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Syracuse University

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ABSTRACT

This study examines how a classroom of elementary students of color constructed their science identities at a time in which the Next Generation Science Standards were taking root within their school's science program. While the standards were developed under the paradigm of science being representative of a body of knowledge informed by student experiences, this study chronicles how elementary students reconciled their multiple identities (as a student, a person of color, and a scientist—their identity work) within the bounds of their classroom and community. In addition, the teacher's positionality and the curriculum materials were studied to understand how they tended to students' identities. Employing critical ethnographic methodology, this exploratory study centers the voices of 14 fifth graders to understand their utilization of the science curriculum as a means of narrating and practicing these multiple identities. Data collection consisted of individual student and teacher interviews, analysis of student work and teacher lesson plans, and video classroom observations. The findings suggest that these students of color espoused color-evasive racial identities early in their academic careers and associated their science identities with how well they could abide by school rules, which ultimately determined their access to science learning opportunities. Although the students were aware of their racial identities and the apparent lack of representation of these identities in STEM-related fields, they have not yet linked their racial identities to their academic or disciplinary identities (e.g. viewing oneself as a Black scientist), indicating a failure of the equity-driven standards to properly center students' identities. The implications of this work bear significance for science teacher education programs, standards-aligned elementary science curriculum development, and the need for increased learning opportunities for pre-and in-service science teachers, as we strive to meet the instructional needs today's diverse student body.

“*Because I did what she told me to do.”* Understanding the Identity Work of Elementary Students of Color in the Science Classroom and how a Teacher’s Positionality Impacts Student Learning

by Terrance Burgess

B.A., University of North Carolina at Chapel Hill, 2011

M.A., University of North Carolina at Chapel Hill, 2015

Dissertation

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Teaching and Curriculum.

Syracuse University

May 2020

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As I reflect on the time leading to this point, I am flooded with a host of emotions which elicit various feelings. For me, this work in identity serves as the manifestation of my own educational experiences. Throughout my journey, I have been constantly reminded that these spaces were not designed for individuals who look like me. Despite these realizations, I am here, and it is my hope that this work encourages those after me.

First and foremost, I give honor to God and the many individuals who have earnestly kept me in their prayers that I might reach this milestone. To my parents, my late father, Adam Sr. and my mother, Deborah: the two of you raised each of us to pursue our dreams through advancing our education. You sacrificed many things so that I may pursue mine and I thank you. My siblings Uleesees, Gregory, Anthony, Saresa, and Eric: I love you dearly and could not have done this without your love and encouragement. To my extended family, I thank you. Your support and has been invaluable. To the countless family members I lost throughout this process: I love and miss each of you. This is for all of us.

It is an honor to have the support of colleagues whose insight has been instrumental in my pursuit of this work. Abundant thanks to my advisor and dear colleague, Dr. Sharon Dotger: Thank you for your continued support and critical insight as it has been influential to my work. To Dr. Marcelle Haddix, thank you for being an embodiment of intentional scholarship; your thoughts and willingness to support my work has meant the world. To Dr. Felicia Moore Mensah, you have truly been an inspiration. I thank you for your work and for pushing me to think of innovative and critical ways to approach my scholarship; I hope to be to others what you have been for me.

Lastly, I must thank those whose participation made this work possible. I sincerely thank the students, the families, the faculty, and the staff for allowing me into your space and engaging me in life-changing conversations. I do not take your participation lightly and am eternally grateful for your willingness to share your lives with me.

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CHAPTER 1—Introduction

Since the launch of Sputnik I, access to science instruction in the US has been predicated on the country's global advancement. As such, science disciplines privileged the "academic elites," only affording access to those who meet its oftentimes marginalizing prerequisites. This notion, coupled with our country's historical conceptualization of race, has greatly influenced who should have access to the various disciplines and named those who are considered incapable of possessing the academic rigor and grit supposedly required of scientists. To meet the global demands of preparing future scientists, secondary schools were among the first to receive a science curriculum and materials developed by prominent scientists in the field. These scientists were responsible for generating the textbooks adopted across our nations' high schools, which explains the overwhelming representation of White middle-aged men as the archetype of science. In recent decades, the science education community has acknowledged this problem and have made several 'science for all' calls throughout curriculum reform efforts. Despite these recent efforts, scholars have been critical of them, because rather than acknowledging how specific groups, namely students of color, have been historically positioned within the science discourse, the "science for all" calls were color-evasive at best, and ultimately did very little to reposition marginalized students as capable knowers and doers of science (Atwater, 2000; Mutegi, 2013; Parsons, 2014).

Within the past few years, the Next Generation Science Standards (NGSS) have emerged as a response to this critique and others. These standards aim to position all students as scientifically literate members of society who can make informed decisions regarding issues impacting our daily lives. In addition, the NGSS overhaul the traditional fact-driven science instruction espoused in previous reform efforts while explicitly acknowledging the exclusionary consequences resulting from the lack of representation of diverse identities across the science disciplines. While previous science curriculum reforms mainly emphasized secondary science (Rutherford & Ahlgren, 1990), these standards recognize the significance of providing elementary students with opportunities to interact with phenomena in a manner that builds upon one another from year to year. In addition, the standards have been written such that students have access to equitable science learning opportunities despite one's mathematics or literacy skills, which have historically been prerequisites for science courses and consumes most of the elementary instructional time (Blank, 2013).

As a result of the emphasis on mathematics and English/language arts (ELA) instruction, much of the research regarding elementary science education suggests elementary teachers feel inadequately prepared to teach science (Berg & Mensah, 2014). In addition, very little is known about what students think of science and how these views are incorporated into their already limited opportunities to engage with science in school. While the standards have slowly been considered for adoption by states across the country, research indicates adoption of new standards will be an insufficient condition for the establishment of equitable learning outcomes (Basile & Lopez, 2015). Students' identities have been shown to be an important factor in engaging students of color in STEM (Brown, 2004; 2006), yet little research has investigated how elementary students' and their respective teachers construct their science identities and the ways in which the curriculum materials allow for such constructions to manifest within the classroom. In the pages to follow, I intend to explain the aims and rationale, theoretical framework, and methods that guide this study.

Aim of this Study

Considering the NGSS' recommendation for teachers to begin science instruction in elementary grades, I have become increasingly interested in understanding how students develop science identities and are subsequently positioned by others as such within the content. Through classroom observations and literature, it is apparent that teachers and researchers argue for recognizing students as *scientists* (NSTA, 2018), but this is taken up in classrooms in various ways. Researchers make the case for centering students in the science discourse (Arnold, 2012; Gomez, 2007), which manifests as teachers referring to students as practitioners of the discipline during the instructional period. For example, during science instruction, teachers may refer to students as scientists in a general sense, or mathematicians during mathematics instruction. However, little is known about how elementary students view themselves as participants within this community, considering their previously limited opportunities to engage in science practices.

Further, given the sociohistorical context of how students of color have been positioned as learners in science and schools writ large, coupled with the overwhelming representation of White women as elementary teachers (NCES, 2019), it is unclear if this rhetoric has any significant role in shaping students' science identities. Although a rather simplistic generalization, does merely referring to students as scientists in fact cause them to consider themselves as such? Do they define science based on their classroom experiences, thus discounting any science-related endeavors at home or within their communities? In addition, while referring to students as scientists, do elementary teachers consider themselves a scientist or science teacher?

Considering the high expectation of having a general understanding of myriad science disciplines with limited formal training, it is clear elementary teachers need support to effectively engage their students in science instruction. As a result, they often rely on kit-based instructional materials to guide their science instruction (Jones et al., 2012). These instructional materials are purportedly aligned to the NGSS, allowing teachers and schools writ large to claim NGSS-based instruction, which calls for equitable science access for all students through a three-dimensional approach. As such, schools theoretically meet the needs of students and teachers alike through the provision of equity-driven instructional materials.

Although the provision of equitable science learning opportunities is intention of the NGSS, I argue translating words to practice is quite difficult, especially given the fact that the NGSS were not designed as, despite suggested within the curriculum materials, a one-size-fits-all approach. As such, given the historical context which undergird the necessitation of these standards, it is critical to understand how they are taken up within schools, particularly schools where the community they serve are constant reminders of how systemic issues of power, race, class, etc. shape outcomes for students from the early grades onward. In addition, high stakes testing practices have pushed science instruction to the margins of elementary school schedules as it is not assessed across all grade levels (Blank, 2013). Because of these issues, this study seeks to address the following:

1. How do elementary students of color construct their science identities in classroom spaces?
   (a) How does the curriculum support elementary students of color's science identity development?
2. How does an elementary teacher's positionality inform her science instruction within a diverse classroom?

Rationale for this Study

Echoing the sentiments of the early beginnings of secondary science education, calls for engaging students of color[1] in STEM education have been articulated as a need to prepare a workforce to perform the 21st-century jobs of our society. In fact, in 1994's *Science in the National Interest*, former President Bill Clinton declared "[America] has not had a coherent policy for developing all our human resources for science and technology" (p. 25). President Clinton was making the case for recruiting and supporting "individuals of underrepresented groups" in STEM fields (p. 25). Rather than positioning access to science as one's fundamental right (Tate, 2001; see also: Atwater, 2000), students of color have been "commodified" (Basile & Lopez, 2015, p. 522) to increase the country's global standing. This message permeates academic literature aimed to understand the persistence of students of color in STEM fields (Chang et al., 2011; Jackson & Suizzo, 2015; Maltese & Tai, 2011; Moore, 2006; Palmer et al., 2011) suggesting the significance of broadening the scope of science access is predicated on the desire to meet labor demands of a country built by those same means.

