and their community, whereas real science is knowledge and content that is connected to serving others such as their friends, families, those in the classroom community, and those in the school building and beyond" (p. 874).

In examining this framework, Calabrese-Barton provides insight into how science teaching is limited based on a lack of resources and how educational policies are counterintuitive to successful science teaching (sense of equity). She explains further that, rather than focus on the limitations of the science classroom, researchers should change their view of the term by concentrating on how teachers are using what is presently in the school, the science classroom, and the environment.[4] By concentrating on what they have rather than what they do not have,

[4] Resources are referred here as "material, social, human, or symbolic" Calabrese-Barton, A. (2003). *Teaching Science for Social Justice*. Teachers College Press.

science teachers are able to lead science discussions and have hands on science experiences for successful teaching by being creative and inventive.

Calabrese-Barton explores social justice in urban science education by identifying how school functions as systems and how the actions of the teachers and students work as agents of change within the science classroom. Exploring social justice further, she provides the perspective that by creating new levels of "interacting, knowing and being" (p.67) for both the students and teachers, the classroom will engage in discussions that distribute power. In other words, students can become teachers, and teachers can become students. As each value, respect and acknowledge the experiences both groups bring to the classroom, both groups are able to create learning spaces that can be occupied for improved science instruction, teaching, and learning. This is not an easy task for teachers as they have to teach in ways that put the "students' interests and questions at the center of the science curriculum" (Finkel, 2018). Research by Finkel (2018) into her teaching methods course provides an example. In her analysis of her science teacher candidates (SCTs), the transformation from this mentality requires that SCTs see all their students as capable science learners and discover that science education is more than just the transmission of science content and skills, but rather, creating scientifically literate citizens who can solve science related problems that are important to students' families and their community. This includes "rethinking the content they teach, adapting more inclusive pedagogical strategies, and reconsidering their beliefs as to who belongs in the science classroom and who does not" (p.41). Dr. Finkel's approach to establishing this shift, is through the usage of reflecting writing, guided classroom observations and critical thinking. This example creates an evolving atmosphere for science teachers as they develop new instructional methods of

incorporating youth experiences in the science classroom by discovering, what is important to them.

The third tenet of the framework, a sense of place, examines how place is a dynamic construct. What this means is that the personalities of urban students are brought to the classroom based on their cultural and social settings. Their sense of place guides their understanding of science in their own methodology and science teachers use this to employ relevant science to the classroom and their lives. For example, a high school that might be close to a beach like setting might have science that specializes in ocean organisms and ocean-based technology compared to a high school close to a desert like setting that might specialize in earth science or earth-based technology. Table 4 highlights the tenets of Calabrese-Barton demonstrating how urban science education conveys a commitment to equity, social justice, and a sense of place.

Table 4

The Three Tenets of Teaching Science for Social Justice (Calabrese-Barton (2003)

1. Sense of Equity	a. The focus is on teacher and what they are presently using in the school, science classroom and the environment.
2. Social Justice	a. How school functions as a system and how the actions of the teachers and students work as agents within the classroom.
	b. New levels of "interacting, knowing and being" are created for both the students and teachers that distribute power.
	c. Creation of learning spaces to improve science instruction, teaching, and learning.
3. Sense of Place	a. Personalities of urban students is brought into the classroom based on their cultural and social settings.

Comparisons. Although there are similarities between Ladson-Billings (1994) and Villegas & Lucas (2002), Calabrese-Barton's science-specific framework provides a very distinct and important view into understanding how science teachers instruct diverse students in urban environments. Similar to Ladson-Billings (1994), using students and their environment as the foundation for purposeful science teaching, she provides the notion that teachers should focus on how students and their personalities coincide with their environment and how their personalities shape the dynamics of the science classroom. This is a very important distinction as her framework assists in interpreting how students in various environments learn and interpret science for themselves and their community.

To investigate the research describing good science teaching for African American males I intertwined the theories of Ladson-Billings (1994), Villegas & Lucas (2002) and Calabrese-Barton (2003) to create a modified framework describing the core attributes necessary for culturally relevant good science teaching. Using these frameworks to investigate the literature, I focused specifically on how science teachers were able to construct that "cultural bridge" to effectively teach students of color in the middle school context. Although, culturally responsive teaching incorporates the culture and perspectives of the students and allows teachers to examine their beliefs in regard to teaching them, the implementation of this practice is a "constantly evolving dynamic which adapts to a changing social, political and environmental landscape (Villegas & Lucas, 2002b, p. 27).

Scientific Literacy

In this study, I use the definition of scientific literacy put forth by Leonard et al. (2016) because it provides a culturally responsive lens that holds true that science can be learned in a variety of approaches within the classroom, with each incorporating their own customs and

standards. Their definition states that scientific literacy is defined as “a cultural enterprise that has its own language, norms, values, beliefs, and shared conventions” (Leonard et al., 2016).. In the case of the urban middle school classroom, the incorporation of “reading, writing, listening, speaking, viewing, and visual representation” are necessary skills needed for the science classroom (Bradbury, 2014, p. 466). The concept of incorporating literacy in the science class, however, is where a varied approach takes place as the culture of the teacher, students and the school can take on many characteristics. For example, while writing in science is necessary for documenting, presenting data, making inferences, allowing for reflection, analysis, thoughts, and discoveries (Glen & Dotger, 2013), one teacher would use writing as a way to engage students in scientific thinking, while another teacher would use writing after implementing reading strategies to engage their students in reading science texts (Oliveira, 2015). Thus, the use of literacy in a science context is ambiguous as some teachers use reading, writing, or both to review past scientific investigations, make informed decisions, and make discoveries by “constructing arguments based on evidence, and word meanings from text” (Pearson et al., 2010, p. 459). Each approach, however different, created experiences to make science authentic to the learner.

Reading and Writing. In the construction of scientific literacy, reading and writing is used as a construct for the development of vocabulary and help students build concepts to understand real-world problems in science. For marginalized students, because of its domain specificity, science teachers must be willing to access various forms of literature that relate to students' own culture, including the use of images, ideas, and popular culture (Hall & Damico 2007; Oliveira, 2015) to support their learning in science. For example, Glen & Dotger (2013) identified how science teachers described and used scientific writing. Teachers, in this case, noted that scientific writing was not deemed a “creative” endeavor, but rather an experience in

which students wrote just “facts and knowledge” and were an essential component in scientific literacy. Teachers also felt that by using scientific writing without applying creativity in personal inquiry (students planning and conducting their own tests, asking questions, reviewing what is already known in light of new evidence, etc.), the task became uncreative for students in explaining their scientific thinking. However, when creativity (imagination, metaphors, descriptors etc.) was incorporated within the science classroom, students were able to gain understanding as to how scientists think and function, thus changing the concept to how a typical scientist is supposed to resemble, think, and act. This example demonstrates that literacy in a scientific context, is seen as a chore or task rather than a creative endeavor in which students could be their authentic selves. In middle school classrooms however, the decline in interest in science is still concerning and ongoing (Lawless & Brown, 2015; National Center for Educational Statistics, 2019) as engagement becomes less and less.

Technology and Science. The use of technology in producing scientifically literate students, especially at the middle school level, has been seen as a solution to enable students to understand science as a local, regional and global endeavor (Marino & Hayes, 2012). Students are provided the opportunity to engage in problem solving that can help students understand science as an inquiry based concept that allows students to question and learn to utilize evidence from real world issues to solve real world problems (Howes et al., 2009; Lawless & Brown, 2015; NGSS, 2013). For example, research by Lawless and Brown (2015) in their investigation of middle school students (535 seventh and eighth grade students) and their usage of the computerized program called, GlobalEd2 (a science curriculum that is problem based which focuses on diverse countries that each; have a problem scenario); demonstrated that after fourteen weeks of student participation, the students improved their ability to construct scientific

arguments. The program, followed by the teacher working as a guide allowed students to react to the scientific challenges and responses of their peers and thus increasing their scientific literacy as well. Overall, creative approaches are necessary in order to engage middle school students in science that create new ways of learning for students. Additionally, using technology as the medium for integrating scientific literacy benefits students as they "connect to new experiences to familiarize and provide personal perspectives" (Howes et al., 2009, p. 193), and while there are science competency gaps between specific student groups and their peers (National Center for Educational Statistics, 2019), research has verified that applying technology with science, students are able to improve in their science abilities (Hall & Damico, 2007)[2].

Scientific Vocabulary. Vocabulary is necessary for developing scientific literacy in that for students, when discoveries are made and inferences are stated, scientific vocabulary is necessary to communicate those findings (Bradbury, 2014; Marino & Hayes, 2012). Yet for some students, various factors play a role in incorporating vocabulary with scientific meaning due to the fact that "schools place little value on what is termed the 'nonstandard English' that some children bring to school even though their language is rich, diverse, and useful" in the classroom (Ladson-Billings, 1994, p. 17). For example, with Hall and Damico (2007) and their research of African American English (AAVE) and their usage in mainstream speech in the classroom, they demonstrated that the identities of students are based on their social codes and the sociopolitical context that are unique to their own personal social worlds. In other words, based on the student's time, place, and location, their vocabulary, speech, their own personal

[2] Science Competency – Defined as a person's ability to learn science, rate their skills in science and how confident they are in performing science based activities. Vincent-Ruz, P., & Schunn, C. D. (2017). The Increasingly Important Role of Science Competency Beliefs for Science Learning in Girls. *Journal of Research in Science Teaching, 54*(6), 790 - 822. https://doi.org/10.1002/tea.21387

dialect will adjust, adapt, and parallel that of their community. The teacher is necessary here as they need to consider the characteristics of their students, their culture, and the language they communicate with in order to construct a scientific identity for them using their language in the process.

For example, research by Koomen (2016) examined how a student named "Wizard" learned science. Working with a Biology teacher and a special education teacher, they exposed Wizard to scientific literacy through the use of multiple guided scientific activities via observations and short experimentation. This allowed Wizard and additional students to generate inferences and make connections to their world via discussion and text. For Wizard, a special education student and the principal subject of the study, the teacher provided an environment for him to learn and develop ideas on his own to gain science literacy. Although given independence to construct knowledge, assistance was still necessary for him to excel in the classroom. Additional examples that focused on teachers that provided the context necessary for students to engage more in science is through the work of Pantoya et. al (2015) and Tatum (2008). Although, Tatum focused on literacy for a particular student group and Pantoya focused more on science identity, they both contend that by engaging students in the text that is meaningful and significant to their lives, students are able to construct an identity for themselves in which they see themselves as scientists (Sharkawy, 2012).

Discussion/Shared Language. The language of science is domain-specific, often seen as "sterile, masculine and objective" and as students and teachers primarily express their science knowledge through the use of facts and information (Elmesky, 2011, p. 54), science teachers, especially those for marginalized students, need to encompass pedagogical strategies that incorporate both students' language with scientific facts, new knowledge, and inferences.

Culturally responsive science teachers understand that science demands a very high level of language to build scientific communication skills and in order to do that they have to create instructional methods to build vocabulary and scientific concepts. As science teachers attempt to create these specialized methods, they must ensure these methods bridge science vernacular to students' cultural language and concepts. In Brown & Kloser (2009) science teachers integrated students' native understandings of baseball and the concept of physics. In a longitudinal study of 15 high school baseball players over two baseball seasons, researchers analyzed their discourse practices to discover that the players' conception of baseball intertwined with the scientific concepts and ideas consistent with velocity and speed. Similarly, additional research focused on the intermixing of science and everyday discourse based on cultural referents. Because culture is dynamic, meaning that it changes day to day, science teachers had to incorporate the current culture of the students into the curriculum (Morales, 2015) and devise techniques to express it in multiple forms.

For Lundin & Jacobson (2014) their research into meaning-making of scientific concepts for students and their analysis of the human body expressed that talking and drawing can also be seen as two different modes of scientific communication among students. In their research, scientific literacy is seen as a situated activity in which meaning is relevant only when students are able to understand the science concept taking place.

Creating a science classroom, strictly teacher focused, robs students of the creativity necessary for them to explore and understand topics for themselves in science through the linking of their personal knowledge and scientific knowledge. Furthermore, if teachers have classrooms that are too student oriented, having students just learn the content on their own, it is possible that students might lose out in building their scientific knowledge. In either case,

science teachers need to strategically examine ways to set up science literacy practices into useable forms that will allow students to learn and use these additional resources to obtain science knowledge to promote scientific literacy that is engaging to students, lead them to reflect on the natural and physical world, and examine how science functions in their society (Enfield, 2017).

Scientific Identity

Science learning for some marginalized students is seen as a construct that has no relevance to their lives and their environment, especially when science teachers, who view diverse students in a negative light, create additional conflicts for them [students] that lead to "school avoidance, declines in behavior, and high levels of perceived aggression" (Rashid, 2009, p. 351). This creates an academic identity crisis in which they are perceived as failures within the classroom. Academic identity is defined here as "students' self-understanding related to their academic values, school belonging, regard and performance" (Pantoya et al., 2015, p. 61). The result is that the students create more damage than good for themselves, by taking a negative stance toward science and choosing alternatives from science learning, such as "skipping class and talking with friends instead of engaging in learning (Strong, 2016, p. 380). Science Identity, incorporates an academic identity, yet there is more. Carlone and Johnson (2007) analysis of the development of a science identity fits here as their analysis of a scientific identity incorporates "competence, performance, and recognition" (p.1196). Thus, the development of a science identity in the classroom, "hinges not only upon having the competence and interest in science, but also, critically, upon recognition by others as someone with talent and potential in science" (p.1197). Here, the academic identity is based on the student who is knowledgeable in science, yet the performance and recognition are what becomes problematic; difficult to acknowledge in

the classroom by teachers. With the *performance* aspect of developing a science identity, the student is seen as credible by their teachers as they enact relevant science practices within the classroom, such as communicating science terms, using tools, etc., and with the *recognition* aspect, the students are recognized by both "oneself and others (teachers, peers, community) as a "science person" (p. 1191).

Constructing a Science Identity. As cultural influences, such as race, ethnicity, and gender affect the development of a science identity, it becomes problematic as the teacher's ways of knowing and behaving as a scientist comes in conflict with the cultural values of their students, and their ways of knowing and learning science. Thus, in order to successfully construct a science identity for students, science teachers need to understand that, students have different cultural patterns of learning and understand that if particular student groups' cultures are not accepted, those student groups then start to associate with each other in the classroom and us that association as a defense mechanism to counter those stereotypes bestowed on them by the teacher and society (Noguera, 2008; Tatum, 2003). This grouping helps strengthen each other mentally in hopes to overcome those stereotypes (Emdin, 2009, 2011) placed on them by society and school and bestows on said group, a form of recognition and acceptance.

Although this paper is situated toward good science teaching practices for marginalized students, I provide the above background information, followed by articles from my review, to highlight how students are experiencing an academic identity crisis in the science classroom and how that crisis shaped the creation of a science identity through competence, performance, and recognition.

Examples of Culturally Relevant Science Teaching. Students are simultaneously negotiating and incorporating their culture within the science classroom while at the same time

maintaining a series of behaviors that garner them respect in the outside environment (Brooms, 2015). In other words, they are unconsciously navigating their dual identities into the academic arena (Brooms, 2015; Emdin, 2011). By teachers creating authentic science experiences within/outside the classroom, science teachers place students in situations that counter the norms of school behavior and create an environment conducive to their individual identities even in elementary school (e.g., Alexakos et. al, 2011); Elmesky, 2011; Pantoya et al., 2015).

An analysis by Walls (2012) on twenty-three third grade students (12 male/11 female) similarly showed how students viewed science teachers and the nature of science (NOS). These students viewed science as a "tool used by humans to learn about the world and its surroundings" (p.12), however when asked what a scientist resembles, the response was a "mature, intelligent, hardworking, White male, wearing glasses, and formally dressed in a lab coat" (p.15). This example demonstrates how *recognition* plays a critical role in the development of a science identity. If students recognize a scientist as a White male, wearing glasses, and formally dressed in a lab coat, students need to see, from the teacher, that they too can be recognized as a scientist as well.

Culturally responsive science teachers counter these views with successful people of different cultures who are viewed as scientists. These teachers understand how imagery plays an important role in shaping identity for marginalized students as they are able to reshape the narrative as to what a scientist resembles for them (Brkich, 2013; Kane, 2012; Varelas, 2011). By finding authentic learning experiences that integrate science through the incorporation of their cultural context and their language (Banner, 2016; Emdin, 2009) teachers are able to create an environment that matches their culture thus ensuring competence (academic success), performance, and quite possibly recognition.

Elmesky (2011) explored the role of culture in science teaching through her research pertained with three students, Shakeem, Ivory, and Randy and their use of rhyming in a science context. Her hybrid approach in understanding how integrating Hip-Hop and science education revealed that students do want to learn science, however, the approach that science teachers take to teach them the content is not always an acceptable practice. Her recommendation was for educators to vary their practice so that "students can be allowed to draw upon each other's dispositions as resources during science activities" (p.74) as a means to understand the content. This approach for students communicating science works twofold, (1) it allowed students to engage in social relationships that help students understand science both within and outside of the classroom (thus demonstrating competence and performance), and (2) allowed students to create a fictive kinship with each other (where students are able to recognize each other's competence).

Fictive kinship, described by Alexakos et al. (2011) is described as "bonds or identification between individuals" outside of a familial relationship (p.851). In their research of high school students (10 students which consisted of Black, Caribbean, and Hispanic students) in a college-level physics class, they discovered that the student's creation of familial bonds allowed them to create a safe space to emotionally support one another within the science classroom. Additionally, this allowed them to "cope, persevere, and succeed" (p.867) within the science classroom. With the incorporation of fictive kinships, students built close friendships with each other despite whether they worked together or not. In other words, they always seemed to communicate with each other regardless of their assignment and respect each other's opinions and values within the classroom. Here, science identity is displayed throughout the research. As the diverse high school students were knowledgeable enough to take a college-level physics

course (competence), the creation of fictive kinships allowed these students to [recognize] each other as physics students, thereby helping each other [perform] in the class by creating a safe space to support one another.

For science teachers of diverse students, the need to craft an environment for students to incorporate their own personal knowledge as well as have them investigate issues related to their lives is pertinent (Gonsalves et al., 2011). The understanding that science teachers have an obligation to adhere to the school district and the science curriculum is known, but they must situate their curriculum and instruction to create an atmosphere that allows for the construction of a scientific identity while simultaneously using the students' own language and beliefs in that process. Students of color are not a monolithic category requiring a single pedagogical approach, however. Implementing one particular strategy in one class may not work in another. As such, it is important that science teachers learn both, the community that they reside in as well as understand their students' learning capabilities as well. Pantoya et. al. (2015) provides an example of this as their analysis of teachers and how they integrated an engineering dialogue via literacy to elementary school students. They found that teachers in their study used varying strategies to "increase the level of scientific vocabulary, understand complex concepts, bridge connections between real-world conceptions of science and understanding experimental design" (pg.62) to build a strong foundation for scientific learning. This was created by developing strategies that continuously expose students to scientific characters and text on a daily basis. Additionally, as students started to develop a sustained interest (Basu & Calabrese-Barton, 2007) in science, their scientific identity started to improve, making them more knowledgeable about science and the world around them.

Environments for Science Teaching

Culturally responsive science teachers who use a constructivist approach in their classroom to incorporate not only the science content, but also the personal and cultural experiences of their students (Wright et al., 2016). This includes incorporating the prior knowledge of students and infusing it within the scientific content as well. For marginalized students, this is troublesome as they have to navigate a series of identity networks to get to their academic identity (Emdin, 2009)[5]. In this case, science teachers should discover techniques in which to reduce this navigation by altering the space of the science classroom that will allow students to be their authentic selves as they provide students with the opportunity to have science experiences that will allow them to experience science from a perspective that recognizes them as scientists and discuss concepts that are meaningful to them and other students (Calabrese-Barton & Tan, 2010; Chapman & Feldman, 2016).

In order for science teachers to successfully engage in this form of culturally responsive discourse, they need to understand how diverse students place themselves in the world and (Dentzau, 2013). Sense of place is defined here as how marginalized students view themselves both culturally and personally in particular situations. For science teachers, they need to examine the students and their place in the classroom as they learn science (develop competence) and navigate their academic identity (show their performance) in the process. As such, they also then, need to examine their own beliefs in understanding that every student and their "place" in society stem from their own unique experiences, how they navigate their culture, and their own social identities (recognition) (Elmesky, 2011; Southerland et al., 2012).

[5] For example, *Seiler, G. (2001). Reversing the ``Standard'' Direction: Science Emerging from the Lives of African American Students. Journal or Research in Science Teaching, 38(9), 1000 - 1014.*

Kamberelis and Wehunt (2012) provide an example for how the classroom environment is used for science teaching. Their analysis of student discourse in science experimentation denotes how students are able to tradeoff their academic and everyday discourse by creating an alternate environment for students to take ownership of their learning. The two students being researched, Kyle and Max, were able to interchange their discourse by applying their "knowledge of genres, social languages, and pop culture to bootstrap their knowledge of genres, social languages, and practices of science" (p.530) as they engaged in deep scientific discussion in their investigations of barnyard owls. Here, the teachers were able to construct an environment in which students were able to demonstrate (performance) their science knowledge (competence) using their cultural experiences. As for [recognition], as the teacher created the environment, the students were able to acknowledge each other as scientists, and possibly the teacher as they discussed science of the owls.

Through students' use of the classroom environment, they can perceive their classroom and learning experiences by constructing science through interactions with their peers in various settings. Their scientific thinking (competence), either individually or in a social setting (Alexakos et al., 2011) allowed them to distribute their ideas and power (performance) to other students as they make meaning for themselves as scientists (recognition) in their social settings (Rahm, 2008). As teachers use these spaces within their classrooms, the scientific language of the students becomes intertwined with the use of their pop culture references to create authentic learning experiences for all.

The classroom then become necessary as students navigate both their conceptual understanding of science and the academic definitions of science by finding ways to interchange both their common language with their academic language in the science classroom. As science

teachers use a constructivist approach to teach science, they are able to draw relevant personal knowledge to the science tasks at hand. This approach allows students to communicate their science literacy via literacy practices (reading and writing) and or talking in a scientific manner (Tank & Coffino, 2014).

Chapter 3—Methodology

This qualitative study investigated science teachers in an urban context and their relationship with good science teaching and their students. Additionally, this research examined how science teachers prioritized students' ways of knowing and learning science to assess their understanding within the science context (Feinstein et al., 2013, p. 316). Furthermore, this study examined how science teachers used culturally responsive science teaching in urban middle school science classrooms to assist marginalized students in helping them develop a science identity.

Research Design and Rationale

Qualitative Study Methods. Due to the nature of this research, I chose qualitative study methods because it was important to understand how "people interpreted their experiences, how they constructed their worlds and what meaning they attributed to their experiences" (Merriam, 2009, p. 23). Using these methods assisted me in understanding how middle school science teachers both prioritized their instruction and utilized culturally responsive teaching in their pedagogy. Using a qualitative study methods approach allowed me to collect data in the form of interviews and observations. This allowed me to examine phenomena by placing myself in the participant's environment, and use open-ended questioning to understand their beliefs, values and prejudices, while also examining mine in the process (Creswell, 2016). As such, the urban middle school science classroom was the environmental context in which I observed my participants and the science teachers, that instructed the students of color represented the real-life phenomenon under investigation.

When using a qualitative study methods approach, the researcher should be aware that they are studying a small number of people who are of interest with the extent they can provide

the investigator with useful information (Merriam, 2009). Additionally, as they inquire into the participants lives, the more they uncover, the greater the perspective as they look into the lives of individuals from "diverse cultures, racial groups and genders" (Creswell, 2016, p. 7). The participants under investigation were small in scope; three participants, with each observation of them lasting 4 to 5 days each.

Selection of Schools and Participants for Study

The goal of my research was to investigate how science teachers in an urban context think about their relationship with good science teaching followed by identifying culturally responsive teaching strategies and how they assisted marginalized students in the development of a scientific identity. In order to collect this data, my criteria for selecting school districts were based on student populations which consisted of students, who qualified for free and reduced lunch (50% or greater) and had a diverse student population. I contacted school districts via email that consisted of a diverse group of students within middle school classrooms. I then obtained permission from Montclair State University's Institutional Review Board (IRB) and secured all the necessary permissions to conduct research in the selected sites following IRB approval.

Purposeful sampling was conducted via the principal or vice principal to determine which teachers were considered the best representatives to teach middle school science (Creswell, 2016) for diverse students within their schools. Next, I spoke with multiple teachers within the school district that were recommended by the principal at different school locations to organize a timetable to observe their practice. In the beginning, my aim was to focus on one middle school, and collect data from 3 or 4 middle school science teachers within that school over one month.

However, due to time constraints, my selection process yielded three teachers in three different schools with a limited time schedule.

Data Sources and Collection

There were two primary data sources used for gathering data, interviews, and observations. I discuss each of these in detail below.

Interviews. To secure the interviews, I visited each of the participants, with the permission from the principals. I discussed with them the purpose of my research. The timeframe used to interview each individual teacher was between 5 to 15 minutes prior to the lesson and 5-10 minutes post lesson. I conducted a total of 20 interviews with Ms. Lera, 10 interviews with Mr. Moon, and 10 interviews with Ms. Padre. I then conducted one final member check interview with Ms. Lera and Mr. Moon. Ms. Padre was unavailable for the final interview.

The interview questions were designed to determine teachers' pedagogical knowledge of science strategies used in an urban middle school science class. Additionally, these questions also asked what good science teaching strategies were favorable to marginalized students. These questions were semi-structured; meaning they focused on specific questions with a series of follow up open-ended questions to probe the subject's responses (Merriam, 2009) and check for themes related to culturally responsive teaching. In qualitative research, according to Creswell (2016), qualitative researchers should pose sub-questions which provides the researcher greater specificity to the main questions utilized in the research and are helpful in understanding the results of the study. The interview guide used for this study is found in Appendix A.

Demographic Information. Demographic characteristics were collected from the teacher participants in the study. The following data was collected and placed in Table 5 (a) Pseudonyms, (b) Ethnicity, (c) Education: Degree and Certifications, (d) Urban School Name

Table 5

Teacher Participants' Demographic Information

Name	Ethnicity	Education (Degree & Certifications)	Urban School/Urban Descriptor (Milner, 2012)	Years of Teaching Experience	Grades Taught
Ms. Lera	White	B.S. Elementary Education / K-8 Elementary Education 6-8 Middle School Science	Pines Elementary School / Urban Emergent	3 Years	$5^{th}/7^{th}$ Grade (A/B Day)
Mr. Moon	African American/Black	B.S. - Sociology; Minor- Biology M. Ed.: Admin/Supervision, Doctoral Student - Ed.D./ K-8 Standard Certification, Supervisor Certification, Principal Certification	Padawan Academy/Urban Emergent	24 Years	8th Grade (7th/8th Period)
Ms. Padre	White	K - 12 Biological S B. S. Biology / Science (Alternate Route Program)	Corps Elementary School/ Urban Emergent	2 Years (Alternate Route Program- 2nd Year)	6th Grade (A/B Class)

and Urban Descriptor, (e) Years of teaching experience and (f) Grade Taught.

The personal backgrounds of the participants were designed to familiarized readers with the demographics of the teachers. This data was collected from each individual person and from classroom observations before and after instruction within the classroom. Though six participants initially agreed to participate, full data was collected and reported here on only three participants. One participant was provided a teaching assignment for an honors middle school science class

(8th grade), with only one African American male student in the class. Another was excluded because after initial observations, I determined that the teacher did not meet the study's selection criteria for "good teaching." The last participant withdrew for reasons unrelated to the study. All names and schools have been given pseudonyms to protect participants' identity and the location of their workplaces.

Observations. I visited each participant's classroom to observe their teaching practice over consecutive lessons. By observing the participants in their classroom, I was able to understand and capture the context of how these teachers interacted with their students in their classroom environment.

These observations lasted for a duration of 45-60 minutes per day for 4-5 days per participant. As these observations entailed sitting unobtrusively in the back of the classroom and making notes during the lesson (Creswell, 2016), this allowed me to get an understanding of their practice and a sense of their urban middle-grade science teaching contexts (Emerson et al., 2011). This allowed me to carefully identify possible instances of culturally responsive teaching practices, as well as collect evidence to help me identify what the teachers prioritized in their classrooms to assist them in the development of a scientific identity for marginalized students. Additionally, this permitted me to see actions and perspectives that might have escaped the interview process as well.