Critiquing the calls recommending 'science for all' for global advancement, Atwater (2000) asserted that this charge cannot fully be pursued until precollege students of color, particularly Black American[2] students, have equitable access to high-quality science instruction. She stressed the importance of not merely providing equal access, as equality from an access perspective only continues to widen gap between students of color who attend urban schools (Milner, 2012) or underfunded rural schools, as the funds would likely not be utilized for the

[1] I adopt Basile and Lopez's (2015) rationale for using the term 'students of color,' as not "ascrib[ing] an all-encompassing, comprehensive set of attributes to the collectives of marginalized and historically oppressed peoples. Rather, we recognize a set of shared experiences of exclusion, oppression, and violence as well as accomplishments, achievements, and advances" (p. 524).

[2] Atwater (2000) uses the term Black American to include individuals who identify as African American, Caribbean, or Africans.

same purposes. In addition to providing equitable opportunities for students of color, Atwater (2000) proposed multicultural science education as a way for White teachers to engage students of color. This multicultural instruction recognizes that students of marginalized identities have lived experiences which must be acknowledged and centered within the sociocultural context of schooling, which has long privileged dominant identities through instruction and curricula.

I provide this overview of Atwater's (2000) call because these issues continue to be evermore pressing two decades later. The National Research Council (2012) echoed the sentiments of Atwater (2000) by declaring:

> Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue connecting to students' interests and experiences is particularly important for broadening participation in science. (p. 28)

This declaration is yet another reminder of the urgent need for equity in science education. These calls are not new, and the repetition indicates our current practices are continuing to perpetuate the status quo. Some scholars have suggested culturally responsive science pedagogy to support students of color, and while this has produced fruitful research (Atwater, 2000; Codrington, 2014; Mensah, 2011a; Parsons, 2008; Parsons & Carlone, 2013; Wallace & Brand, 2012), in some cases, the interpretation of culturally responsive pedagogy has become muddied, resulting in the perpetuation of inequitable science opportunities for students of color. Others have argued that for authentic equitable science opportunities for students of color to exist, we must understand their science identities (Brown, 2004; 2006; Brown et al., 2005; Carlone & Johnson, 2007;Varelas, 2012; Varelas, Kane, & Wylie, 2012), which could potentially eliminate the cultural border crossing students of color often experience in navigating STEM disciplines (Brand et al., 2006).

The National Academies of Sciences, Engineering, and Medicine (2019) argued culturally responsive science pedagogy can "support the learning of all students by situating differences as assets, building on students' life experiences, and leveraging local and dynamic views of cultural life for the study of science and engineering" (p. 4). This report explicitly recognized these practices to engage secondary learners (grades 6-12), "as they are a key time to foster students' agency in their own learning" (p. 10) and encouraged other scholars to provide research-based recommendations for elementary-aged learners. The NRC (2012) also recognized this need, as the NGSS addresses K-5 science teaching and learning because young children's everyday experiences allow them to build an understanding of the world. In turn, children bring this understanding into the classroom, serving as the foundation of how they view science. Thus, through the provision of science instruction, I argue elementary students develop scientific literacy and agency as learners within the discipline. As such, I conceptualize science identity as the manifestation of students' opportunities to learn science.

Previous Work

This work began in 2017 as the result of pilot study I conducted with fourth and fifth-grade students of color where I aimed to understand how these students constructed their science identities as learners within their classrooms as their school was implementing NGSS-aligned curriculum materials. Throughout this time, I immersed myself into the culture of Central Elementary (a pseudonym), and its community in various ways (e.g. conducting informal classroom observations to support teachers' science instruction, volunteering to assist staff during school-wide activities, volunteering as a teaching assistant during summer school) and built rapport with the students, faculty, and staff.

As a result of my work within the school, I recruited 16 fourth graders and 8 fifth graders to participate in an exploratory ethnographic study. Students participated in semi-structured interviews designed to understand how their experiences in science class coupled with their out-of-school science experiences fostered a space for the construction of their science identities. Classroom observations were also conducted to contextualize my conversations with students and supplemented with science notebook entries to further understand how students' science identities manifested with their science instruction.

Findings from this study suggested that although the students considered themselves scientists during classroom instruction, these identities hinged upon teacher recognition. Students only viewed themselves as scientists if their teacher recognized them as such (either through assignment feedback or piquing students' interests through interactive lessons). Additionally, fifth-grade students reported experiencing gaps in science instruction, presumably due to the absence of a statewide exam.

While these initial findings were generative, the limitations of the study were perhaps more significant, as they influenced the design of the current study. Because all fourth-and fifth-grade students were invited to participate in the study, student participants were dispersed across nine different classrooms and since science was taught at the one time for all fourth graders and another time for all fifth graders, it was impossible to observe each student during science time in a consistent manner, resulting in scattered observation data. Further, when interviewing students about some of my classroom observations regarding their participation, many students would not recall the instances I referenced throughout the interview.

To mitigate this limitation, the current study focused on one teacher and her classroom. This project serves as an ideal opportunity to understand how students' science identities are fostered in the absence of high stakes testing and the role their teacher plays in supporting said identities. In other words, it is critical to explore how students' science experiences are impacted from one year to the next, especially when the teacher is not pressured by a high stakes test. Given that students are formally introduced to science and engineering-specific courses in middle school (grades 6-8), it is important to understand how these identities are shaped by their elementary science experiences if we are to consider ways to foster their agency in later years (NASEM, 2019).

Considering the NRC's (2012) assertion that elementary students enter classrooms with lived experiences allowing them to make sense of their worlds, we can assume they transition to middle school with many of these same understandings. In other words, they fail to enter middle school as blank slates awaiting the scientific explanations to their already plausibly rationalized phenomenological understandings. As such, it is important to explore how the recommended instructional practices (e.g. three-dimensional science teaching, centering students' identities) allow students to "foster agency" in earlier grades, a gap this study intends to address.

Theoretical Framework

Constructing Identity

Because the purpose of this study is to understand how elementary students of color construct science identities and the degree to which the science curriculum and teacher's science identity influences them, I draw on Varelas, Martin, and Kane's (2012) *Content Learning and Identity Construction* (CLIC) framework to anchor this study. Understanding one's science identity development requires an acknowledgement of the racialized underpinnings of both school and science writ large (Mutegi, 2013). The CLIC framework was developed as a tool to understand how African American students' identities can strengthen their learning in science and mathematics and is comprised of two main parts: Content Learning (science and/or mathematics learning) and Identity Constructions (disciplinary identity construction as a scientist, racial identity construction as an emergent understanding of one' Blackness, and academic identity construction as a student engaged in classroom practices). Identity construction is conceptualized as being "connected and intertwined with content learning and how children see themselves and others vis-à-vis disciplinary knowledge and practices" (p. 323). This is significant because it recognizes that "learning is a sociopolitical activity where issues of authority, power, and hierarchy affect social relations, access to ideas, and positionings that learners of a particularly socially constructed racial group, ethnolinguistic affiliation, class, gender, and so forth, must negotiate" (p. 324). The CLIC framework attempts to position Black students' identities as a complex entity influenced by an array of environmental factors that constantly intersect with one another, leading to identities which may become more salient from one moment to the next (see Figure 1 for a conceptual model of the framework).

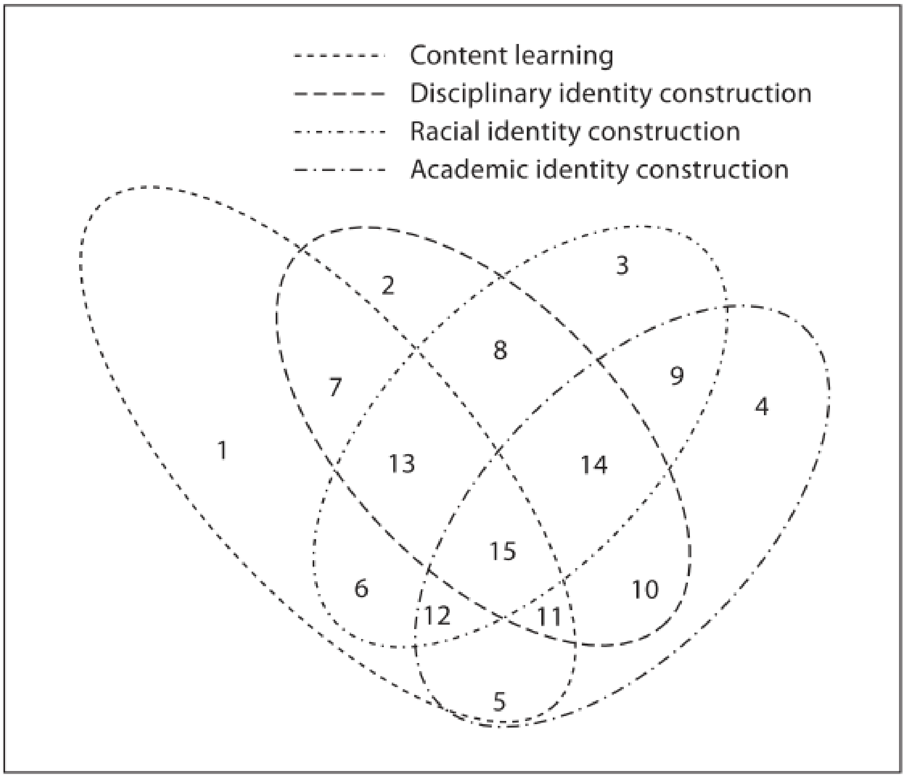


Figure 1: CLIC framework conceptual model. From Varelas, Martin, & Kane (2012).

This schematic illustrates the various interactions between content learning and identity constructions and their variations across students depending on their interpretations of a particular construct. For example, Varelas, Martin, and Kane (2012) unpacked the notion of *obedience* through this framework to explain how it may be interpreted through these intersections. If a teacher interpreted science learning to be a representation of what they considered to be "well-behaved" students (academic identity construction), the student may subsequently consider themselves a scientist only if they behave well in class during science time (disciplinary identity construction). This is represented as section 14 in Figure 1.

Identities Through Narratives

CLIC further offers a way for students to describe their identities through narratives, (Sfard & Prusak, 2005) reconciling their personal perceptions of who scientists are with the general accepted notions of a scientist. Sfard and Prusak (2005) suggested viewing identity as a narration of oneself, allowing the storyteller the power to decide who they are on their own terms. They distinguished between first, second, and third person identities as the basis to describe one's narrative identity. First person identities are stories the individual tells about themselves, second person identities are stories told to the individual by someone else, and third person identities are stories which are generated by a third party and disseminated to a third party. These identities were further classified as one's *actual* or *designated* identity based on the person's narration. For example, the phrase "I am a scientist" would be classified as one's actual identity, as it is the first-person account, whereas the phrase "I would like to be a scientist" serves as one's designated identity, as it represents what is either expected of the individual or projected onto them by an undefined source. While self-reported actual identities may become one's designated identity, the teacher's or society's perception of an individual (designated identity) can influence this identity. Consider the example illustrating section 14 in Figure 1. Although not explicitly stated, we understand the existing power dynamics between the teacher and student to influence the student's actual identity. Because the teacher considered science learning to occur when students displayed desired classroom behaviors, this teacher's expectation became the students' designated identity.

Student narratives serve as an example of their creation of a *storyrealm* (Young, 1989), which aims to humanize their experiences. In other words, they provide a contextual counternarrative which helps situate the students' actual identities despite the teacher's designated identity. Overall, narratives are a form of discourse that seeks to change the Discourse (Gee, 2005), repositioning the power dynamics between an individual and their community, which in this case, are the historically marginalized identities in science. Narratives are powerful devices that allow people to be humanized such that researchers can develop a “feeling for the learner” (Varelas, 2012, p.1). In addition to humanizing marginalized individuals, first-person narratives have the power to directly challenge the dominant discourse, serving as a counternarrative (Yosso, 2006), providing the researcher the opportunity to observe the students' *identities in practice* (Holland et al., 1998) which are influenced by institutions of power and contextualized by three factors, ones' figured world, positionality, and the process of authoring oneself. Through understanding how students of color practice their identities with respect to these factors, we begin furthering a much-needed area of research (Varelas, Martin, & Kane, 2012).

Organization of this Document

Throughout this document, I will provide a comprehensive account of how I came to understand the overall research questions. In Chapter 2, I review relevant literature related to central categories of each of the research questions: identity development, elementary science teacher development, and science curriculum reforms. Within this chapter, there are several discipline-specific terms which I define within the text; I also include a glossary in Appendix H for ease of reference. In Chapter 3, I introduce the participants and overview the design of the study along with the methods employed to address the research questions. In Chapter 4, I detail the findings of this work supplemented with illustrative vignettes of student voices alongside deep analysis of the curriculum materials and teacher accounts of her science instruction. Lastly, in Chapter 5, I conclude this work with a discussion of the findings, while detailing how various stakeholders are implicated in this work in addition to providing additional areas of further research with concrete ways to embrace an equity-driven agenda in elementary science instruction.

CHAPTER 2—Review of Related Literature

Scholars suggest exploring the science identity development of students of color[3] through the centering of their voices as this begins to address issues of equity and social justice that have been longstanding issues within science education (Brown, 2006; Brown et al., 2017; Hanzari, et al., 2013; Johnson et al., 2011. As such, this work addresses these recommendations through the exploration of three research questions. To understand the existing literature related to these research questions, I have organized the literature review into three main sections, the students, the teacher, and the curriculum. These sections are further divided into multiple subsections intended to frame the research questions. To contextualize the first research question, I provide a general conceptualization of identity, and subsequently connect this conceptualization to intersections of both race and gender to understand their overall influence on one's science identity. Because the research question is centered within a science classroom, I review literature related to instructional practices which center students' identities (e.g. classroom discourse) and the effects of enacting such practices (e.g. student agency). To address the second research question, I review literature related to the science identity development of elementary teachers. Although this study involves the work of a veteran in-service teacher, much of the existing research regarding the terms "elementary teachers," "science instruction," and "identity" has centered pre-service teachers (PSTs), and as such, will be the focus of this review. I conclude with overviewing reforms in the science education, which are central to understanding how the science curriculum is positioned in this study with regards to eliciting and supporting one's multiple identities.

[3] Although I utilize the terminology 'students of color,' I explicitly refer to the ethnicities as described by the authors in the literature reviewed for this study.

Defining Identity

Gee's (2003) work on defining identity and its respective domains has been widely used to conceptualize identity within science education. He defined identity as "being recognized as a certain "kind of person," in a given context" (p. 99). In addition, he provided four domains for which to view identity: Nature-Identity, Institution-Identity, Discourse-Identity, and Affinity-Identity with the purpose of providing contexts for which one may be deemed as such a person. This framework has been applied to research aiming to understand how students of color develop science identities (Brown, 2004) which upon unpacking the domains can be quite problematic. Lisa Delpit (2006) critiqued Gee's N-and D-identities, as they relied on arguments which suggest it virtually impossible for a person of color or other individual of a marginalized identity to become part of a dominant discourse. Delpit claimed because of these positions, teachers can feel "powerless to effect change, and a student feeling hopeless that change will occur" (p.154). Because science has been a discipline reserved for enabling the advancement of middle-class White males (Ashbacher, et al., 2009), Gee's assertions based on genetics or one's socioeconomic upbringing implicitly uphold these notions.

To address this critique, Brown (2004) argued students of color have rather fluid identities consisting of domains that may be "socially constructed in the moment" (Brown et al., 2005, p. 783). He further identified this fluidity as a continuum of discursive identities, allowing for the appropriation of scientific discourse. As such, the discipline becomes accessible for these students despite the existing limiting factors. These four domains of discursive identity development are: *Opposition Status, Maintenance Status, Incorporation Status,* and *Proficiency Status*. Although these domains suggested ample opportunities for students of color to engage with STEM, Brown complicated this assertion by highlighting the alienation experienced by students while navigating these discursive domains. For example, a student of opposition status "avoids the use of science discourse as a rule" (p. 824). In his study, high school students demonstrated this status by making a conscious decision to deny public displays of their content knowledge or by deflecting their speaking time to other classmates. Because science discourse is uncompromising, a student who chooses to oppose the discourse is not afforded access to science vis-à-vis this discursive identity.

Further, Malone and Barabino (2009), complicated the notion of identity formation, positing that underrepresented students are identified as invisible due to a lack of recognition. Because of this lack of recognition, underrepresented minority students are not provided an opportunity to develop a science identity, as they are unable to overcome the feelings of isolation experienced in collaborative spaces.

Building on Vygotsky's notion of self-management, Holland et al. (1998) described the process of identity formation as being "cultural or collective resources first experienced by children and neophytes in social interaction" (p. 281). These resources are used as signs to represent one's behavior, which is further influenced by their surroundings—one's *identity work.* Calabrese Barton et al. (2013) furthered this notion through their conceptualization of identity work as a process. They defined the term as "the actions that individuals take and the relationships they form…at any given moment and as constrained by the historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place" (p. 38). This definition allows one to view identity within the context of oppressive structural institutions (such as schools) while understanding how these structures may influence shifts in one's identity, and as such, is most fitting for defining identity in this study.

Racial Identity Development

When considering Critical Race Theory's (CRT) perspectives on race and racism, it is important to understand how one's racial identity is conceptualized. Delgado and Stefancic, (2012) contends that racism "is a means by which society allocates privilege and status" (p. 21). As such, when acknowledging the historical whiteness embedded within science education vis-à-vis teacher education programs (Mensah & Jackson, 2018; Mensah, 2019), if left unchecked, we might expect science instruction to continually engage and privilege the dominant (White) identity. Research regarding one's racial identity development for persons of color has largely been group-specific (Jackson, 2012; Cross et al., 1991; Sellers et al., 1998), and rather than provide an exhaustive review of literature related to each individual ethnic group, I intend to present an overview which forms the basis for the conceptualization of race within this study.