Timeline

Following the approval of my proposal from my dissertation committee and successful completion and acknowledgement of my consent letters from the administration and teachers at the proposed research site, I estimated that I would be able to observe and interview each teacher for one week. Unfortunately, due to time constraints and the issue of obtaining acceptances from

various school districts, my window of opportunity allowed me to interview 3 teachers for 4-5 days.

Research started during the Fall of 2019 (between November 11th - Nov 22nd, 2019). The process lasted for two weeks. I estimated that 1 week per teacher would be sufficient to obtain data on teacher practice. My timeline of interviewing my participants is outlined in Table 6 below.

Table 6

Timeline of Research for Observing Culturally Relevant Science Teacher Practice

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
	11/11/19	11/12/19	11/13/19	11/14/19	11/15/19
Mr. Moon Ms. Lera (5th grade)	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview*

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday
	11/18/19	11/19/19	11/20/19	11/21/19	11/22/19
Ms. Padre Ms. Lera (8th grade)	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview	Pre-Interview Classroom Observations Post Interview*

Data Analysis

According to Creswell (2016), the "qualitative researcher analyzes the words to group them into larger meanings of understanding, such as codes, categories and themes" (p.19). The data collected from the preliminary and post interviews, the field notes from my observations and reflection memos; they were organized into a manageable system in which the data was housed into various themes and categories under the semblance of culturally responsive teaching.

Creswell (2016) notes the importance of placing data into a reasonable form for analysis. By placing them into themes, this practice allowed me to find pertinent information that was both insightful and significant for my research. I was able to take words, and phrases and place them into particular themes. By creating labels and noting particular thoughts and concepts within the text, this allowed me to understand what the participants were expressing in their classrooms, and which teacher practice corresponded to my research.

I used an inductive and analytical approach to interpreting the themes. For my inductive approach, my notes were read and re-read to interpret meaning, identify key words I wrote through my observations of the participants' practice, interviews, concepts, and particular phrases they used either once, on any given day, or on consecutive days.

During the categorizing process, one question guided me along the process: What stood out within their practice? This question helped me think about urban middle school science teachers and their pedagogy as a whole as I navigated my research, my biases, my beliefs as an African American middle school science teacher with over fifteen years of experience as an educator, and as a novice academic researcher.

Trustworthiness

As a science educator myself, I was conscientious of my identity: a Black, male science educator, making sure that my views and opinions in regard to culturally responsive teaching practices was not expressed or implied during the interview process or during my role as an observer. This included making sure the teachers were in a comfortable position to discuss their teaching abilities as science educators and reinforce to them that my goal was to improve science learning for students of color in urban middle school science classrooms and not to exploit them as subjects.

Triangulation. Merriam (2009) defines triangulation as "cross-checking data collected through the use of observations at different times or in different places or interview data collected from different perspectives or from follow-up interviews from the same people". To establish trustworthiness for my case study, interviews with my participants was necessary in order to establish themes throughout the data and to find disconfirming evidence, which could counter the 'themes' established (Creswell, 2016). This allowed my evidence from the themes investigated to be either acceptable or paint an alternative picture opposite of them. By providing follow up questions to the participants via member checking, this ensured the data collected from them would be accurate and devoid of any misleading information.

Member Checking. A member check was conducted for any emergent findings conducted through fieldwork and to limit the amount of misinterpretation in the data. Creswell (2016) identified member checking as very important as it allowed both the research and participants to identify any "inaccuracies in observations, any themes that may be missing, and what participants disagreed with" (p.193). Participants were emailed a summary of my observations of them to discuss with me if there were any discrepancies in my analysis. Additionally, follow up questions were asked as well to rule out any misunderstandings I may

have had with my participants and my observations of them. Only two out of the three participants were available for the follow-up questions.

Reflexivity and Bias

Creswell (2016) noted that researchers "bring their own cultures and backgrounds" to the research and that "shapes how they view the social world they see" (p.8). As such, as I am an African American male who has experienced teachers who have doubted me, I find it crucial that my data needed to be recorded exactly how it was observed. During my observations, I listened to the instruction of the teachers and noted any particular aspects of their lessons in my notes that resembled culturally responsive teaching. This allowed my research to be as accurate as possible as I distanced myself from bias. As I actively listened to my participants, I was able to follow not only what was being stated, but what was being meant by their statements (Yin, 2003).

The themes that I shared in chapter four reflected the results of my observation and reflected the lens of my conceptual framework, which was created under the guise of Calabrese-Barton (2003), Ladson-Billings, (1994) and Villegas & Lucas (1994). Chapter 5 provides a discussion across all three cases, answering my second research question and concluding with a discussion of how my research assisted in laying the groundwork for my analysis of middle school culturally responsive science teaching.

Chapter 4 – Findings

This chapter reports the findings of this study based on data collected from three middle school science teachers and the culturally responsive teaching practices each teacher used within their classroom. Each teacher is presented separately with data about their school, followed by a description of their physical classroom. Next, I will discuss each teacher and their approach to using culturally responsive science teaching with specific examples from teacher interactions and statements from interviews. Each teacher's case will conclude with an analysis of their practice through the culturally responsive teaching (CRT) lens of Ladson-Billings (1994), Villegas and Lucas (2002) and with a specific focus on how science teachers prioritize their teaching (Calabrese-Barton, 2003) and are able to build that cultural bridge to effectively teach marginalized students

Ms. Lera: 5th and 7th Grade Science Teacher

Pines Elementary School

Pines Elementary school is a Title 1 school situated in the northeast section of New Jersey in an "urban emergent" school district. The schools' student enrollment consists of 397 students, with the school's racial demographics having 47% Hispanic, 50.5% African American or Black, 0.5% White, and 2% Asian students. Ms. Lera taught fifth, sixth and seventh graders on a weekly basis. Within her classroom, Ms. Lera's walls are fortified with science posters and science stations that comprised of an area used for laptops, a station for students' binders that are used for science note taking, and an area for students to leave their coats and bookbags. Additionally, most notable within her classroom, was a science station that encompassed a "refuel" area for students to get tissues and resharpen their pencils, with a science poster that

focused on what makes a scientist. She also allowed them to drink water in class to prevent them from leaving instruction.

Ms. Lera

Ms. Lera identified as a White female teacher, who had 3 years of teaching experience at Pines Elementary School. Ms. Lera indicated that she enjoyed teaching at Pines, saying, "It's like a family" (Interview, 11/19) with teachers assisting and helping each other out at times. She interacted with her students like a concerned family member, meaning if students were having an issue with their assignments or any personal issues, she was willing to offer assistance and guidance. Additionally, she also stated that:

> Students at the middle school level are experiencing copious changes within all aspects of their lives. Although it can be challenging at times, to consider these social and emotional adjustments, it makes my profession and rapport with my students [more] meaningful. (Questionnaire Response, 11/13)

Although Ms. Lera's educational program prepared her to teach science, she reported that it did not prepare her specifically to work in urban areas. As such, she created adjustments to her practice that seemed to assist her greatly in her science pedagogy. During her program, she gained teaching experience by working in kindergarten, 7th and 8th grade, in various school districts in New Jersey. Additionally, she also worked, subsequent to the program, as a permanent substitute teacher for a 2nd grade inclusion classroom.

Ms. Lera reported that her closeness with her students was based on the fact that she "looped with them since 5th grade" (Interview, 11/19) and it created within her a disposition to care for her students. She "loves her kids" (Interview, 11/19) and she felt that they "need somebody in their life…to look up to" (Questionnaire Response, 11/13). She was both

compassionate with her students, and fair with them. Ms. Lera is considered a novice teacher, yet she also had curriculum experience as she was able to work as a summer curriculum writer. This allowed her to understand her pedagogical practice more closely and adjust her pedagogy when necessary for her students.

Ms. Lera's teaching day at Pines Elementary consisted of three different lessons for ninety minutes a day, every day, for the school year. Her love of her students and the family-like atmosphere of the school staff were the motivating factors that made her teaching experience at Pines worth the commute.

Teaching Practices for Students

Sense of Equity. Sense of equity, defined by Calabrese-Barton (2003) describes how science teachers use what is presently in the school, the science classroom, and the environment to lead science discussions and have hands on science experiences for successful teaching by being creative and inventive. Ms. Lera's approach to developing her student's science identity consisted of crafting an environment that encompassed a sense of equity between her and her student population. Here she focused on using the school's science materials, provided by her district, and incorporated students' personal environments to help them negotiate their scientific ways of thinking and behaving. Her belief, with her student population that consisted of students of color, was that she was there to help them, by being a role model for her student population:

> For me, particularly, my vision of a strong science teacher or good science teaching would definitely be somebody who not only uses methods of taking notes and presentations but also incorporates those hands-on experiences…. I think, providing those hands-on resources, allowing students to experiment with topics and really be able to not

> only physically work with materials, but be able to explore the topics critically by critically thinking, I think that really shows. (Follow-Up Interview, 1/5)

She approached her work with her students as more than just an educator. She saw her work more as a family member, being protective and endearing with her students:

> Building a rapport with them is a really big thing, but I don't think a lot of educators realize how important that is and I don't know if it's maybe because I'm in an urban area versus other educators who are not...When I'm having conversations outside of work, I just; I don't call them my students, my kids like 'oh my kids', I just, it comes so natural to me because they are…I care about them in a sense, where if they're going to be going home and having an issue that doesn't relate anything to science, I'm totally willing to sit with them and having a conversation and help them work through it.

Ms. Lera's approach to the handling of her students also extended beyond the classroom. She provided not only a sense of equity for her students, but also provided a gentle, warm demeaner as she was willing to sacrifice her time to speak and help her students with personal issues, if need be. For example, during my observation of her, there was one instance where a student was off task during a lesson. Rather than speak with the student loudly about his disengagement for the class to hear, she walked over to the students and softly spoke with him. The student explained that the reason for the disengagement was because he did not understand the assignment and instead of being embarrassed by asking what to do again, he retreated to just working on his computer on another assignment. Ms. Lera, rather than chastise him, reexplained the assignment and assisted him without any reprimand.

In line with culturally responsive teaching as portrayed by Ladson-Billings (1994), successful teachers of students of color are those who care about their students' well-being and

their personal success. Thus, providing a culture of caring for middle school students seems a necessity as relationships between teachers and students become genuine and students' perceptions of their teachers resemble more of a familial parent or close relative. Examples of her caring demeanor are demonstrated throughout the themes below.

Academic Success. Ms. Lera's approach to ensuring that her students are successful in science, was based on a myriad of factors that included the usage of the school district's science tech applications incorporated with various pedagogical strategies that resembled culturally responsive science teaching.

Use of Technology. Students in Ms. Lera's class used various scientific technological applications such as *Readorium*, *Gizmo*, and *Discovery Education*. In her classroom, students used these applications to assist them in the building of their science writing abilities. For example, during Ms. Lera's lesson on continental drift for her 7th grade students, she split the class in half to have some students work with her on a project and the other half to work independently on their science essays, using *Engage, Explore* and *Explain* strategies. Following the geological time scale project, Ms. Lera had students respond to the research question: "What are plate tectonics, how are they related to changes that occurred on the Earth's Surface?"

Ms. Lera allowed her students, who were working independently, the opportunity to respond to their essay by allowing them to use their Geologic timescale projects as a resource and various readings from the science site, *Discovery Education*. As students worked on their essays, trying to gather their thoughts, some students were confused as to what they could provide as evidence for their essays. Ms. Lera, noted the emerging confusion and assisted her students:

> Well, yes, you kind of want to get an idea of what your points are going to be before you just go into writing. So yes, so come up with your claims. What are the claims that are going to help you answer the question? So, what is your topic? Good. How are plate tectonics related to changes that occur on the earth's surface? Make sure that your claims have to do with that question. (11/19, 7th Grade)

As she aided her students, she also expressed concern for them as she was willing to do what was necessary to make sure her students understand the exercise. This included altering the writing prompt, changing the number of paragraphs required, or just having them identify the thesis statement:

> I'm telling you; I'm not going to give you a set number. I want you to... *This is the beauty of science.* I don't have a kind of guide here. I want you to come up with the evidence. If your evidence takes three paragraphs, cool. If your evidence is only going to be one paragraph, okay. *But it's about the quality*! I don't care about the quantity. But that's not just, "Oh, okay, I can just give one paragraph." No. You still must have the detail and the evidence and the reasoning behind it that explains thoroughly, okay? Yes? (11/19, 7th Grade)

Ms. Lera's approach to teaching science using technology ensured that students were able to understand the content and express that content in their own words. Additionally, her guidance through the science writing process effectively assisted students as they identified what they did successfully or unsuccessfully during the assignment. Ms. Lera's approach to ensuring academic success for her students was based on the following pedagogical strategies: She provided academic assistance for her students as needed by altering the science instruction based on her students' needs and abilities. Additionally, her approach to her students was to get them to

provide “quality” work, whether it was one paragraph or three. She also ensured that her students were successful by encouraging them to take a more positive role in their science learning. Ms. Lera also provided an environment of caring both in and outside of class as she offered genuine support for her students. Academically, she wanted them to try to complete the assignment and become successful regardless of the instruction. Personally, she wanted to provide students with an atmosphere that informed them that teachers really do care about their success. Overall, Ms. Lera understood that her student population had trouble expressing themselves on paper and had to reestablish the learning community in order for them to be successful. This included changing her pedagogical strategy of what it meant for students to write a science response essay. The altering of this assignment reflected both the personalities of the students, their level of interacting with the assignment and creating ways to get her students to showcase their writing skills in the classroom.

Honoring Students Ways of Knowing. Ms. Lera’s approach to ensure her students comprehended the science assignment incorporated a two-part process: 1) By meeting students at their learning ability and 2) By offering help when students did not want to admit they needed assistance. Regarding students’ ability to learn, Ms. Lera knew her 7th grade population as she had looped with her students since the 5th grade. Using compassion as a tool to improve the performance of her 7th grade population, on several occasions, Ms. Lera expressed to them that if any student had an issue or a problem with any of their assignments, she would assist them and help them, but only if they acknowledged they were having issues.