In their synthesis of previous literature on group identity Sellers, et al., (1998) developed the Multidimensional Model of Racial Identity (MMRI) framework to account for the significance of historical and cultural experiences and their effects on the group identity of African Americans in the United States. This framework conceptualized racial identity as "the significance and qualitative meaning that individuals attribute to their membership within the Black racial group within their self-concepts" (p. 23). The MMRI is significant because it offers an intersectional approach (Crenshaw, 1989) to understanding one's racial identity development, as it "provide[s] the opportunity to investigate race within the context of other identities such as gender or occupational identity" (p. 23). An emphasis is placed on the individual defining the significance of their racial identity for themselves (e.g. defining what it means to be Black), and consists of four dimensions: racial salience, racial centrality, racial regard, and racial ideology. Two dimensions, racial *salience* and *centrality*, are categorized as "the significance that individuals attach to race in defining themselves," and racial *regard* and *ideology* are categorized as "the individuals' perceptions of what it means to be Black" (p. 24).

Sellers et. al. (1998) developed an accompanying quantitative measure, the *Multidimensional Inventory of Black Identity* (MIBI) to further understand the enactment of the Black identity development of college-aged students in the US. This device served as an operationalization of the MMRI and measured three of the four scales of the MMRI: centrality, regard, and ideology dimensions.

Although it provided users with specific prompts to situate one's identities within each of the dimensions, this scale was unique because it centered the voices of the individual person as it relied on the values one attributed to each dimension. The inventory was administered to a sample of 474 undergraduate students who self-identified as African American across two universities, one Historically Black College or University (HBCU) and one Predominately White Institution (PWI) for reliability and validity measures. A factor analysis was conducted for the centrality and ideology scales, yielding alpha coefficients ranging from 0.70 to 0.79 for predictive and construct validity. The *public* and *private* regard subscales of the *regard* domain yielded weak and modest alpha coefficients (0.20 and 0.60, respectively), leading to revisions of the items of associated with this domain.

In the text *New Perspectives on Racial Identity Development* (2012), Bailey Jackson presents an updated version of his 1976 Black Identity Development (BID) framework, in which he accounts for the influential nature of Black culture on one's identity development. Originating from his earlier work, Jackson acknowledged the similarities among his framework and Cross' (1971) Nigresence model; however, he asserts that the models were developed separately from one another, further providing contextual descriptors for each of the BID stages: *naïve*, *acceptance, resistance, redefinition,* and *internalization*. In the space below, I provide a brief description of each stage along with an overall analysis of the framework.

Descriptions of each stage

- *Naïve:* children (ages 0-3) who have no notion of race. This stage marks a point where children may begin to recognize racial differences between individuals but largely rely on external factors to influence their positive or negative associations with said differences.
- *Acceptance:* person begins associating Blackness with societal (stereotypical) representations, which are usually negative. Young people (teenage to early 20s) have a difficult time navigating racism as they decipher their role in challenging these notions. This is a time when acceptance of Black culture is beneficial in fostering a positive Black identity.
- *Resistance:* Individual begins to understand the systemic nature of racism and resents elements of Whiteness and other Black individuals in the acceptance stage. This stage is highly emotional, with Black individuals electing to either: fully embrace the resistance phase where they understand the risks of losing the benefits experienced during Acceptance, or passive resistance where they aim to "stay in favor of White society while rejecting racism" (Jackson, 2012 p. 44).
- *Redefinition:* Individual develops and refines their Black identity for personal edification without concern for how it is interpreted through Whiteness. Actively seeks other Black individuals in this phase.

- *Internalization:* This phase marks the period where an individual focuses on "nurturing their Blackness." Individuals in this phase are not inclined to "explain, defend, or protect their Black identity" (p. 45).

Recognizing the linearity of his framework, Jackson (2012) acknowledged the significant role of intersectionality in shaping one's identity within the post-internalization phase. He lamented that in previous iterations of the framework, "when one reached this stage, the process of developing a full and healthy Black identity was complete" (p. 46). However, through the incorporation of intersectionality and the recognition of the significance of environmental influences one's identity (Tatum, 1997/2017), Jackson (2012) argued that one must now contend with what it means to be Black and *fill in the blank*, representing the various social identities which may intersect with one's racial identity.

When understanding the racial identity development of multiracial individuals, Wijeyesinghe (2012) also called for an intersectional approach, largely as earlier scholarship chronicled individuals' difficulties navigating their multiple ethnic identities (Thornton, 1996). The intersectional approach, she argued, allows one to account for the role of choice in influencing one's multiracial identity construction. One must account for other social identity markers (e.g. gender, sexual orientation, and class), which also suggests one's identity is fluid, as their "racial identity can change or remain the same throughout a person's lifetime" (p. 82). In her review, she acknowledges her previous work (1992; 2001) in developing the framework, the *Factor Model of Multiracial Identity Development* (FMMI). In this framework, she argued that identity was a choice made by the individual based on some combination of 8 factors: racial ancestry, early experiences and socialization, cultural attachment, physical appearance, social and historical context, political awareness and orientation, other social identities, spirituality.

These eight factors were understood to overlap and influence one another, which ultimately leads to an individual's racial classification. Unlike Jackson's (2012) framework, there is no linearity in arriving at one's racial identity, and rather than advance through various stages, one's racial identity may be a fluid, constant reflection of their lived experiences and surroundings.

Continuing the argument of the role of choice on a multiracial individual's racial identity development, Root (2002) provided the *Ecological Framework for Understanding Multiracial Racial Identity Development*. Like the FMMI, this framework relies on choice, but focuses on the visible and invisible factors which were viewed as influencing one's identity. These factors, physical appearance, family socialization, generation, geographical region, gender, and sexual orientation were also viewed as intersectional, and through these interactions influenced one's choice of their racial identity. While useful in conceptualizing one's racial identity, Wijeyesinghe (2012) acknowledged the lack of this framework's accounting for "the impact of the salience of these factors on choice of identity" (p.94). In other words, although the framework identifies the various ecological factors influencing one's identity, the movement and interactions amongst these factors is not directly visible.

Science Identity and Gender

Women of Color in Science

In a case of examining the science identities of young women of color, Brickhouse and Potter (2001) conducted a qualitative longitudinal study to explore the various facets in which middle school students gained access to higher-level science learning opportunities. Data collection methods commenced over a span of 3 years and consisted of written autobiographies, journal entries, and interviews. The authors argued that "individuals have some control over identity yet are also constrained by structure and power relations that may limit the kinds of identities that are viable" (p. 966). In essence, young students can manipulate their identities only if it is in the interest of the greater society. This led to reinforcing stereotype roles of students in school (e.g. Black women who are stereotyped as "loud"), or cases in which students were expected to assimilate and accept the conditions of Whiteness. Young women of color's identities are silenced as they enter schools established on a European foundation, which is unhealthy for the student, as it can present further complications for identity development (Brickhouse & Potter, 2001). Further, this is a direct manifestation of the *cultural mismatch* between the white-established school and the student of color (Atwater, et al., 2013).

For the purposes of this review, I define cultural mismatch as the misalignment between the lived (cultural) experiences of African American students and the established traditional (White) culture of their science classroom (Parsons, 2003). Because of this misalignment, African American students fail to engage in science learning that holds significance for them. These students are also expected to conform to the preexisting expectations and views of what has historically been interpreted as being a "scientist." That is, they cannot see themselves as scientists because society has deemed science as a field dominated by middle-class White men donning a white lab coat commonly embodying the Albert Einstein-like "mad scientist" identity (Atwater et al., 2013). Because the students' cultural capital is not considered in the instructional planning and execution (Emdin, 2011), they are expected to rely on the rote memorization of facts passed off as quality science education (Atwater et al., 2013).

To allow young women of color a space in which their science identities can develop and thrive, some scholars recommend broadening the definition of science and what counts as authentic science. This expansion would function as a hybrid space, where girls' *figured worlds* (Holland et al., 1998), defined as "[the] socially and culturally constructed realm[s] of interpretation in which characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p.32) becomes an acceptable part of the science discourse, ultimately resulting in young women, particularly those from marginalized identities seeing themselves as scientists. For example, Gonsalves et al. (2013) conducted an ethnographic study grounded in sociocultural theory to illustrate this point. The study was conducted in a local community center dedicated to providing afterschool programming for youth of all ages. The *ConvoClub,* as it was known to the women, was a discussion-based club created exclusively for young women to discuss any issue the group deemed relevant for their lives. Through the club, the young women could engage in science in a way which held significant personal relevance, resulting in a genuine interest in science.

Similarly, Calabrese Barton et al. (2013) explored the ways in which Black girls engaged in identity work through afterschool activities. The case study explored how two young women (Diane and Chantelle) both engaged in identity work but had opposite experiences of one another. In the case of Diane, she spent a significant amount of time and energy ensuring a complete understanding of the scientific concepts resulting in longer completion times of in-class tasks. Her grades bordered on the B+/A- range, yet Diane was perceived as disinterested in science despite her ability to articulate a deeper understanding of the concepts, whereas her peers could only generate responses indicative of surface-level understandings. This miscategorization of Diane's identity work resulted in her eschewing science as she transitioned from 7th to 8th grade.

Chantelle, a student at a different school, had the opposite experience. She combined her love for dance with her budding science interests vis-à-vis the *GreenClub,* and developed a sustainability initiative within her family and school to educate others on the benefits of using compact fluorescent light bulbs. Her identity work resulted in a figured world where she leveraged her interests in the arts and science to become a leader within her grade. In both cases, the young women's figured worlds did not map directly onto the accepted notion of what constitutes science; hence the scholars' calls for the broadening of the definition.