For example, when her 7th grade students had issues with their science projects on *Eras and Periods*, she offered guidance by informing them that they first needed to ask questions before she can assist:

> Two years each. Okay? I see, oh, now we're understanding. Okay. So, as you're doing your project, what I would like you to do is come up with five different events. So, say one of your events was learning how to ride a bike. Learning to ride a bike. Okay? So not only did some of us not do our projects, but we didn't do it correctly…. So please focus right now because I'm giving you the opportunity to fix it. And looking at some of your projects, not everybody did it incorrectly. But those of you that didn't, maybe you were confused by it a little bit, or didn't do your project over the break like you were supposed to, that's a problem. Pay attention, please, so I can help you. I can't help you if you don't ask questions because I have no idea. All right? Come on. (11/12, 7th Grade)

Students in her class were not very forthcoming when they had issues with their projects in the beginning, however after she communicated with them using a compassionate conversational tone rather than using authoritative speech, students started to ask questions and admit their issues.

As Ms. Lera provided a safe space for students to confess their issues in learning science, a student named Neil (pseudonym), not only had an issue with the project itself, but also in publicly speaking about the project. Ms. Lera accommodated him and worked with him to prevent him from being embarrassed. She mentioned that she was proud of him, asked if she could accommodate him by closing the door and proceeded to guide him through the project. When Ms. Lera, closed the door to the classroom, she demonstrated to Neil, that she was willing to assist him by making the classroom as comfortable as possible for his authentic self to be present in class. Additionally, she also revised her questioning to accommodate his science research as well.

Furthermore, when students had issues with their claim, evidence, and reasoning assignments on continental drift for their *Discovery* platform assignments, Ms. Lera continuously reminded them that she would be available to assist and guide them using a compassionate conversational tone:

> All right, even if you think that you are cool and you're like, "All right, I got it, I don't have any questions," just ask me to clarify. Because when I'm moving around and being like, "Do you know what we're doing?" I have people who are just looking at me. But I just asked, is there any questions, does everybody got it and nobody raised their hand. Everyone was like, "Yeah, we're cool, we're cool." If you're confused, you need to let me know… (11/19, 7th Grade)

Her ability to speak with her students in this manner helped them in confessing their issues with their writing assignments. As students started to express what actual areas of the writing assignment, they were having problems with, students felt comfortable in confessing their errors and mistakes after the conversation rather than prior. Here, Ms. Lera's approach for working with and supporting diverse students is rooted in culturally responsive teaching as she fashioned her classroom to be supportive of students' learning.

Ms. Lera created a student-centered classroom in which students felt empowered to express their issues, engage in science content by becoming active learners (Basu & Calabrese-Barton, 2007) and allowed students to share their knowledge to their peers with students took notes, asked relevant questions and engaged in scientific discourse (Ladson-Billings, 1995a) without fear of embarrassment.

Creating Spaces for Science Learning. As a science teacher, one of Ms. Lera's goals for her students to learn science consisted of creating a community of learners to help them discuss

science in a manner that was conducive to her student's own language. Because she looped with her students, she established a foundation for learning with her fifth-grade population:

> When they're coming in and I'm thinking about my students…I know that my fifth graders are probably going to be way more excited for whatever it is we're going to do. I don't know if it's just like their level of learning still or they're level of maturity. I can't really put a pinpoint on it, but for the last several years, my fifth grade seems to be the most engaged with science. (Follow-Up Interview, 1/5)

For her 5th grade population, Ms. Lera's pedagogical approach to create an alternate space for students to communicate their research and findings to her started at the fifth-grade level. For example, with Ms. Lera's 5th grade student population, the students examined the solar system by using a deck of solar system cards, but used a more personal approach, by allowing them to investigate commonalties among the celestial bodies:

> I'm going to pass out these solar system cards to you guys. There are planets in here. There is [the]sun. There are, let's see what else we have, asteroids. There are comets…
> …With your group, you're going to try to organize these cards, the best that you can, how a regular solar system works. You guys have a little advantage because I have the planets up at [the] front. Try not to use them though. (11/13, 5th Grade)

Though Ms. Lera's directions may have sounded vague, she reported that the ambiguity of the instructions were designed to allow students to create organizational strategies on their own as they arranged the solar system in accordance to how each group approached the lesson. As Ms. Lera approached students working in their groups, her main question appeared to be the guiding focus of the lesson:

> How are you classifying these [planets] into groups? How are you grouping them together? …Get a rough idea of how the order goes but I want you to try to classify them into different groups. You can go based off color, based off shape. What do you think? How are you going to put these into different sections? How are you going to separate each of these planets or each of these objects that are in the solar system? (11/13, 5th Grade)

By allowing ambiguity in the instructions, Ms. Lera created an environment for students to experience trial and error in their tasks and provided for them, a comfortable experience for students to learn science in the process. This pedagogical strategy reflected the tenets of Villegas and Lucas (2002b) as her approach to instructing her students was by creating a constructivist view of learning for her students. In this lesson, her vagueness with the instructions allowed students to construct their own personal learning by involving students' own experiences, with peer group discussions. In this example, the students' learning represented the process in which they were able to generate meaning with responses leading to new beliefs, assumptions, and theories. Overall, Ms. Lera provided a constructivist atmosphere for her 5th grade students to experience science in a way that fostered learning through observation, grouping and collaborative working with peers.

Incorporating Students Culture

Though I did not hear Ms. Lera mention or discuss any BIPOC historical events or scientists during my observations of her pedagogy, I did observe that she infused students' culture into the curriculum. Ms. Lera's approach to incorporating student's culture was through merging science lessons that focused on students' lives within the nature of science itself.

Science and Culture. Ms. Lera's instructional practices in the classroom were designed to build student's knowledge of science on their own accord. During my observation of her pedagogical practice, her 7th grade students discussed their science projects within the class. The student's science projects consisted of a *show and tell* using a geologic timeline of their own personal historical events. Students discussed five events in their lives and classified them into different time frames and labeled them as either geological *Periods* or *Eras.* This methodology of incorporating students' culture within earth science was one pedagogical strategy Ms. Lera used to scaffold students' knowledge of their family, their culture, and their personal identities under a science context. This strategy in cultural competence allowed students to share knowledge about a specific topic (their lives) to their peers while students asked relevant questions through scientific questioning. This approach was also a way for the teacher to get to know her students as well. This assignment also provided a bridge for students' culture to be recognized by each other as they discussed their own personal story using science as a medium.

Science Writing and Culture. Ms. Lera created an environment where students could be successful in scientific writing by offering guidance and having students approach the issue of writing on their own. Ms. Lera had students work on their writing assignments on their own and if any problems occurred, aid when necessary. Ms. Lera divided the class into two groups and proceeded to work with one group collectively as the remainder of the students proceeded to do their independent writing assignment. Students had a degree of responsibility for their work as she allowed them to question and make mistakes and she use those mistakes as learning opportunities for the group. For example, when the independent students had an issue with the writing assignment, Ms. Lera offered guidance:

> Your intro and your closing are separate from your claims and your reasoning and your evidence. You're trying to answer this question. So, the Can You Explain (CYE) question is the response that you are coming up with. That's all you're formulating. Your answer, based off of that question. Okay, so, when you're writing, you want to try to answer that question because that's where you're going to develop your claims from, based on that information. So, what I would do is brainstorm a little bit while you're reading.
>
> Take some notes to try to answer this question. If you want, write the question down. So, on an empty piece of paper, what you can do is have this question on the top of your paper and as you read, jot down some points that help you answer this question. That way, when you go back to write your answer or formulate your essay, you're going to be able to come up with claims and then you'll be able to write your evidence and your reasoning much more quickly. Yes. (11/19, 7th Grade)

When a student asked if having evidence was enough, she responded:

> As long as you have evidence for it, can you be wrong. As long as you're supporting your claim and it's not like so far stretched. Take the evidence that you find in the [Discovery] Program... Don't just take it from anywhere. (11/19, 7th Grade)

When a student asked about the number of paragraphs that would be needed, she replied informing them that the quality of the paragraph was more important than the quantity.

Here, Ms. Lera's approach ensured her students had grasped the concepts of scientific writing as students first worked in their writing communities to question each other's approach to the science problems and if those issues exceeded their own writing abilities, they then asked the teacher to gain further understanding. Additionally, by offering no ideal set number of paragraphs for this assignment, Ms. Lera provided a way for students to respond to the

assignment in their own way. Ms. Lera's approach to scientific writing allowed students to respond with as many sentences as possible if they could explain their reasoning altogether.

Summary of Ms. Lera's Science Teaching

Ms. Lera's approach to teaching science was one that allowed her students to think and discuss content within the classroom, as well as to be creative and have meaningful authentic learning experiences that incorporated their opinions and ideas. Furthermore, she crafted *bridges* to incorporate students' prior knowledge while including new ideas and experiences within the conversation using students' culture as the foundation (Villegas & Lucas, 2002a) for her lessons.

Ms. Lera's approach to creating bridges and incorporating their knowledge into classroom activities was twofold. First, for those students who "looped" with her from 5th grade, her experiences working with them from grades 5 to 7 cemented specific strategies that she felt worked best for her students. Secondly, Ms. Lera was able to create visual models to bring vague academic concepts to life by having students engage in cooperative science learning with their peers. Here, Villegas and Lucas (2002) would describe Ms. Lera's approach to teaching in which she negotiated students' ways of thinking, behaving, and using their language as being sociocultural conscious in which she was able to understand her students' perspectives over time, and how they viewed science and their world at large.

Ms. Lera's approach to constructing relationships with her students and differentiating science assessments to her students' liking, created an authentic learning space for students to receive instruction and translate said instruction by having them use their own language to interpret and better understand the concepts of science.

My classroom observations of Ms. Lera in helping her students develop their science identity revealed that she was focused on the competency aspect (academic identity) of her

students. On numerous occasions, she assisted her students to get them to perform by creating personalized learning opportunities for them, yet at times, they needed assistance in demonstrating their competency. As she laid the foundation for her students in learning science in fifth grade and looped with them accordingly to help them build up their science competency by using students' own knowledge to communicate their thoughts and ideas with each other, the recognition of them being "scientists in their own right" appeared minimal as students were not able to express particular science terms and contexts.

Mr. Moon: 8th Grade Teacher

Padawan Academy

Padawan Academy is a Title 1 public school located within an "urban emergent" school district that is located within the northeast section of New Jersey. Although, Padawan Academy is considered an urban emergent public school, the term preparatory is used to describe how teachers assist students in preparing them for the academic rigors of high school. Encompassing only 8th and 9th graders, the school's student enrollment at the time of this study consisted of 679 students with its racial demographics comprising of 44.5% Hispanic, 55.1% Black or African American, 0.1% Native American and 0.1% Asian students.

At Padawan Academy, science teachers worked together to design science assessments for the science department. The goal for this collaboration was so the school "can collect data and see where the weaknesses are and are not across the board to ensure the supervisor can assist the teachers to keep growing" (Follow-Up Interview, 1/02). This approach was developed between the administrator of the school and the science supervisor to ensure that science teachers are not misguided and doing their own thing, thus disrupting the district's vision of educational equity. The district does provide flexibility, in that the teachers were able to design their own

quizzes, yet the quarterly exams, finals, or midterms were generated collectively. To note, when teachers created an assessment, the science supervisor had to approve the assessment in order for it to be distributed to students.

Mr. Moon's classroom consisted of lab tables with a series of lab chairs arranged in groups of 4-5 students per table. His walls were covered with big easel pad styled post-it notes around the classroom with science references and definitions. Student work was also displayed in front of the classroom (parallel to the white board and the entrance of the classroom) for students to see their academic achievements. Intertwined were various affirmations informing students "not to give up," followed by various morals for students to live by. One area worth nothing was the teacher's desk itself. Although it is positioned in front of the class, the teacher's seat was positioned in front of his desk. During my observations of him, he never sat behind the desk at all during instruction.

Mr. Moon

Mr. Moon identifies as an African American male who has been in the teaching profession for approximately 24 years. His educational background consisted of a bachelors' degree in Sociology with a minor in Biology, a master's degree in Education, with a concentration in administration and supervision, and at the time of this study, he was enrolled as a doctorate student in a university in New Jersey. Prior to teaching, Mr. Moon worked in an environmental laboratory as a technician.

Mr. Moon was aware of the delicate balance of not only being a middle school science teacher, but also an administrator, a science coach, and working with students as a counselor, semi-parent, and for some, a friend. As he provided guidance when teaching middle school science, he felt this was especially true for his students of color who were heading into a high

school environment. Although he has taught many grades, his preference was middle school as he understood the challenges that came with it:

> After teaching every grade level, I prefer the challenges of middle school. Middle school students are not mature enough for high school yet not as immature as elementary school students...Middle school students are chemically challenged. Puberty brings them into a very confused state of being where they do not know if they are children or adults…. They have to develop social skills that are acceptable to others as well as themselves. Middle school teachers must be aware of these challenges and work to make these transitions as smooth as possible. (Interview Questionnaire, 11/8)

For Mr. Moon, caring played a critical role in his pedagogy as he provided opportunities to create personal connections with his students. By approaching his students in this regard, he was able to work with them and created lessons that connected to his student's life. His vision for his students to succeed in science involved allowing them the "opportunity to explore, make mistakes, and use science equipment" with the hope that they could get a "good STEM job, or any job that pertains to science" (Follow-Up Interview, 1/3). Mr. Moon's approach to his students involved a variety of pedagogical strategies that allowed his students to flourish both academically and emotionally in science and in their lives.

Mr. Moon's entry into the teaching profession was a second career choice. Once he was laid off from his job as an environmental technician, he decided to pursue teaching through an alternate route program which afforded him the opportunity to obtain his teaching certificate. Within the program, he stated that he was not "trained as a teacher per se, but was able to learn pedagogical techniques and methodology through the state of New Jersey" (Interview Questionnaire, 11/8) to become an efficient educator and while "formal training did not teach

him to handle all the nuances of working with children in an urban educational setting," (Interview Questionnaire, 11/8) he asserted that being a person of color himself allowed him the social emotional skills to instruct students of color:

> Being a Black child growing up in suburbia and in some urban settings gave me more insight into the backgrounds of these children that I would be teaching….
>
> Having one on one experiences with so many African American males, Hispanic males and various children who have special needs, I have collected a variety of skills that I did not receive in a college setting. (Interview Questions, 9/29)

Although his alternate route program prepared him to be a teacher, the program was not specific to an urban middle school teaching program. His journey into middle school science first started as a substitute teacher for a third and fourth grade class in an urban school district and then, he was hired as a Math/Science/Technology teacher for the 7^{th} - 8^{th} grade. His approach toward teaching was anchored in a shared personal identity with his students. His belief was that "Honesty, integrity, personal conviction, and strength are the most important characteristics to possess as a middle school teacher" (Interview Questionnaire, 11/8) of students of color. Additionally, he felt his students could relate to him because he spoke to them as a person they can trust.

Mr. Moon's approach to ensuring his students could trust him followed the tenets of Calabrese-Barton (2003) and Villegas and Lucas (2002a) in which he created an environment in which students could interact with their teacher and he, in turn, could engage with them on a more personal level as he sometimes discussed with them any "social issues or insecure feelings" they might be having. With the understanding of his students' emotional and social needs, followed by an observation of his pedagogical practice, I was able to identify particular themes

during my observations that helped him create, for students, a scientific identity and in turn, enhanced their scientific literacy, which are discussed below.

Teaching Practice

Second Chances. Mr. Moon's approach to ensuring that his students were academically successful in science was by allowing students opportunities to complete their work (before the cycle ends) and he enforced those opportunities through conversations with his students individually, and by having conversations with students' parents or collectively, with students as a group.

For example, Mr. Moon discussed with me about how he had to have a meeting with a student's parent to discuss their behavior and how that meeting led to a change in the student's attitude and behavior:

> His dad came in and... then he showed up. And he said, "I'm tired of this"…And I'm telling you he did a 180. Since his father came in, he's been on top of everything, all his work is done, project got done, homework was getting done, and his grade went out from the 50 up... It's now in the 70s… It might be a little higher than that now. I'm like, "Did you check your grade? See, you need to." Because his father said, "I want you to open him up too. I mean it. You know, bust him up!" Said, "Oh, Lord." Busting up people's kid, boy. Huh! (11/13, 8th Grade)

This example demonstrated his practice of developing a repertoire with his students' parents as well as the students themselves. Although, the parent above said jokingly to the teacher to 'bust his son up' (to physically discipline him), the relationship between the teacher and parent demonstrated that the teacher was seen as an extended family member in addition to being an educator. This conversation would be described by Alexakos et al. (2011) as a *fictive*

kinship. Here, a close friendship manifested between the parent and teacher as they worked together to assist the student's development of his academic identity. Close bonds are key between individuals in a fictive kinship as outside members become extended family members. For BIPOC, fictive kinships commonly describe close friendships between strangers by incorporating them into an external family with them being labeled as a "cousin" (relationship between peers), "uncle", or "auntie" (relationship between adults and children) (p.851). For the example mentioned above, the development of a fictive kinship allowed the student to look beyond the science classroom as a classroom with four walls, but rather, a room in which Mr. Moon, would be considered an "uncle" to the student whose purpose is some respects, is to take care of family.

Collectively, Mr. Moon had conversed with his students during my observations to ensure that they would be able to complete their schoolwork before the end of the first term. His approach to ensure that students were able to complete their academic work, is of interest here as he used two methods: (1) storytelling and (2) applied pressure, to pursue his goal. These two methods provided students a second chance to complete their assignments before the end of the marking period.

Storytelling. Mr. Moon's approach to convincing his students to be academically successful was by telling stories of failure and success by using his children as the main characters. Mr. Moon spoke with his students in regard to plagiarism and missed homework assignments and discussed with them how plagiarism was an academic problem that could lead to more severe consequences in high school. The parallel between his students and his family in this story pertained to the student's missing homework. He explained to them that his children were missing assignments and that they forged his signature on their progress reports. As a

result, he removed the doors from their rooms and informed them until "life got better," meaning homework was completed, classes were attended and grades improved, the doors would not be returned to their hinges. Overall, the purpose of this conversation was to demonstrate the academic expectations of his students and to inform them that if they did not complete their assignments before the end of the cycle, life could be problematic for them by their parents.

Applied Pressure. The pressure that Mr. Moon applied to his students was in the form of negotiating with his students as to what to do with their test scores for the first cycle:

> Now, we need to have a discussion. All right, wait. Now, we need to have a little discussion on what we're going to do with these grades because the marking period is closed today, closing. I still have a little bit of wiggle room of what I can do with this particular grade. I'm a little concerned. So, can I see the show of hands... No. If you have 80 or above, bring me your paper. I love the level of concern that is raised. I love it. …Should I put this in as a first market period grade? I need you to give me some reasoning for the evidence. (11/13, 8th Grade)

Here, Mr. Moon, offered them a chance and a choice. He gave students a chance to decide how this last grade affected their academic outcome and as the students realized they had a choice to decide which term this grade could be inputted, they established a democratic voting system, that allowed them to decide whether to place their test scores in their first cycle grade to improve their overall performance for the first cycle or start their second cycle grade with a higher grade point average. Here, Mr. Moon's approach to improving their academic success consisted of allowing them to decide whether or not their grade(s) were important to them. It is important to note here that for Mr. Moon, 1) students seemed excited that Mr. Moon listened to them and 2) Mr. Moon gave students a choice in which to improve their science grades so that, even at the

end of the marking cycle, students still had an opportunity to put their best foot forward; yet this effort, the development of their science competence, was not shown here. To explain further, this observation did not directly link to the development of a science identity. Instead, it highlighted the environmental context of the classroom and how it can sometimes take on a life of its own outside of the context of science learning. Here, Mr. Moon, understood the culture of the classroom and had to lay the foundation for them in developing their scientific competence, by first providing the reasoning for why grades in science are important.

This empowerment paralleled the academic success of Ladson-Billings (1995a) whereby teachers created opportunities for students to choose academic excellence and referencing the tenets of Villegas and Lucas (2002b), the teacher also engaged students in issues that were meaningful to them. Although it did not lead them to develop their science identity here, the next set of themes laid the groundwork for the development of an academic identity and possibly a science identity.

Use of Technology. Mr. Moon's approach to ensuring his students were successful in science appeared driven by the use of scaffolding through technology. As students used scientific applications (apps) for their assessments and their science projects, his students used various apps to assist their science learning in discussing science topics. Additionally, students used their notebooks and FOSS kits to assist them in lab exercises, yet the science applications were the main component of his classroom during my observations. For example, he incorporated mini quizzes using the app *Kahoot* to help students remember the various science terms and definitions used in physics. Some of the applications that Mr. Moon used in his classroom were *Discovery Education*, *Readorium, Google Classroom*, and *Gizmo*. During my classroom visits, I observed students using *Kahoot, Google Classroom* and *Gizmo*. Mr. Moon's usage of technology

in the classroom helped students easily recall information in a rapid sequence as well as having students communicate with each other as they discussed scientific phenomenon. Additionally, the usage of technology also allowed his students to work with dangerous materials, such as acids and bases in a programmed digital setting, as students were able to "collect data easier in a shorter amount of time" and conduct "simulated investigations" (Follow-Up Interview, 1/3) that might otherwise be harmful at their age level with real chemicals. Culturally responsive science teaching in this regard, involved creating a learning community in which students were able to discuss scientific phenomenon in ways that were vital to students. Although, this would not be considered "real" science, this form of "good teaching" allowed students to interact with technology to help students connect the major concepts of science to the big ideas and principles.

Mr. Moon's approach to using technology empowered his students to have the necessary tools to succeed in science learning (Ladson-Billings, 1995a) by creating digital lab spaces within the science classroom. Rather than look at what the students didn't have in the science classroom, technology altered the students' learning experiences by having the same experiments in a digital ecosystem (Calabrese-Barton, 2002). Using technology allowed his students to develop their competency (academic identity) by having them individually answer science questions and experience science learning in a fast-paced environment. If a student answered a response incorrectly, their names would not be called out in class about their low grade. Additionally, if Mr. Moon wanted to keep their grades, the application did the grading for him making the grading process easier and less time consuming for him. As for the development of a science identity, depending on the science app, the technology would recognize you if you were in the top tier of the application, such as Kahoot and how it identified the top three participants with the highest score in class. If it was another app, the teacher would collect the data and make

mention of it at their discretion. This also became problematic as peers would not be able to recognize each other's competencies or achievements, thus keeping each students' science identity hidden from each other in the classroom.

Honoring Culture

In my observations, Mr. Moon made a conscious effort both to respect the language of his students, and to communicate with them in familiar ways. Both of these practices were rooted in his effort to honor his students' culture.

Language. Mr. Moon's approach to honoring students' culture was by allowing them opportunities to express their scientific knowledge using their own language in science discussions with their peers and with the teacher. Here Mr. Moon, created different opportunities to improve scientific literacy for his students by incorporating their culture into the science classroom through listening, speaking, and using visual representations in the class (Bradbury, 2014). Mr. Moon's approach to empowering his students was also observed here as his students had an opportunity to communicate their scientific reasoning, both with their peers and the teacher. Mr. Moon usually did not correct them regarding their grammar and syntax; however, he did have students explain their responses further to ensure that they understood the science terms and theories they were expressing. While the use of the students' language was used as a tool to bridge the students' ways of knowing, the teacher still needed to hold students accountable in learning the language of science altogether.

For example, a student discussed that air is made from matter and described the experiment to prove her theory. When the student completed their discussions, Mr. Moon asked students to constructively critique them. At the end of the student's presentation, Mr. Moon

surveyed the class for constructive feedback, saying, “That was good. What else? How about her reasoning? Was her reasoning based on scientific principles?” (11/14, 8th Grade)

Mr. Moon’s approach provided students with an opportunity to speak about their science projects using their own language, and other students were able to examine their peer’s assignment by questioning them in their own language as well. Because Mr. Moon created a safe space for students to express themselves without disrespecting each other, students were receptive of their peers’ comments and criticisms. Here, the emergence of a science identity is present as students were able to express (perform) their competence by using their own language to describe the science phenomenon taking place in their projects, and were recognized by both the teacher and their peers as being a “science person” (Carlone & Johnson, 2007).

Warm Demander. Mr. Moon’s approach to speaking with his students resembled speaking with close family members, specifically his children. Referencing Delpit (2012), she described that teachers who treat students as such, are considered to be *warm demanders*. For definition purposes, these individuals are considered to provide students with the ability to “take risks, admit errors, ask for help, and experience failure along the way (pg. 82). His *warm demander* approach did not disrespect his students, yet his language in interacting with them seemed to resemble more of a parent sometimes disciplining their child. For example, one situation that took place was when a student had trouble reading a particular part of the rubric for his Claim, Evidence, and Reasoning (CER) assignment:

> Yes. All right. Now if you have the rubric, there should be so many items under that that talk about your claim, evidence, and reasoning. Somebody read the first one out loud, really quick. Fast. Faster. Nobody can read?

> Is the… Now listen, I'm going over this for a reason. Just like I'm in church. I'm going to go over it, word for word. Is the statement what?
>
> Is the statement a one-sentence answer to your question? I hope you're getting this in, because you're going to go back into your slides and you're going to make sure it is.
>
> That's what it said. It said one sentence. You all go to church and the preacher says read? (11/15, 8th Grade)

Here, the references of "church" and his assumption that all students attended religious service led to the belief, by the teacher, that all of his students attended a place for religious service. Here, he signaled a cultural connection as the student understood the church reference and started to work on his one sentence response to the *Claim, Evidence and Reasoning* assignment. Possibly, the reason for his reference of church, could be that he thought he related to his student so much, he felt that he might have had a similar religious upbringing.

In order for science teachers to successfully engage in culturally responsive teaching, they need to understand how diverse students place themselves in the world (Dentzau, 2013) and although Milner (2016) stated that teachers need to find ways to navigate an environment that encompasses both students' social backgrounds and prior knowledge in science, teachers still need to be careful how they implement it. Maintaining cultural integrity is important here as Mr. Moon assumed the students' religious background and made assumptions that they attended religious service in some way. This example, serves as a caution that simply incorporating the students' culture into the classroom is not enough, teachers need to be cognizant in the sense that acquiring "skills in additional cultures" would be essential for the teacher to work and exist in an ever changing, diverse classroom (Ladson-Billings, 2016, p. 36).

Summary of Mr. Moon's Teaching

Mr. Moon's classroom practices encompassed creating a science classroom that had social-emotional care as the foundation for learning. His approach to assisting his students in becoming scientifically literate incorporated using technology and students' language within the science classroom. Mr. Moon's approach to using technology during my observation of him made science learning easier for his students to grasp, and allowed his students to understand vague science concepts, followed by discovering scientific phenomenon through graphics and multi-colored imaging. Although I only saw him use two of these apps during my observations, the students understood the programs and explained science concepts in class from them. However, there were examples of apps that were mentioned and not used in class. For example, *Readorium*, an application that contained reading comprehension passages using scientific text was mentioned multiple times, however I was unable to see the platform being used by students. The *Gizmo* application, however, was used as students used this application to discuss their science projects to their peers.

Technology created new levels of learning, allowing students to access science information, do science projects, analyze data, and communicate their findings with their peers and teachers. Additionally, the onset of technology created for students an emergent science identity in which students were able to demonstrate their competencies and showed their peers that they were knowledgeable in some respects. Here, the teacher facilitated the science learning by guiding them through the process in the development of their usage of science vocabulary. Mr. Moon did hold them accountable in which they had to communicate their findings using both their language and science vocabulary, however, this only appeared during students' discussion of their science projects with the projects having no real semblance to students' everyday lives outside of the classroom.

Overall, Mr. Moon did focus on his student's scientific competency, but it was limited in that his first initiative was to develop their academic expectations for learning science, then their competency. In regard to performance, technology was the pedagogical engagement for students, yet scaffolding, collaborative group discussions, and hands on activities were minimal in my observations of his classroom.

Ms. Padre: 6th Grade Teacher

Corps Elementary School

Corps Elementary School is a pre-k – 7th grade Title 1 school located in northeastern New Jersey. With a student enrollment of 931 students, the majority of students were on free and reduced lunch, meaning that students participated in, or whose family participated in economic assistance programs. Corps Elementary School consisted of 51% female and 48.5% male student population with a racial demographic enrollment of 63.9% Hispanic, 35.2% Black or African American, 0.2% White and 0.5% Asian students.

Ms. Padre's class consisted of 6th graders with their desks placed in group of two to four toward the center of the class with paired desks circling around the walls of the classroom. Significantly, her classroom had a materials table that allowed students to grab their science resources for experimentation and analysis as well as a laptop cart that housed students' laptops for use with digital applications similar to Mr. Moon and Ms. Lera. At the front of the classroom is a digital whiteboard for student learning, displaying comprehensive assignments that the teacher used with the class. Along the left side of the classroom wall are FOSS science kits provided by the district for science learning and experimentation and along the walls were science posters that demonstrated science theory and student work.