Perhaps an extension of this argument lies in where the bulk of science learning takes place: the classroom. Requiring women of color to rely on the offerings of afterschool clubs or supplemental programming does little to disrupt the hegemonic structure of the science classroom. In addition, if classroom structures are not addressed, these structures are likely upheld as young women advance in their science trajectories. For example, Johnson et al. (2011) utilized multiracial feminist theory to explore the experiences of three women of color in science-based professions to understand how these women authored their identities as they navigated their respective disciplines. The findings suggested the structural components of science presented various challenges for these women as they were forced to assume multiple identities to be recognized as a valid contributor to their respective disciplines. This notion of identity assumption was further complicated as these were all women of color, and oftentimes various identity markers (e.g. being a woman, being a person of color, being a scientist, etc.) competed with one another in certain spaces, limiting their access to science. These identity markers interact to influence a female's overall science identity and can affect how she is recognized by her peers, especially when considering the performance of such identities (Carlone & Johnson 2007).

Students' identities are also fluid, and for some, rely heavily on the relationship between their self-identity and the perceived identity of themselves predetermined by scientific experts (Carlone & Johnson, 2007; Sfard & Prusak, 2005). According to Carlone and Johnson (2007), an individual with a strong science identity is “[one who] is competent, motivated to understand the world scientifically, [and] has the requisite skills to perform for others her competence… [and] recognizes herself, and gets recognized by others as a 'science person'” (p. 1190). This conceptualization is important in understanding the development of a science identity of successful undergraduate women of color pursuing degrees within science disciplines because it acknowledges how influential self-perception, which can be influenced by others, is in shaping one’s identity.

Additional studies examining the science identities of Black women within the K-12 classroom argue for access to advanced courses as a means of supporting an emergent science identity. Young et al. (2017a) conducted a quantitative study utilizing a sample of 1,810 self-identified Black girls from the High School Longitudinal Study of 2009/2012 (HLS:09/12) to determine the relationship between Black girls’ science dispositions (identities, utilities, self-efficacies, and interests) and access to Advanced Placement or International Baccalaureate science courses. The findings of the study suggested a correlation between one’s science disposition and their enrollment in an advanced science course. More specifically, positive science dispositions were correlated to such enrollments. Although the study cannot claim causation between the two variables (science disposition and advanced science enrollment), the findings were useful in recognizing the need for access to advanced science courses for young Black women.

In a separate study, Young et al. (2017b) suggested providing academically gifted programs for Black girls, which would help close the STEM achievement gap between Black girls and their White counterparts. They further argued the rigorous programming offered through gifted education programs would allow Black girls to transition into advanced placement courses. The scholars' conceptualization of *academically gifted* was not defined, which is problematic because the provision of these programs can result in cohorts of students being hand selected by teachers or advocated for by parents for access to its services, perpetuating the inequities that exist within schools. Although access to gifted programming and advanced STEM courses may ultimately affect Black girls' science dispositions, Young et al. (2017b) failed to identify any contextual information regarding the source of these science dispositions nor any information regarding Black girls' experiences within gifted programs, indicating the need for further research, likely through narratives (Sfard & Prusak, 2005) which could offer a deeper perspective not exclusive to programming. Further, this represents the need for science education to shift its focus such that Black girls' science identities shape their science experiences, because although access to advanced courses and programming may affect their identities, the structure of science in these spaces still center White men, only allowing few to persist while traversing such dangerous terrain.

Men of Color in Science

Rather than exploring ways in which Black males foster science identities in traditional science classrooms, Brown et al. (2017) explored the ways Black males' racial identities become synonymous with being a scientist in an intentional space designed to elicit such an intersection. In this case, a local elementary charter school designed for African American males created a space where the boys' identities were affirmed and celebrated through noting the achievements of prominent African American male scientists. Brown et al. utilized contextual analysis to document representations of how the school affirmed the young men's Blackness through teacher-parent correspondence, student recognition, and school artwork (e.g. posters, bulletin boards, etc.). Here, students could embrace their science identities as a tool of agency rather than alienation from their Black peers (Fordham & Ogbu, 1986). This is significant as it offers an alternative narrative to much of the existing research regarding the school experiences of males of color.

For example, in Gilbert and Yerrick's (2001) study, they chronicled the experiences of a young Latino male who transferred to a rural school in the South. Because he was a transfer student with a transient schooling history, he was tracked into a lower-level science class. As a student who did not find any other Latinx students within the school, he immediately found refuge with the other young Black males in his class. While some scholars may describe this as self-segregation (Conchas, 2006), this may be a coping mechanism for students of color as they seek to develop senses of community within foreign environments. This particular student was forced to choose between a science identity and a racial identity, a choice the charter school in Brown et al.'s (2017) eliminated by design. The structure of science classrooms in traditional schools can be conducive to young Black males' racial and science identities but requires an emphasis on student narratives (Kane, 2016) rather than teacher-centered content delivery.

Kane (2016) utilized narrative inquiry to understand the dialogic classroom space where Black boys' science identities were welcomed. For example, one student, Lawrence, described himself as being "good at drawing" when asked about his science identity. He elaborated stating that he drew well through practicing at home, which allowed him to excel in communicating his science ideas in his science notebook through illustrations. The narrative inquiry allowed the students to construct their own identities of what they considered science while also defining who they were and how they desired others to view themselves based on their lived experiences. Rather than approach science through traditional instructional means, the teacher utilized narratives to create dialogic space where students felt comfortable participating in class and viewed themselves as actual scientists (Aschbacher & Ing, 2017). This stands in stark contrast to how science is traditionally taught within schools. The teacher incorporated students' ways of knowing (Calabrese Barton & Tan, 2009, a practice reminiscent of culturally relevant pedagogy. Through the utilization of this pedagogy, students, particularly students of color, developed a sense of agency as their science identities developed. This agency allowed students of color to change the narrative of their science education, ultimately discrediting stereotypes of who has the right to know and "do" science.

Funds of Knowledge and Science Literacy

When exploring the science identity development of elementary students, many science education scholars have utilized discourse analysis as a means of centering the voices of marginalized identities within the science discourse (Arnold, 2012; Brown & Spang, 2008; Brown et al., 2016; Emdin, 2011; Kirch & Siry, 2012; Siry et al., 2012). Further, elementary students' science identities have traditionally been constructed around their content acquisition (Reveles et al., 2004). One area of research attempting to disrupt this narrative is through studying elementary students' *funds of knowledge*. A phrase coined by scholars Vélez-Ibáñez and Greenberg (1992), funds of knowledge was conceptualized as "the strategic and cultural resources…that households contain" (p. 313). These scholars argued that these resources were invaluable to addressing the deficit-oriented educational inequities experienced by Latinx students throughout the US by intentionally establishing relationships between teachers, students, and parents. When considering individuals' funds of knowledge within the scope of science education, scholars argue that through this consideration, the identities of underrepresented minority students are incorporated into the discourse of science (Arnold, 2012; Barton & Tan, 2009; Brown, 2006; Gomez, 2007; Varelas et al., 2014). Further, these students' cultural experiences are privileged in such a way that ultimately creates a knowledge-producing space reflective of a diverse group of learners.

Arnold (2012) utilized discourse analysis to understand how students positioned themselves as participants in science. This was done through following the experiences of a middle school teacher and his science class. Arnold selected this teacher's classroom for the study because he was identified by colleagues as one of the strongest science teachers within the building. The students were completing their first year of middle school, and the researcher was interested in understanding how students positioned themselves as science learners, as research suggested they begin to lose interest in science during their middle school years (Aschbacher & Ing, 2017).

The study's design involved individual interviews and video recordings of groups of students who participated in the science lessons. Through discourse analysis, Arnold unpacked how one's *Umwelt*, a historical case of one's positionality in various discursive practices, informed their science understandings. Tasha, a student in the study, indicated an umwelt that suggested her positionality as a knower of science was contradictory to her actual science understanding. Videotaped lessons were analyzed in conjunction with interviews to understand how Tasha's discursive practices situated herself as a knower (or not) of the science discipline. Although there were instances in which Tasha positioned herself as a knower of science, her classmates' responses indicated a contradiction to these claims, resulting in a repositioning of her actual science identity as a designated science identity of one who was not "good" in science (Sfard & Prusak, 2005). Science discourse has historically been understood to be a collaborative practice, but this serves as a clear example of how discursive classroom practices can function as a means of discrediting students' science identities.

Reveles, et al. (2004) utilized Wenger's (1998) notion of *communities of practice,* which was conceptualized as a group of individuals defined by what they do and is governed by three dimensions, *what it is about*, as established by its members, *how it functions,* or the rules which govern the community, and *what capability it has produced*, or the shared routines established by the community. In Reveles et al. (2004)'s piece, the discursive practices (e.g. the construction of scientific language and activities) were developed within the classroom, the community of practice. As such, the authors promoted scientific literacy as the vehicle for the construction of scientific language, arguing for the direct instruction of these skills to students as they are unable to instinctively develop them. They asserted that students developed academic identities as scientist as a result of their scientific literacy, and despite making the case for direct instruction, they situated students as constructors of knowledge, which seemingly undercuts this claim.

Gomez (2007) further complicated the notion of teacher-instructed science literacy practices by claiming teachers must know how to translate scientific discourse into colloquial language as students have their own understandings of how the world in which they live functions around them. Rather than directly instructing students on how they *should* view this world, they must allow these student constructions to drive instruction. While arguing for a space where students can engage in the discursive practices of science can be helpful for students, Brown (2006) claimed this could ultimately result in further marginalization of students of color because science discourse does not traditionally center their voices in its practices. Because their voices are not centered, they must assimilate into the science culture to gain access to the discipline, resulting in a form of cultural appropriation which can impede their identity development writ large.

Student and Teacher Talk

Classroom science discourse focusing on teacher talk reveals a distinct pattern. Lemke (1990), referred to classroom science discourse at varying grade levels as manifesting in *triadic dialogue*, which follows a teacher initiation, a student response, and teacher evaluation pattern. This is likely one of the most common experiences that binds all who have participated in schooling as either a teacher, student, or both. Because science has traditionally been taught by inundating students with factoids deemed important by teachers, textbooks, state tests, etc., this sequence has demonstrated very little need, if any, of the actual student in instruction, meaning they are not considered in the planning of instruction nor curriculum development by the teachers' standards.

Other scholars refer to this triadic dialogue as the initiation, response, evaluation (IRE) model of instruction (Harris et al., 2012; Rees & Roth, 2017). In all cases, there is no space for the consideration and/or incorporation of student's funds of knowledge because they have been pre-determined by the curriculum. Bazzul (2014) utilized critical discourse analysis to illustrate this point. In this work, he explored how subjectivities related to neocolonialism, sex/gender and sexuality, neoliberialism, and ethical engagement are communicated through discourses in science education texts. He argued that science has been situated as an objective discipline, and as such, claims of subjectivity are baseless. However, through his analysis of biology textbooks, he uncovered how the effects of power are presented as objectivity in science texts.

An example of this is evident in examining any introductory science textbook. If one were to peruse the first chapter of text, the likelihood of a person of color being represented is slim, which communicates to a student or other reader of color that they have not contributed to the discipline in any meaningful way, or their contributions are not significant enough for textbook recognition. Further, Bazzul (2014) argued because of the ways curriculum and associated materials are presented in schools, schools essentially function as an institution of control.

Coupling this argument with the lack of representation of diversity within science texts, I extend Bazzul's argument to assert that schools allow for structures that enforce systems of power (namely racism), to perpetuate themselves in a matter-of-fact manner. If students are unable to see or imagine themselves within their curricula, this could alter their perception of themselves, influencing their choice to enroll in additional science courses in subsequent years (Aschbacher & Ing, 2017). There are also cases where teachers' instructional moves, while well-intentioned, makes student thinking visible, but the teacher fails to connect the student thinking to their instructional practices due to their lack of confidence in teaching the science content, a significant issue for elementary teachers (Gunning & Mensah, 2011; Harris, et al., 2012).

While analyzing teacher talk within a science classroom, it is critical to understand the nature of the teacher's instructional choices and their bearings on students' identity development. Putney (2007) employed interactional ethnography while incorporating critical discourse analysis to explore this area. The study followed a fourth-grade classroom over the course of several years to understand how the teacher utilized discursive practices to create a classroom community, specifically from a perspective of "talking and acting into being" (p. 131). Putney crafted event maps allowing the reader to note specific talk moves implemented by the teacher. Several moves were of interest in determining how the teacher, Ms. Falls, created a classroom community space.

In the event map, Ms. Falls followed a distinct pattern where she asserted her authority as the teacher followed by the reference of herself as a member of the community. This was largely noted by the usage of the pronoun “I” and the subsequent transition to the use of the pronoun “we.” This choice positioned the students as contributors to the creation of the norms of their community, as they were assigned community roles in addition to determining the rules every citizen should follow. However, when applying these talk moves to instruction, Varelas, Martin & Kane (2012) warned these moves, if not cognizant of the multiple identities of students, could translate into the perpetuation of deficit-oriented thinking. Although the teacher may have well-intentioned motives, this deficit thinking influences what teachers believe students are capable of, and rather than allowing them opportunities to construct their own knowledge or incorporating students’ funds of knowledge, the teacher dictates what students are capable of learning from their own positionality. I provide a similar example of a teacher referring to students as mathematicians below to illustrate this point.

Teachers are not the only individuals who utilize the IRE sequence. According to Rees and Roth (2017), students commonly used the sequence in their responses to one another during collaborative activities. This was evident in Arnold’s (2012) study where the students evaluated Tasha’s contributions to the classroom, which is detrimental to one’s science identity development because these instances can reinforce notions of power on a micro-level, causing students of marginalized identities to eschew science over time. These spaces further allow those in power to either affirm or deny one’s science identity if it fails to fit their notion of what is considered science. Utilizing a conversational analyses, Rees and Roth (2017) sought to understand “how agents in a conversation take up what has been done and said on the part of others” (p. A24). This allowed for understanding how students made sense of what happened during an IRE exchange, resulting in a recommendation for teachers to shift from teacher-centered instruction to more improvisational methods, allowing for the public display of student ideas for the entire classroom community.

Improvisational discourse is beneficial as it allows teachers to re-voice student ideas so that they become intelligible to others (Jurow, 2005) and relies heavily on student responses rather than the teacher initiation or evaluation of the IRE sequence, resulting in student-centered instruction. Jurow's (2005) study utilized discourse analysis coupled with ethnography to explore the impact of the incorporation of improvisational discourse within a second-grade classroom. Although not a direct goal of the study, Jurow (2005) argued that the teacher's instructional practices contributed to the science identity development of the students. For example, the teacher in the study referred to the students as scientists while explaining their roles during the investigation. Scholars argue students should be able to do science which, in effect, positions them as capable scientists (Reveles et al., 2004; Varelas, Kane, & Wylie, 2012; Varelas, Martin, & Kane, 2012). Although the labeling of students as such may yield some positive results regarding student's science identities, simply referring to students as scientists is not enough to actively influence their identities. To illustrate this point, I provide an excerpt of a transcript referenced in Reveles et al.'s (2004) piece. In this excerpt, the teacher, Mr. C, was trying to position his students as mathematicians as he was preparing them for a science investigation. He stood at the front of the classroom leading a discussion while recording student responses on the board:

24. Mr. C: what does that doing look like when you say "do" mathematics?

25. R: they write problems down on paper.

26. Mr. C: okay so they write problems down on paper.

27. Mr. C: boys and girls the reason.

28. Mr. C: I'm wanting us to talk about what these actions are that mathematicians do.

29. Mr. C: so I want us to think about what it is that mathematicians do.

30. Mr. C: because I want you to start thinking like mathematicians. (pp. 1121-1122)

Although Mr. C utilized tenets of improvisational discourse, namely revoicing student responses (Jurow, 2005), there was no evidence of the teacher demonstrating his own understanding of what mathematicians do. It is also not clear if the teacher considered himself a mathematician who was encouraging others to assume this identity or merely a teacher working to convince his students of their mathematics identities, as there was no evidence provided to illustrate students engaging in the work of mathematics. In utilizing the analytic framework of Lemke (1990), it is rather apparent that Mr. C followed the IRE sequence to engage with his students, albeit in a slightly different manner. Although students' responses were not directly affirmed or denied based on accuracy, Mr. C determined which ideas were made visible for students through his calling on them or choosing what to make visible to students through his whiteboard recordings. He also dominated the dialogue, implicitly enforcing his authority over his students (Bazzul, 2014) while communicating a subtle emphasis on being "right" (Kirch & Siry, 2012).

Varelas, Martin, and Kane (2012) attempted to address this issue by arguing for teachers and students alike to do more than simply recognize students' funds of knowledge and cultural ways of being, and to acknowledge students as "capable doers of science and math in ways that build strong connections between their racial and ethnic identities and their disciplinary identities" (p. 325). In the case of Mr. C, he demonstrated an attempt to allow students to define their disciplinary identities (as mathematicians), but there was no explicit evidence of attention given to students' racial and ethnic identities. Doing so would begin addressing the power dynamics between teachers, students, and the curriculum such that students play an active role in creating their own learning opportunities based on their science identities.

Shifting from utilizing discourse analysis to understand teacher talk, several scholars implement the methodology to understand what students are saying and how these utterances serve as representations of their understandings of science. For example, Kirch and Siry (2012) explored the notion of uncertainty, namely through the use of modifiers in student talk to make sense of their science knowledge. To ensure an accurate analysis of student utterances, the researchers crosschecked the thematic groups (discernment, potentiality, and challenge) of adults from an array of professions. The findings suggested these modifiers were ways to allow teachers an opportunity to shift instruction to a more student-centered approach, likely through improvisation (Jurow, 2005). Evaluating student talk also revealed potential problematic consequences for students' science identities. In Tasha's case (Arnold, 2012), she used her opportunities to talk, her umwelt, as a means of positioning herself as a student who did not understand science as a symbol of solidarity with her peers, despite her actual mastering of the content. If students, particularly students from marginalized identities, fear negative social consequences of associating with science, they may be more likely to disengage from the discipline despite their interests (Gilbert & Yerrick, 2001) ultimately stifling their science identity development.