Ms. Padre

Ms. Padre is a native of South Jersey who teaches sixth grade science at Corps Elementary School. She is identified as a White female teacher who possesses a bachelor's degree in Biology from a 4-year university. To date, she holds a certificate of eligibility in K-12 Biological Science. Ms. Padre was considered, by definition to be a "novice" teacher.[7] Her only teaching experience was a class she had prior to the one she was working with at the time of this study. She was chosen as a participant by her administrative team because her class had a very heterogeneous group of students, that consists mostly of Black and Hispanic students.

Ms. Padre's teaching program and entry into teaching was unconventional. Ms. Padre went to college to become a pharmacist. She was accepted into a medical program at a college located within South Jersey, but the cost was too high, '…it was like $150,000 to go and they're like, 'we'll give you $2000', and I was like 'Yeah, I'm trying to pay off my student loans, not get more,' (11/20, 6th Grade) she explained. The recommendation to become a teacher came from her family and friends and her dream of becoming a pharmacist, she explained, was "placed on the back burner."

As of this research Ms. Padre was in her second year of her alternate route program at a university in northern New Jersey. Though she reported that she was not being prepared specifically for teaching science in an urban middle school setting, she noted that she was able to learn the necessary skills to teach her student population via her teacher peers. Ms. Padre mentioned that her guidance and support system came primarily from her colleagues as they formed a "clique" that "went to each other's houses to have game nights, hang out", and decompressed about their activities and offered solutions to their teaching. It was this "support

[7] Novice teacher, under the definition of Hargreaves, A., & Fullan, M. (2012). *Professional Capital: Transforming in Every School*. Teachers College Press. is defined as a teacher who has 0-3 years' experience.

group", she stated, that offered her the best guidance and assistance with her pedagogy, more so than the mentor assigned to her by her school. Although Ms. Padre's teacher preparation program did not prepare her for working in an urban school district, she managed to obtain the necessary pedagogical tools necessary to do so by bonding with other novice teachers and discussed, with them, her students' behavior in their prior grades with various teachers. This allowed her to obtain the pedagogical skills necessary to lead her students into developing their scientific literacy and to help them discover their science identities within the classroom.

Ms. Padre's strengths lay in her ability to provide sound instructional practices for her student population through resourcefulness, experimentation, and reflection. Additional pedagogical practices were also highlighted as well below.

Teaching Practice

Ms. Padre's approach to helping her students construct a science identity consisted of creating a science ecosystem that incorporated a hands-on approach to science learning. Prior to creating this atmosphere of science learning, she first researched her students by speaking with teachers who instructed them in previous years. This allowed her to understand her student population, their behavior, and their attitudes in the classroom. As she sought guidance for her student population, she also disclosed to me that any attempt to discipline her students came solely from the recommendations of her teacher peers. Her resourcefulness as a novice teacher, led to the following pedagogical strategies that assisted her and her student population.

Academic Success. Ms. Padre's pedagogy that ensured her students comprehended science and developed a science identity was by creating bridges to new ideas and learning and crafting a classroom for students to collaborate and examine scientific phenomenon.

Scaffolding Science. Ms. Padre's effort at scaffolding science, resembled Ladson-Billings (1994) definition of scaffolding; rather than reprimand them for what they do not know, Ms. Padre made attempts to incorporate students' own thoughts and opinions about what they knew and learned about a particular topic into the class discussion. Ms. Padre's approach to scaffolding science instruction took place during the beginning of class. When she started a new lesson or conducted a lab, she constructed introductory questions for her students to assess what they learned the prior day. As students responded, she created innovative ways to incorporate their own language into the science classroom and used their language as a bridge to connect science vocabulary by taking their own terminologies and definitions and translating it into scientific verbiage. For example, during an exploration about magnets, Ms. Padre asked students questions about what would happen if the same sides of the magnet interacted:

> So, what we're going to do is, we're going to go around and you guys, in your groups, are going to share something that you discovered about magnets that you know about magnets…I would like you to write it down on yours as well if you do not have it. What do you know about magnets? (11/22, 6th Grade)

Ms. Padre's approach to incorporating science vocabulary for her 6th grade population encompassed a call and response methodology in which students were able to answer science-based questions using their linguistic background as a resource. Here, Ms. Padre's use of scaffolding created an opportunity for students to dig deep to recall the vocabulary and science terms (competence) that was used to describe magnets and their properties. This approach to learning and re-learning science allowed students to recall (perform) the previous day's activities to reassess what the students may or may not have understood about magnets. Ms. Padre's approach in not discrediting their responses due to their lack of science vocabulary also

demonstrated that she was accepting (recognition) of her students' personalities and ways of knowing (Calabrese-Barton, 2003; Ladson-Billings, 1995a) as she used their language to translate phenomenon to science terms. Cultural congruence "signifies the ways in which teachers alter their speech patterns, and communication styles" to resemble students' own culture. She also allowed her students to feel welcomed with their language, without fear of being embarrassed or criticized if they answered the question incorrectly using the wrong language or science terminology.

Exploring Scientific Phenomenon. Ms. Padre's approach for students to learn science consisted of providing them with hands-on activities that allowed them to make scientific discoveries independently and within a group setting. Additionally, this methodology allowed students to discuss their findings with their peers and communicate their results with the teacher. Learning science through this format allowed students to not only be themselves but learn about scientific phenomenon in a less stressful environment. In creating a community of learners, Ms. Padre allowed students to interact with their peers about a specific topic (magnets), interact with the science materials, and create opportunities for learning science through self-discovery.

Ms. Padre ensured students were on task during the exploration and was attentive as she circled the classroom to probe students' thinking in regard to their experiments. For example, during their lesson on magnets, Ms. Padre assessed how some items in the bag of materials were or were not magnetic:

> All right, so, what did we determine? All right, so, what did we discover when you tested the different objects?
>
> What did we discover about the magnet and the objects that you tested?
>
> We're going to be testing our results…

> So, we're all going to hear and we're going to talk about whether you guys found the same thing to be true or if you discovered something different. So, what did you notice about the objects that you tested? (11/22, 6th Grade)

Although Ms. Padre had a few disciplinary issues, as she probed students thinking, I use this example to express how Ms. Padre assessed students' behavior and academic performance during the lab exploration.

She assessed students' thinking by first, asking questions to the students about the magnets, then she assessed their competency as she observed how the students worked with each other and then measured their academic performance by probing their thoughts. For Ms. Padre, by evaluating her student population, it not only reflected her students' performance and academic abilities, it also revealed which students performed well with each other, which students did not, and which students treated class time as an opportunity for play and recreation. This constant reflection made Ms. Padre reorganize students' seats on a weekly to bi-weekly basis to determine which grouping of students could maximize their learning. Here, Ms. Padre's approach to using the students' behavior and cultural upbringing as a means to connect students learning abilities is tantamount as she recognized students' auditory, visual, and kinesthetic responses to working with their peers and to the science instruction. As she recognized these differences between her students "ways of knowing", she continued to establish a classroom environment by using their talents and placing them with a peer, who could best assist them in understanding the content as well as applying the science content to their lives.

Student Reflection. Ms. Padre expressed to me that she assessed her student's learning abilities and behaviors on a continuous basis and adjusted their seats to accommodate their individual learning and collective behavior. As both qualities (behavior and learning) contributed

to the classroom dynamic, Ms. Padre's continuous reflection of her students ensured they performed well during instruction and that appropriate behavior was taking place in class. For example, Ms. Padre relocated one student's seat, and his relocation led to improvements in both his behavior and academic performance:

> I moved his seat in the beginning of the year, and he wasn't happy about it. But since I moved his seat… And he sits next to the girl (L), who's a really sweet girl, and (S). (S) loves to read so she gets distracted with that and drawing. But both really good students. They've brought him up, and he improved so much since the beginning of the year. And I had a conversation with him not that long ago. And I was like, "I know you weren't happy with me moving your seat because you were not with your friends." I'm like, "But your friends weren't helping you. Do you see the progress that you've made?" And he was like, "Yeah, I notice a difference." And then he came back to me after parent conferences, and he's like, "You know when I look sad, that's like my serious face." And I was like, "You were not happy when I moved you. You can't even tell me you were happy." So that's kind of funny. But he's improved tremendously. (Post lesson Interview,11/21)

According to Ladson-Billings (1994) culturally relevant teachers create learning environments that affirm students' identities and backgrounds, thereby providing a means for students to "maintain their cultural integrity while succeeding academically" (p.476). Ms. Padre viewed her gendered grouping of students through this lens. Additionally, by minimizing student disruption through continuous reflection, she was able to create an ecosystem that allowed her students to participate in authentic hands-on learning experiences by testing magnets on specific objects and identifying which materials were attracted to the magnets and which did not. Here,

students were able to stay on task, question scientific phenomenon, record data, respond to each other, and offer each other guidance, when necessary, when investigating the magnets.

Summary of Ms. Padre's Teaching of Science

Although Ms. Padre was a second-year teacher, she was establishing and developing her pedagogy to best assist her students in learning science to help them develop an academic identity in science. Her approach in doing this encompassed asking the students questions from the previous day to check for students' competency, she then created opportunities for them to develop their scientific literacy by implementing hands-on activities to allow students to investigate phenomena in which students asked each other questions, were questioned by the teacher, and report their observations to the classroom at large. Her implementation of culturally responsive teaching strategies created learning spaces to improve science instruction and allow students to use their language in class as a means to scaffold instruction and help facilitate student discussions to help them answer (perform) scientific inquiries and understand scientific phenomenon. By creating an environment for science learning, Ms. Padre provided an opportunity for students to investigate phenomena, communicate their findings and ask additional questions. This allowed them to build their competency and be recognized as students of science.

Summary

As an observer for this research, I highlighted themes from each teacher that occurred in their classroom which I considered to be good science teaching under a culturally responsive teaching lens. For each teacher, descriptive themes were identified and presented as each teacher exhibited a degree of culturally responsive teaching that best suited their pedagogy for their classroom, and for their students. While each participant worked to ensure they were being

culturally responsive, prioritizing their students' voice, language, and culture in the classroom to discuss science, some focused more on creating opportunities for academic expectations rather than developing their student's science identity.

The development of their students' academic identity, however, did emerge from the observations as each participant created an opportunity for their students to display their competency in science, however, not all the students were recognized as a student of science as some students were limited in demonstrating said abilities to their peers due to the nature of the classroom and the technological applications used.

For Ms. Lera's fifth grade class, their investigation into the solar system allowed students to communicate their findings among their peers. With her seventh-grade students, their explanation of the geologic time scale using their personal history also allowed each student to explain their personal history and be recognized as a student of science, yet when it came time to participate in science writing, they had a hard time trying to demonstrate their competency in the task. For Mr. Moon, one of his eight grade classes was able to discuss their investigation into science phenomena by demonstrating their science research, while another group was subjected to technological applications in which they had to showcase their scientific literacy on Kahoot with recognition only being applied to the top tier students. As for Ms. Padre, both of her 6th grade classes had an opportunity to investigate, discuss, and explain scientific phenomena with students providing explanations for their decision making. This allowed students to be recognized as students of science, but it was limited as some of the students was able to express their competency to just the teacher and not the group at large.

Overall, each teacher supported their students' academic success in their classroom and through varying degrees, demonstrated their culturally responsive pedagogy that enabled

students to display, however brief, their scientific identity. Additionally, the construction of a science identity was minimal as some students had trouble, depending on the assignment, expressing their competency in a particular science context.

Chapter 5 – Cross Teacher Analysis

A cross teacher analysis is necessary to not only expand on the knowledge of culturally responsive teaching, but to use that knowledge for broader purposes (Khan & VanWynsberghe, 2008) in education. The previous chapter examined each teacher's pedagogical practice and how their practice resembled researchers, scholars, and definitions of good science teaching for their students. Additionally, their practice also mirrored culturally responsive teaching as the pedagogy they implemented in their classroom, incorporated students' language, and their culture in developing their science identity and improving their scientific literacy.

The purpose of this study was to discover how middle school science teachers in an urban context think about their relationship with good science teaching and their students. This study offers to help educators and educational researchers understand what culturally responsive science teaching practices are prioritized through the discernments and actions of three participating urban middle school science teachers that have impacted science learning for their student population.

Additionally, this chapter will also draw upon the findings to address the research question:

1. What do middle school science teachers prioritize in an urban classroom?
2. In what ways does culturally responsive teaching occur in an urban middle school science classroom?

Commonalities in teaching practice were discovered across participants as their relationship to students expressed the tenets of culturally responsive teaching. Affirming attitudes toward culturally diverse students and providing students a sense of equity for successful science instruction were key themes that emerged.

Affirming Attitudes Towards Culturally Diverse Students

Culture, as defined by Villegas and Lucas (2002a) is the "way life is organized within an identifiable community or group. This includes the habits of the community or group members, their use of language, how they interact with one another, take turns at talk, relate to time and space and approach learning" (p.35). Under Villegas & Lucas' framework, teachers who possess affirming attitudes toward their students view their students as capable learners who bring their own knowledge and experiences to the classroom and are viewed as learners that can succeed. While each participant demonstrated this tenet in their own way, the participants first had a belief that their student population can learn science. One of the ways they achieved this goal was by first developing a rapport with their students.

Belief System. Each teacher's approach to developing an affirming attituding toward their students, started with a belief system. Teachers are more than just educators, they "develop a personal vision of why they are educators and what is important to them" in the larger context of education (Villegas & Lucas, 2002a, p. 54). For these participants, teachers took on the roles of managers, supporters, and leaders as they provided guidance to their students. Not only did they focus on their schoolwork, they also focused on students' personal lives as well.

Ms. Lera believed that her pedagogy incorporated all students, irrespective of race, religion, and cultural backgrounds. Her belief was that it was important to incorporate and celebrate diversity within the classroom, as well as challenge students to strive for careers in science pathways and STEM careers. For Mr. Moon, his belief followed a similar pattern in that his vision for students was that they should be able to explore their creativity and develop their reasoning and problem-solving skills. Additionally, he stated that his students should be able to observe, analyze, and create their own hypotheses using their own experiences in a lab setting.