Science discourse, along with classroom practices, represents a cultural practice (Putney, 2007). When considering these practices from an identity development perspective, scholars have critiqued the rigid, White cultural norms that represent the "objective" enterprise of science

(Bazzul, 2014; Brown, 2006). These cultural norms have the tendency to alienate marginalized identities in science, unless these marginalized identities are willing to assimilate into this dominant culture. This parallels the notion of "whiteness as property" (Harris, 1991; Mensah & Jackson, 2018), where science serves as a representation of whiteness, having the right to exclude those who do not embody its tenets. Brown (2006) explored this idea through scientific language in a high school life science course. In his study, Brown situated science as an "elite discipline" with associated discursive practices. He uncovered ways students utilized discourse to assimilate into the culture of science, resulting in the emergence of an identity conflict where this assimilation impeded students' identity development. Students noted the unique specific discourse associated with science, and its lack of transferability to their colloquial linguistic practices. While the adoption of this discourse presented challenges, students experienced success from their ability to participate in "hands-on" instruction (Brown, 2006). Similarly, Varelas et al. (2014) noted experiences where Latinx third graders utilized both textual and hands-on experiences to develop scientific meaning, allowing the students to develop a sense of agency.

Agency

Scholars contend that by centering the science identities of students of color, they develop a sense of agency. Perhaps the most salient example of how this occurs is evident in Basu et al.'s (2008) piece where they provided a foundation for developing what they referred to as "critical science agency." The tenets of critical science agency were developed in a physics context but I argue their transference to science education writ large. According to Basu et al., (2008), students who develop a critical agency in physics:

> (a) gain deep understandings of physics and the processes, skills and modes of inquiry associated with this content, (b) identify themselves as experts in one or more realms associated with physics, (c) and use physics as a foundation for change, such that their identity develops, their position in the world advances, and/or they alter the world towards what they envision as more just (p. 346).

Thus, research suggests agency does not function in isolation; rather, it functions as a by-product of several intersecting variables, such as (but not limited to): scientific inquiry and student narratives.

Scientific Inquiry

Rivera Malucci et al. (2014), conducted a study that chronicled the scientific inquiry experiences of six middle school students through the development of an inquiry-based science program. In the study, the authors worked with teachers throughout the school district to develop a rubric for an upcoming science exposition program where student inquiry projects would be displayed. The authors noted the significance of this choice as it eliminated teacher deficit-oriented thinking regarding student ability, providing both teachers and students a sense of agency because they could define the parameters around learning and instruction. Authentic scientific inquiry was conceptualized around the idea of orienting student practices to the practices of scientists, and as such, they would develop their own research agendas in a collaborative space. As a result, students developed and explored their own research questions utilizing their own funds of knowledge (Tan & Calabrese Barton, 2009; Vélez-Ibáñez & Greenberg, 1992), a demonstration of their development of science agency. Because students could use their own experiences to develop their science project ideas and inform their science learning, they gained deep understandings of the content while positioning themselves as experts (Basu et al., 2008) during the science exposition.

Authentic scientific inquiry also positions teachers and students alike as learners of the scientific discipline rather than content experts (Kirch, 2010; Kirch & Siry, 2012). Exploring classroom discourse in science inquiry investigations creates an opportunity for students to demonstrate the third tenet of Basu et al.'s (2008) critical science agency. For example, in Kirch and Siry (2012)'s study, the authors explored student's uncertainties as agents of disruption in their science instruction, namely by breaking the authoritative discursive practices of their traditional classroom instruction.

The longitudinal study took place throughout two years across two second-grade classrooms. The two teachers selected for the study participated in one professional development workshop designed to improve their science teaching and learning skills while using the Full Option Science System (FOSS) instructional guides and accompanying materials. Elementary students investigated the source of algae in their class' fish tank and the preferences of mealworms when exposed to multiple environmental settings and conditions. The authors analyzed the students' usages of 'uncertain' modifiers (might and maybe) as ways in which students challenged one another's ideas. Their findings indicated the students demonstrated similar discourse practices as scientists, and as such, they were effectively using their emerging identity as a scientist to enact change by challenging one another's ideas. While it is critical for students to use their scientific understandings for change (Basu et al., 2008), it is equally important for authentic scientific inquiry instruction to serve as a foundation where students can develop skills such as argumentation, generating claims, and collecting evidence, as these allow students to think scientifically (Crawford, 2014).

Student Narratives

Student narratives serve as a space for agency in science education because it allows students to view themselves as scientists on their own terms. Sfard and Prusak (2005) provided a theoretical basis for this argument through their articulation a students' differing identities. According to Sfard and Prusak, students use narratives to illustrate their actual identity, which, simply put, is the students' ability to describe themselves as something. However, this actual identity can potentially become overshadowed by my designated identity, the identity ascribed onto an individual by societal inferences. Although both identity markers may be true for an individual, one's actual identity may only become their designated identity if it is recognized by society. While this is a rather simplified description of Sfard and Prusak's theoretical basis, the importance rests on the narrative as those are what one uses to represent themselves, and through these representations, one may utilize their narration as a form of agency.

Varelas, Kane, and Wylie (2012) explored written narrations of 30 Black students in science through their science journals to understand how the students used that medium to present themselves as scientists. They utilized narratives and analyzed them through the Bakhtin's (1981) notion of chronotope to understand how students considered themselves as scientists over time. These narratives were a form of an integrated literacy practice (writing) in the students' science instruction, and students constructed themselves as knowers and doers of science throughout the academic year as an illustration of their agency. Narrations, written or oral, serve as a product of students' authentic inquiry practices (Rivera Maulucci et al., 2014), and allow for students to construct their own identities. Oral narrations provide students of color with a way to reconcile being a student and a scientist, which could have differing identity markers (Kane, 2012).

Hybrid Spaces

Another way in which students of color may develop agency is through the creation of a hybrid space, a space designed for the merging of conflicting discourses. Calabrese Barton and Tan (2009) anchored their study in an intersection of discourse and identity, while defining discourse as a “reflection of one’s identity” (p. 51). As such, sixth grade students’ funds of knowledge were explored to figure out how they supported student engagement in science. These funds of knowledge, coupled with their scientific knowledge, allowed students to create hybrid spaces in which these two identities could co-exist. Contrary to Arnold’s (2012) piece, students could use their umwelt in a way that did not challenge their social status, seemingly allowing for the existence of positive science associations.

Brown, et al. (2016) built on the notion of identity development through the creation of a third space, but these scholars view lyricism, specifically the students’ own discourse, as the third space. Using Gee’s (2000) notion of identity, they argued one’s utterances or speech serves as a representation, which determines others’ perception of us. If scientific discourse’s objectivity (Bazzul, 2014) continues to function in its rigid manner, students of color will not have access to the discourse. However, in their study, students leveraged their cultural capital, lyricism, as a means of providing themselves access and agency within science. Students demonstrated mastery of science concepts through explanations, which were generated through their lyricism. This lyricism required students to utilize a variety of mechanical techniques (e.g. similes, metaphors, polysemy, irony, narrative, etc.) and to properly use these techniques, students had to demonstrate sufficient content mastery.

In addition to articulating a science identity vis-à-vis demonstrating mastery of the content, lyricism may also serve as a representation of one’s ethnic identity (Samy Alim, et al.,

2011) or speech community within a science classroom (Ogbu, 1999). Although this is promising, requiring content mastery as a prerequisite to any lyricism practices potentially requires students to subject themselves to learning science through traditional exclusionary means, an issue Brown et al.'s (2016) study intended to address.

Hybrid discourse spaces have the power to culturalize instruction (Parsons, 2003) in a way that involves the intersection of three domains. Kamberelis and Wehunt (2012) describe hybrid discourse practices as "involve[ing] the dynamic interplay of three key elements: 1.lamination of multiple cultural frames, 2. shifting relations between people and their discourses, and 3. shifting power relations between and among people" (p. 510). The lamination of cultural frames is evident in how students of color navigated the scientific discourse through the acquisition of multiple identities in Brown's (2006) study. However, assimilation should not be a necessity, as science is not objective, as noted in discipline-specific texts (Bazzul, 2014), and through the creation of this hybrid space, students can bring their full selves into the classroom with multiple opportunities to construct their own community-based knowledge (Brown, 2016; Kane, 2016; Varelas et al., 2014). The construction of shared knowledge based on students' own funds of knowledge shifts power dynamics between teachers and students, ultimately disrupting their respective discursive practices.

Teacher Identity Development

Much of the literature aiming to understand the science identity development of teachers has been divided into two categories: the science identities of elementary teachers and the science identities of secondary teachers. While literature studying science teacher identity is sparse (Avraamidou, 2014b), much of the existing literature centers on the identities of elementary preservice teachers (PSTs), and as such, will be the focus of the literature reviewed here.

Chen and Mensah (2018) argued that elementary PSTs experience low self-efficacy regarding science teaching, largely due to the coupling of content acquisition with the emphasis on mathematics/ELA instruction (Upadhyay, 2009). Their collective case study was situated in an elementary science methods course designed to provide PSTs with a space to develop their science teaching identity. Three PSTs were the focus of the study: one identified as a Black/Jamaican female, one an Indian American female, and one a White/Hispanic female. Prior to the methods course, none of the PSTs viewed themselves as science teachers, mainly because of their low confidence in their science content knowledge. Data was collected from three sources: classroom assignments (final paper and teaching journal), observations, and two semi-structured interviews with a questionnaire.