For Ms. Padre, her belief is that her pedagogy has an impact on everyone in her classroom, and although "everyone struggles in their own way with their own thing" (Interview 11/19), students can overcome and be successful. Although the participants mentioned that their teaching program did not prepare them for instruction in an urban school, each teacher possessed a belief system that their students could learn science. This internalized belief system that all students can learn, despite their culture, demonstrated that a personal, internal belief system was necessary to instruct students whose culture differed from theirs. Villegas and Lucas (2002a) suggest that teachers who have positive attitudes toward their students, "are convinced that they are capable learners who bring a wealth of knowledge and experiences to school" (p.37). Furthermore, as the "racial, ethnic, linguistic, and class backgrounds of students influence teachers' responses to students and events in the classroom" (Bryan & Atwater, 2002, p. 830), the participants belief systems guided them as they modified the curriculum to accommodate their student population. For example, Ms. Lera mentioned that in order to teach her English Language Learners, she "started learning Spanish, to make connections to science terms, and English terms to meaning…by using visuals to help the students identify with each of the terms" and concepts (Interview 12/21). With their belief system in place, the participants were able to create opportunities for students to succeed (Ladson-Billings, 1994).

Rapport, as defined by Tickle-Degnen and Rosenthal (1990) is an interaction between individuals in which the qualities of each individual emerge and there is a mutual attentiveness, a positive interaction, and a successful coordination between the participants. In other words, a meaningful and close relationship between people. With culturally responsive teachers, educators see beyond the classroom and the curriculum and try to establish a rapport with their students. This establishing of a rapport could extend, beyond the classroom as teachers try to engage with,

not only the students, but the students' parents, and the community (Ladson-Billings, 1995a). By teachers establishing a rapport with their students, they are able to understand their learning abilities and their capabilities as science learners. Having a rapport with students both socially and culturally is paramount as each participant created an environment that was conducive to science learning and the creation of a science identity. Ms. Lera's approach to building a rapport with students consisted of relating science concepts to situations that occurred in her students' daily lives and having them share their personal-science stories. Additionally, she also used positive reinforcement as a key factor for her students. Mr. Moon's approach to building rapport with his students consisted of communicating with them as a person they can trust to speak to in regard to personal issues. For his academic approach, he created an opportunity for students to explore their creativity and helped develop their reasoning and their problem-solving skills by using technology to help them observe, analyze, and create their own hypotheses based on their digital lab experiences. For Ms. Padre, her academic approach in creating a rapport was first asking her colleagues to describe their academic and personal abilities, then asking the students directly about their enjoyment and experience with science and describe any issues they had with previous science teachers.

Culturally responsive teachers who are able to build a rapport with their students create structures that are based on their students' culture. Ladson-Billings (1994) identified that teachers who have positive beliefs about their students' capabilities and success are teachers who can create an environment of learning, a sense of engagement and provide learning opportunities for students to succeed. As the participants started to understand their students, they were willing to adapt and go out of their way to provide opportunities for their students to successfully learn science. Overall, each teacher respected their students' cultural differences, their ways of

thinking, talking, and behaving, and provided opportunities for them to learn science in an environment that was conducive to their specific student population.

Academic Success. Academic success, as defined by Ladson-Billings (1995) is the development of a student's "literacy, numeracy, technological, social and political skills to be active participants in a democracy" (p. 160). Under her theory of culturally responsive teaching, the term academic success is something that is not forced on students by teachers, but rather, something that is chosen and accepted by students. In other words, it is the student's choice whether to accept the instruction from the teacher. Here, I believe this is where beliefs and rapport formed the foundation for successful science teaching with academic success being the result. As each participants' practice took hold, each participant realized that the science curriculum, prescribed by their district had scientific theories and practices that seemed ambiguous to their student population and implemented novel strategies to overcome this vagueness. Here each participant first assessed what was wrong with their students and then created pedagogical strategies that best suited their students in the classroom.

Learning about Students. For Ms. Lera, her approach, after establishing a rapport with her students, was first recognizing what science content was out of context for her students; topics that did not relate to their life outside of school. Taking initiative, and still following her belief all students can learn, she worked alongside the science department's curriculum writing department for the school district. Here she was able to garner understanding about what topics were intangible and helped in creating teaching strategies for students to overcome them. These pedagogical strategies allowed her to instruct her student population more efficiently as she was able to decide what topics to circumvent, modify and ignore altogether in the science curriculum.

For Mr. Moon, his approach was first examining, internally, what experiences he lacked in science, and examine the experiences he had as a Black child growing up in suburbia and in urban settings. This self-examination led him to develop his pedagogy through professional development and the pursuance of a masters and a doctorate degree. His pedagogical improvements led him to examine the academic competence of his students as he grouped them in order of "(1) advanced, (2) struggling, and (3) those who are just there" (Interview, 12/ 21). His approach to grouping these students were based on various assignments and projects he distributed in class and created heterogeneous groups to diversify the population for better student learning.

For Ms. Padre, her approach was different compared to the other participants. A novice teacher with limited experience, she sought guidance from her peers in order to understand her students' abilities and characteristics. Additionally, she also approached her students directly to inquire about their personal experiences in science and what they learned in prior grades. From the conversations with both her students and peers, she discovered that investigating phenomenon and participating in hands-on real-world problems was an ideal way for her students to be engaged in learning science, thereby reducing student disengagement altogether.

Each participant realized that additional insight was necessary in order for their student population to succeed. They each revealed that additional research was necessary for them to address any instructional deficiencies they had with their pedagogy. Furthermore, as teachers addressed these issues, they were able to identify which learning deficits students had in the classroom and created personal learning strategies that best helped their population. What is important to note is that each teacher realized that their pedagogical skills, while they were efficient, required modification to work with students who were culturally different from them in

an urban classroom. This acknowledgment further enhances the argument that culturally relevant teaching "varies across individuals within a group and across communities within a larger cultural group" (Villegas & Lucas, 2002a, p. 27)

Understanding Students Ways of Knowing. Students in each of the participant's classes learned differently from each other. The teachers, still holding on to their beliefs, understood that their student population had prior knowledge that could be brought into the classroom. In order for them to reach their students academically, they first needed to create an ecosystem in which the students' classroom environment shaped their view of science learning, and allowed them to share knowledge, take notes, gain new ideas and construct new knowledge (Calabrese-Barton, 2003; Ladson-Billings, 1994; Villegas & Lucas, 2002a).

This approach allowed students to view school as a non-hostile place in which students could be themselves and create an atmosphere of learning and enthusiasm (Ladson-Billings, 1995a). For example, Ms. Lera's attempt at teaching solar systems with her middle school students encompassed having students in groups of 4-5, with a set of solar system cards. Each group had to organize their cards in a particular order, however the approach varied between students and as the students collectively expressed their findings, students started to question each groups approach to organizing their celestial bodies. Her approach at introducing a new topic to her students allowed them to familiarize themselves with the content and take ownership of their learning by engaging with it on their own and with their peers.

For Ms. Padre, her attempt started from speaking with the teachers and her students. When she gathered her information about her students, she altered the classroom landscape by grouping the students in pairs of two to four students, supply them with manipulatives for exploration and questioned them continuously throughout the class to ensure the students were

on task. For example, as students were working on changes in energy using a hand-crafted pendulum, they became engrossed in the engineering aspect of the exercise rather than the data gathering process from it. Ms. Padre noticing the issue, began to question the students' phenomena, by asking "what data they collected", and "what type of energy did their pendulum have before they released it, or after they released it?" (Observation 11/20), to see if students understood the concept or had difficulty constructing the lab.

For Mr. Moon, his approach differed from the other participants as his attempt to have his students understand science was through the use of individualized technology. Mr. Moon's student population utilized specific science apps (Kahoot) in his class to bring about their awareness of science vocabulary and science-specific terms.

Overall, each participant's approach to gathering data about their students, their learning ability, and navigating the science curriculum helped them to develop their students' scientific literacy and identity in their own particular way.

Students Sharing Knowledge. Participants allowed their students to share their knowledge in different ways within their classroom. Additionally, as they shared their knowledge about a particular science topic, students were given the opportunity to question their peers. Most notable and necessary to discuss here are the sharing strategies of Ms. Lera and Mr. Moon and how they created opportunities for their students to incorporate science into their students' lives. While each student had a choice to decide what science project topic to discuss with their peers, the approach to the project is what is critical and necessary for discussion. For Ms. Lera, her students were required to incorporate their personal life stories into their earth science projects, whereas Mr. Moon's students were required to investigate a scientific phenomenon and present their findings individually. As both groups discussed their projects with

their peers, students felt empowered as they shared what they knew about their lives and science with their peers and teacher.

Sense of Equity

Calabrese-Barton (2002) posits that rather than focus on the limitations of the science classroom, the focus should be on the teachers and what they are doing presently in the school, the science classroom, and the environment. With each participant, not only did they analyze their student population, they also implemented strategies necessary for students to receive instruction. One commonality among the teachers was their importance of creating student centered instruction for them to understand science on their own terms with the teacher as facilitator and the students as explorers.

Student-Centered Instruction. Participants planned activities that focused on raising students' curiosities in learning science. Additionally, lessons were designed that created moments where students were able to understand new phenomena and question that phenomena with their peers. With Ms. Lera, one of her approaches to ensure students learn science, was by creating lessons that catered to them and brought about *teachable moments* within the classroom. One example of this instruction was when she had her fifth-grade class examine the solar system using earth science cards. Being that the solar system was part of the curriculum, she designed a lesson that was both tangible and engaging. The solar system, from my science teaching experience, is an intangible topic that required multiple media to view, read, and observe the phenomenon taking place. Ms. Lera created lessons that had visual images of the celestial bodies with written data to accompany them. As she made the students do research, they had a *choice* to decide how they should categorize the data. Students, from observation, were working together to 1) decide how to organize the data, and 2) discuss facts about the data. As students were

discussing the data, they started incorporating the data in their vocabulary, as students started asking “what if” questions and started to recall scenarios and experiences they had about the celestial bodies.

Mr. Moon’s approach to student centered instruction was to have them discuss and question scientific phenomena. Students investigated science theory on their own and made a choice of what to discuss in class. The teacher allowed students to decide what was of interest to them, thus allowing students to take ownership of their learning as they chose the phenomena. Also noted here is that, once again, students had a choice on what to learn and discuss in science. Additionally, Mr. Moon provided a platform for students to discuss said phenomenon with their peers.

While the other two participants allowed students within class to discuss their research and findings, Ms. Padre partitioned a segment of time in her class for students to engage in group discussion. Students, she stated, had a “tendency to talk” repeatedly in class and on multiple occasions, she had to continuously reassign seats due to their talking. By partitioning the class time, students in the beginning of class were able to investigate questions posed by the teacher, allowing students to discuss responses with their peers, and contribute to the class, collectively, by providing their responses to the group as a whole.

Although each teacher created a student-centered strategy for science instruction, the implementation of that strategy and how it was used is what differed between the participants as each teacher, based their approach on 1) their students’ behavior, 2) their work with the science curriculum, and 3) their students’ academic abilities. Each teacher discovered what was limiting for students and still, incorporating their belief that all their students can learn, adapted, and created strategies that best assisted them.

Honoring the Culture of the Students. Identity, described by Brown (2004) "reflects a person's individuality and distinguishing style and personality" (p.812). For urban middle school students, the participants were able to honor the culture of their students by first developing a rapport with them. What emerged from this observation was that students' voices were heard and acknowledged by both the teacher and their peers. Each of the students in the participants' classes were given an opportunity to speak and discuss their cultural worldview, whether it was academic, personal or a combination of both. Students were able to be their authentic selves and speak about their science experiences in some science classes as their peers were able to question, respectfully, their culture and values in a science context.

As this study assisted in helping educational researchers understand the themes of culturally responsive science teaching within an urban middle school context; the study also revealed what science teachers prioritized in the science classroom as well as possibly uncover the underlying tenet of culturally responsive science teaching.

Sub Question 1: What do middle school science teachers prioritize in an urban science classroom?

Specific strategies that centered around developing students a science identity varied as each teacher developed their own pedagogy to best instruct them and their diverse student population. Villegas & Lucas (2002) noted that culturally responsive teaching is a continuous evolving dynamic and based on geographic and cultural characteristics, teachers need to adapt their pedagogy in order to be successful when dealing with students whose cultural backgrounds are different from the teacher. The study demonstrated that the foundation of culturally responsive teaching is based on teacher beliefs. Bryan and Atwater (2002) state that teacher beliefs play a significant role in determining the nature of their purpose in the classroom.

Additionally, it also exposes their interactions with students as well. As participants held fast to their beliefs, their beliefs also shaped their practice (Calabrese-Barton, 2003) within the classroom as they created student centered lessons that honored the culture of the students and helped them in knowing and understanding science (Ladson-Billings, 1994) while, utilizing their students' skills and talents in the process. Participants realized that beliefs alone were not enough. Participants then proceeded to research pedagogical strategies which worked best for them. This is where the participant's culturally responsive teaching practices and research into their student population differs.

Ms. Lera's beliefs were that her students can learn, and she incorporated those beliefs by treating her students with a sense of equity, honoring students' ways of knowing, and creating opportune spaces for science learning. Those beliefs led her to research and investigate the science curriculum as a curriculum writer to further enhance her pedagogical practice. Mr. Moon's beliefs led him to provide students with opportunities to improve their performance, learn science through the use of technology, and honoring their culture via respecting their language and participating in familial interactions with students and their parents. Finally, Ms. Padre's beliefs led her to research her students' past academic history and behavior from her peers and students directly. Those actions allowed her to speak with her students to fully gauge how they learned science and led to the discovery on how to shape those responses into instruction and science content that was relatable to them.

What is important to note is that each of these participants had a deep personal belief that they could and can teach their diverse student population. By being proactive in their pedagogy, they were able to explore instructional strategies that could benefit their students regardless of

their geographical location and cultural experiences. What the participants prioritized in urban science classrooms are in Table 7 below.

Table 7

Participants' Priorities in Their Urban Science Classrooms

A. Affirming Attitude towards Culturally Diverse Students	
1. Belief System	Teachers are more than just educators, they "develop a personal vision of why they are educators and what is important to them" in the larger context of education.
2. Academic Success	Academic success is something that is not forced on students by teachers, but rather, an entity that is chosen and accepted by students.
3. Learning About Students	Teachers take initiative to investigate what science instruction is out of context for their students and, taking initiative, creative pedagogical strategies to help student overcome them.
4. Understanding Students' Ways of Knowing	Teacher understands that students learn differently. They create a classroom in which prior knowledge can be brought into the classroom.
5. Students Sharing Knowledge	Teachers allow their students to share their knowledge about science in innovative ways.
B. Sense of Equity	Teachers create opportunities for students to implement strategies necessary for students to receive instruction.
1. Student-Centered Instruction	Teachers plan activities that focus on student's curiosities in learning science enabling them to understand science phenomena and question that phenomena with their peers.
2. Honoring the Culture of the Students	Teachers develop a rapport with students, allowing their voices to heard as they discuss their cultural worldview.

Sub Question 2: In what ways does culturally responsive teaching occur in an urban middle school classroom?

I expressed in Chapter 2 of my research that urban schools are sometimes located in a community characterized by high crime rates, extreme exposure to hazards, with lack of resources, qualification of teachers, and academic development of students. Incorporate a middle school science classroom into the setting and difficulty arises as to the best approach to teach marginalized students within a science setting. As research dictates that some teachers find it difficult to instruct students from multiple backgrounds (Hollins et al., 1994; Ladson-Billings, 1995a; Villegas & Lucas, 2002b), the participants themselves, discovered the best approach to instruct their student population. Additionally, they were also observant as to who they were instructing and what their needs were in the science classroom (Milner IV, 2011). This is no easy task for two reasons: 1) The teacher workforce is still one-sided with the majority of the teaching population being White and female, and 2) The student population is becoming more diverse in many communities across the country (National Center for Education Statistics, 2019). As such, culturally relevant pedagogy is not only essential, but a necessity as the teaching workforce continues to remain White, female, and middle-class (National Center for Education Statistics, 2019), with some teachers still unable to provide a quality education for marginalized students whose level of knowledge and skills are different from their own. As the teaching workforce continues to be ethnically different from that of the student population, some students are still being subjected to stereotypical prejudices and misconceptions by their teachers at large with views and opinions of them that continue to diminish their learning abilities.

Culturally responsive teaching is a transformative process that focuses on disrupting the traditional model of education by centering on the students who do not share the culture of those

in power and provide teachers with the tools necessary to help students "develop social consciousness, intellectual critique, and political and personal efficacy so that they can combat prejudices, racism and other forms of oppression and exploitation" (Villegas & Lucas, 2002b, p. 37) in the classroom and society. This pedagogical approach often runs counter to the traditional approaches to teaching because it focuses on the voices, sensibilities, and lived experiences of youth of color throughout the classroom (Ladson-Billings, 1994; Villegas & Lucas, 2002a).

The teaching strategies observed by the participants and mentioned in Chapter four and five, highlight how their practice was deeply rooted in their beliefs as educators. While each teacher demonstrated a belief in their practice and belief in their diverse student population, their approach to engaging their students in science instruction differed as each teacher investigated the best attempt to instruct their students. All three participants stated that their teacher education program did not prepare them for their journey into teaching in an urban school district, yet their lack of training did not deter them. Each educator regardless of their education program; whether it was a 4-year teacher education program or alternate route program, decided to create a learning environment that encompassed their voices, their culture, and their approach to learning. Their culturally responsive teaching incorporated the student's lived experiences and culture as resources to be leveraged for learning (Calabrese-Barton, 2003; Ladson-Billings, 1994).

The foundation of culturally responsive teaching, based on my observations, are the teachers' belief system. Each teacher's belief stemmed from an internal system rooted in the foundation that, regardless of the students in front of them, they will be successful. Milner IV (2011) discussions of teacher beliefs under the framework of Ladson-Billings (2006) described culturally relevant teachers' beliefs perfectly:

> Ladson-Billings suggested that people practice democracy because they think and believe in its fundamental principles and ideals. Thus, more than a set of principles, ideas, or predetermined practices, the practice of culturally relevant pedagogy involves a state of being or mindset that permeates teachers' decision-making and related practices. (p.68)

Villegas and Lucas (2002) also reinforce this view of teacher beliefs by stating that teachers who hold positive attitudes toward their students identify their students as "capable learners who bring a wealth of knowledge and experiences to school" (pg. 37). In brief, teacher's attitudes toward students shape their experiences that students have within the classroom. As such, when students are treated as knowledgeable, determined, and hard-working, students feel empowered as they choose to accept science as a part of their lives (Ladson-Billings, 1994; Villegas & Lucas, 2002).

With the teacher's internal belief that their students can learn science, each teacher used varying instructional methods to accommodate both their students' learning abilities and individualized behaviors. For two of the participants, the teachers implemented opportunities for students to decide what topic in science they were going to research and investigate, whereas one teacher had to partition their time for students to discuss and interact with phenomenon in science. Although the participants, had diverse backgrounds, each teacher had a belief that their students, despite their ethnic and socioeconomic backgrounds, could learn science and become successful. Each teacher continued to believe in their pedagogical practice and made specific attempts to provide an educational experience for each student to develop a science identity. From the research, the students, realized that they had a choice to learn the content, and accepted the science pedagogy based on the pedagogical themes provided by the teachers and responded

by asking questions not only to their peers about science, but to their teacher as well. They felt comfortable as their voices and culture were respected by their instructors.

Teachers play an enormous role in how their students behave and learn in an educational setting. When teachers have an internalized belief system that their students can learn, they will find the opportunity to acquire the knowledge and skills necessary to ensure that they are able to meet the needs of their students. In the next section, I will share what these findings mean for educational research and for the school community.

Implications for Educational Research

Findings from the study uncovered that culturally responsive teaching is a continuously evolving dynamic that varies in accordance with the culture and climate of the students, and the community at large (Villegas & Lucas, 2002). For marginalized students, one of the many issues affecting them in science is the trichotomy of holding on to their cultural identity, their academic identity, and their science identity. Culturally responsive teaching then, offers a solution to this crisis as this pedagogy provides positive learning experiences for them to learn science both independently and collectively with their peers (Basu & Calabrese-Barton, 2007).

Culturally responsive teaching in a teacher education context encourages preservice teachers to understand their roles in designing and implementing curriculum that corresponds to the diversity of their students (Villegas & Lucas, 2002b). As the United States continues to become more “racially, ethnically, culturally, linguistically, and socioeconomically diverse, teachers must find ways to educate themselves on their students’ communities, connect the curriculum to student experiences, and recognize that the rich cultures their students bring to the classroom can and should serve as resource for their academic success” (Kumi-Yeboah et al., 2021, p. 236). Although most of the teachers in schools are White and female, future teachers,

regardless of race should, by default, be cognizant of the students they are instructing, build cultural competence in understanding their students' skills and talents within the classroom, and provide opportunities for students to showcase their science identity through a modified science curriculum. For teacher educators, this may include creating education programs that focus on diversity among preservice teachers, exposing preservice teachers to urban schools that showcase diverse students and their communities, and perhaps expose faculty to professional development that draws on the frameworks of Dr. Gloria Ladson-Billings, Drs. Ana Marie Villegas and Tamara Lucas, and Dr. Angela Calabrese-Barton to ensure they are culturally proficient enough to advise and instruct preservice teachers before certification.

Implications for Teacher Practice

Teachers who teach in urban districts have a very demanding workload. They work in communities that are perceived as high poverty, have increased rates of crime, and adverse social and economic conditions that lead to an impact in school performance such as the students' well-being and their health and safety (Noguera & Wells, 2011). Teachers in urban schools need to know more than just subject knowledge to instruct students in urban schools. Calabrese-Barton and Tan (2010) state that creating safe spaces for students to learn science empowers students as they engage with the content more, allowing them to feel empowered in their learning.

As the study demonstrates, participants were able to integrate pedagogical strategies that included small group discussions, hands-on activities, and individual work on computers for laboratory exercises, that allowed students to discuss phenomena to demonstrate the competencies in science, using students' own language, voice, and culture. These participants "tailored instruction to their students rather than impose a single style to which students had to adapt" (Villegas & Lucas, 2002a, p. 102). Here, teachers created long lasting learning

opportunities using students' experiences (culture, native languages, and upbringing) and linked those qualities through learning activities that were considered culturally congruent (Osisioma & Moscovici, 2008) as teachers incorporated students' own language into the context of science.

Science teachers need to establish an approach to teaching science that encompasses a belief system that all students can succeed. This includes creating opportunities for students to demonstrate their competency in science, demonstrate that competency in a manner that is reflective of students' culture, and include science that provide students the opportunity to be recognized as a student of science. Science teachers must realize that students come from a variety of cultures and that each culture contributes to science in their own way. Science teachers then should capitalize on this attribute by establishing assignments, lessons and experiments that highlight the richness of the students' science literacy and provide pedagogical methods that showcase this richness that they can be recognized as students of science.

Limitations

Although the research consisted of three participants, their responses were utilized to construct and validate the findings for my research question. With the participants findings however, one limitation to the research is that the sample size used in this study may not be generalizable to a larger population of educators.

My second limitation pertained to time. My observation of the participants took place during the month of November for a series of 4 -5 days over a two-week span. Observing practice within this span compared to the entire school year likely does not fully capture the full pedagogical practice of the participants. Although themes were identified and captured through observations, and interviews, the timeframe of the study was limited by how much data I was able to gather on middle school science teachers and how they interacted with their student

population. A recommendation would be to interview the teachers using a culturally responsive observation guide that highlights the richness of the teacher, and their pedagogical strategies could have yielded a more complete representation of what takes place in a culturally responsive classroom. This would have been useful in helping teachers utilize culturally responsive science teaching in their classrooms over a longer period of time.

A third limitation to my research were the possible issues I might have had with the data. As a novice educational researcher, it is possible that there may have been small emerging themes, that I may have missed. These emerging themes could possibly further contribute to the ongoing dialogue to assist in creating a science identity for marginalized students.

Final Comments

This research initially sought to understand how culturally responsive teaching practices assisted in the developing of a science identity for diverse students in middle school science classrooms. What emerged was evidence that pointed to a greater focus of the teachers in this study on the development of students' academic identities, and less attention to the development of scientific identities. What I observed and what resonated with me was that the teacher participants had a strong belief in their diverse student population, so much so, that they discovered alternate ways to get students engaged in science. These teachers were influenced in some way prior to the beginning of their teaching careers as some explored curriculum writing, sought teachers who previously taught their current students, and used technology in ways that offered students a second chance to be successful. Some of these teachers had a strong interest in learning about their students' culture and others created opportunities for students to take the lead and explain their knowledge of science, empowering them to understand and know science using their own voices. The message being conveyed is clear; marginalized students can learn

science and future research is necessary to examine these culturally relevant practices to ensure that all students can develop a science identity for years to come.

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Appendix A

Interview Background Questions:

- Please tell me your name. If there is a pseudonym name, you would like to call yourself please let me know.
- Highest Education received: (B.S., M.S., or Ph.D.)
- What was the name of your teacher education program (if applicable), years of experience, and type of settings taught (inner-city, magnet setting, charter, etc.)?
- Did your college/university have a specialized middle-school level teacher preparation program available at the time you attended? If so, please describe. If not, how did you become certified to teach middle school?
- Do you believe your academic/content coursework in college adequately prepared you for teaching in an urban middle school science class?

Professional Questions:

- What is it like to be a middle school science teacher?
- When you decided to become a teacher, was it your intent to be a middle school science teacher?
- What teaching strategies do you use in your middle school-grade science class?
- Do you believe these strategies have a positive impact on students of color in science learning?
- What areas of middle school science do you see as a challenge for students of color?
- What forms of instruction/assessments have you used that have been most effective with students of color?
- What characteristics do you believe are important to possess/develop in order to be an effective middle school science teacher for students of color?

Post – Interview Questions

Goal: This research aims to examine middle school science teaching in an urban context.

Research Question: How do middle school science teachers in an urban context think about their relationship with good science teaching and their students?

a. What do middle school science teachers prioritize in an urban science classroom?
b. In what ways does culturally responsive teaching occur in an urban middle school science classroom?

Part 1: Member Check

Share a copy of the case with participants in advance. At the start of the interview, say:

Thank you for taking the time to read through what I have written about you and your teaching. In order to ensure that I am representing you and your teaching practice correctly, I would like to ask two questions.

- First, is there anything about the story that I did not get correct or that you think should be changed?

- Second, is there anything else missing about this portrayal of you and your teaching that you think I should add?

Part 2: Interview

I am researching how middle school science teachers in an urban context think about their relationship with good science teaching and their students……

1. Can you tell me a little bit about your vision of good science teaching?

2. Can you tell me about how you put that vision into practice with your students at _____(school)_____?

The next few questions are about connecting students to science learning.

3. What comes to mind when you think about your students and what they bring with them into science class?

4. In what ways do you try to connect your students to science in your teaching?

   - *if the participant does not give an example, ask:* Can you give me an example?

- *if the participant does not mention curriculum or science topics, ask:* In what ways do the students influence what science content you teach?

- *if the participant does not mention communication, ask:* In what ways do the students influence how you communicate science content with them?
- *if the participant mentions students' culture, ask:* People use the word "culture" in a wide variety of ways. Can you tell me more about what you mean when you talk about students' culture?

5. Sometimes teachers modify their teaching based on what they know about their students. Can you tell me about a time, recently or in the past, when you've made changes in what you planned to teach because you thought those changes would help your students learn better?

   - *if the participant does not give an example, ask:* Can you give me an example?

6. Could you share any other teaching methods that you use that seem to resonate with the students?

7. The last time we spoke, you mentioned that support for your teaching was important, and noted the science supervisor was one source of that support. Can you tell me more about how such support—from the supervisor or anyone else—helps you be a better teacher for your students?

8. How does the school and community environment influence your thinking about how you make connections between your students and the science you are teaching them?

9. Some conversations about current science events and culture are more difficult than others. Can you share an example of a conversation you have had with your students—recently or in the past—about a challenging topic, and how you approached that conversation?

10. Some science teachers introduce science topics that are connected to issues of social justice, socioeconomics, race, etc. into their classroom. I'm interested in this practice and would like to know how you think about this idea. Is this something that you try to do or try not to do?

    - *if the participant does not give an example, ask:* Can you give me an example?

11. Some students are more challenging to teach than others. Can you share an example of a challenging student with whom you felt successful in teaching?

This concludes the interview. Thank you for your time.