The findings indicated a significant influence of the teachers' interactions with their cooperating teacher (CT). The ways in which the CT recognized the PST as a teacher—rather than an observer or assistant—were influential in the PSTs consideration of themselves as a teacher. Further, the CT's emphasis on science also contributed to the PST's science identity and thus their science teaching identity. Given the significance of these findings, Chen and Mensah provided the recommendation for PSTs to have as many opportunities to teach science as they have with other core subjects such as mathematics and ELA to begin developing a science teaching identity. Because the teachers' science identities are linked to their confidence with the content, teacher education programs would also need to provide additional opportunities for PSTs to learn science content, potentially through partnerships with informal science agencies (Avraamidou, 2014a).

Avraamidou (2014a) conceptualized identity as "the ways in which a teacher represents herself through her views, orientations, attitudes, emotions, understandings, and knowledge and beliefs about science teaching and learning" (p. 826) and used this conceptualization coupled with her notion of reform-minded science instruction to make the case for including informal science instructional opportunities for PSTs. These informal opportunities could be useful in encouraging PSTs to focus on areas of scientific literacy in students, as well as the recognition of students' funds of knowledge and inquiry. Allowing PSTs to develop their science identities through these means can prepare them to begin adopting a social justice lens for science instruction (Rivera Maulucci & Fann, 2016).

Further, per the recommendations guiding the Next Generation Science Standards (NRC, 2012), informal science learning opportunities for PSTs may help bolster the content knowledge of beginning teachers, giving them the confidence to effectively teach science content to elementary students, as it improves their attitudes, motivation, interest, and engagement in the discipline (Avraamadiou, 2014a). However, when considering the geography of suburban/urban and rural school districts, access to these opportunities could present issues for teachers, especially if there are an uneven distribution of centers who provide these services (e.g. museums, nature centers, local universities, etc.) or limited district funding.

Arguing for a clearer definition of science teacher identity through a reform-minded lens, Avraamidou (2014a) did not clearly articulate the significance of the reform efforts. The NGSS (NRC, 2012) explicitly addressed the need to foreground access and equity for students of marginalized identities, hence their inception, but she positioned the reform-based instruction as a tool to benefit elementary PSTs and cited museum education experiences embedded within teacher preparation programs as a potential solution. However, this may be limiting to the students the standards are aimed to support, a clear limitation of her study.

However, while not an explicit recommendation of reform-minded science teaching, Rivera Maulucci and Fann (2016) might argue teaching for social justice should greatly influence the educational reforming efforts. Defined as “an ongoing struggle for more caring, equitable, and agentic schooling at the classroom, school, and community levels” (p.112), Rivera Maulucci and Fann utilized this framework to make the case for social justice teaching. In their study, the authors recounted the ways in which Karen, a Physics major who eventually decided to pursue a career in education, became a social justice-oriented teacher. They made a clear distinction between *being* and *becoming* such a teacher, as becoming implied “gaining an appreciation of how students need opportunities to discover and to develop as agents of change in their community even in the seemingly right/wrong, correct/incorrect world of science” (p. 112). This is a significant identity for science teachers to adopt because the reform efforts that have led to changes in the science curriculum, namely the NGSS, directly address this critical area (NRC, 2012).

For teachers to begin shifting their identities toward adopting this lens, an acknowledgement of the historical oppressive context of science must be recognized (Mutegi, 2013). Rivera Maulucci and Fann utilized a case study approach where they tracked the development of Karen’s social justice lens over the course of the three courses required for initial licensure. Data collected and analyzed consisted of written reflections and other class assignments and revealed growth across five identified domains of knowledge pertaining to sociocultural awareness: “self, students, science, pedagogy, and school contexts” (p. 126). Although Karen had sufficient content knowledge, it is important to note her content understanding was not enough to allow her to become a social justice-oriented teacher. She had to recognize how the domains interacted with one another to incorporate them into her physics knowledge, indicating a need for further research for the reform-based science identity development for secondary science teachers. This is a critical recommendation, as it has been argued that their science identities are communicated through their respective disciplines (Mensah, 2016).

In understanding how teachers can develop social justice-oriented science identities, studying the domains of their science identities in practice (Holland et al., 1998) may offer a place to start. Madden and Wiebe (2015) utilized this approach and identified the domains as three distinct perspectives: the perspective of the teacher themselves, the perspective of the researchers, and the perspectives of the students. The definition of a teacher who holds a science identity according to these authors is one “who hold[s] scientist, science teacher, or science leader identities” (p. 393). This narrative case study occurred over the course on one full academic year and the three teachers were identified as experienced teachers, defined as having four or more years of teaching experience. While the science identities were situated across the three domains, those domains were further analyzed through Gee’s (2000) identity framework (nature, institution, discourse, affinity) and a fifth category, expertise, which was incorporated from Beijaard et al.’s (2000) professional identity framework.

Although the teachers and students narrated identities for each of the teachers in the study, the teachers’ identities were ultimately assigned to them by the researchers. For example, one participant, Donna, was the most senior teacher of the three selected for the study, having taught for 26 years. Donna participated in district-offered professional development opportunities to enhance her science teaching but had no additional formal science training aside from her science methods course during her initial certification, likely indicating a 20-plus year gap in her opportunities to formally learn science content. Despite this gap, Donna's self-described science identity was that of confidence and one who enjoyed science (her N-identity).

However, upon classroom observations from the researchers, they noted Donna devoted a significant amount of time during one lesson to classroom management, leading the research team to conclude her discourse and expertise identities were those of a "weak classroom manager" (p. 404). Her self-reported science identity was overshadowed by her classroom management skills, yet there was no description of what the researchers considered "proper classroom management." Perhaps the days in which the researchers conducted the observations prevented them from truly observing the enactment of Donna's self-described identity, indicating a need for additional time for data collection (Avraamidou, 2009; 2014a; 2014b). Assigning identities based on limited interactions results in viewing identity as a product rather than a process and may be addressed by viewing identity as a social construct influenced by interactions (Avraamidou, 2014b).

While much of the research pertaining to elementary teacher science identity development has centered on understanding their identities in practice, Forbes and Davis (2008) viewed identity through the lens of the curricula teachers were expected to deliver. They referred to this as the *curricular role identity* and defined it as "those dimensions of an individual's professional teaching identity that are concerned with the use of curriculum materials" (p.910). Here, identity was conceptualized differently from other scholars, namely Avraamidou (2014b), and was conceptualized through Lemke's (2000) framework as "a person's evaluative stance toward interaction" (p.283). This evaluative stance suggests one's identity is fluid, and Forbes and Davis (2008) further claimed identities manifested through roles, or "role identities."

These authors aimed to understand how these role identities were developed and negotiated in the context of implementing science curriculum, hence the emphasis on PST's curricular role identities. This mixed-methods study consisted of a cohort of 47 total PSTs enrolled in a science methods course who participated in quantitative (survey) data collection, with nine of the total participants who also participating in two semi-structured interviews. The findings suggested the need for PSTs to be provided opportunities to amend existing curriculum materials during their preparation programs. However, this is complicated by issues regarding the PST's or emerging beginning teacher's pedagogical content knowledge (Gunning & Mensah, 2011). The curriculum materials are often scripted in ways that make deviations from the script difficult for a novice teacher (Jones et al., 2012), resulting in the perpetuation of misinterpretations of scientific concepts or ideas. This could be mitigated by additional opportunities to teach science in PST preparation programs and schools, as this allows PSTs to continuously engage with the content (Chen & Mensah, 2018; Forbes, 2013; Gunning & Mensah, 2011; Mensah, 2016).

A few scholars have addressed and provided ways to understand how in-service elementary teachers develop and navigate their science identities. Upadhyay (2009) chronicled the experiences of Daisy, a Black 5th grade science teacher who was formally trained as a biologist. Daisy taught in what Upadhyay described as an underprivileged elementary school in an urban school district for six years. It is important to note Upadhyay provided no description of what constituted an urban school; rather, context leads one to assume the author is utilizing the term to refer to a school which categorizes its student population as "largely Black" (Milner, 2012) and underfunded. He conducted a yearlong qualitative study and utilized social identity theory to understand the various identities Daisy articulated for herself, social and personal identities, and how these two identities were negotiated within various contexts.

His findings claimed that Daisy constantly negotiated her identities as a teacher who taught science because students had the right to learn it and a teacher who must appease the administrative staff to ultimately meet the state's evaluation criteria. This resulted in Daisy's students completing dueling and somewhat contradictory science activities. One such activity focused on memorizing vocabulary (for administration) while others were inquiry-driven investigations (for Daisy). Daisy's case was unique for multiple reasons. She, as a Black female, was formally trained in biology, yet taught elementary science. As such, her positional identity (Mensah, 2016) as a teacher was influenced by her experiences as being Black, a female, and a biologist. The intersection of these three identities allowed Daisy to recognize the importance of her students having access to authentic science experiences, yet her identity as a teacher acknowledged the expectations of the administrative faculty regarding what her science instruction should entail (e.g. the rote memorization of disconnected facts). These two sets of identity-derived expectations were not always in alignment, which led to the resulting compromise of her fitting hands-on inquiry activities along the margins of her regular classroom instruction.

Kane and Varelas (2016) proposed the creation of communities of practice where both elementary teachers and students' voices were centered as a means of agency for teachers navigating the pressures of a test-driven school administration. As such, teachers can develop identities of practice (Holland et al., 1998), ultimately shifting their teaching identities from that of a generalist to considering themselves science teachers. These recommendations came from a yearlong study conducted with six teachers across five elementary schools.

The teachers in this study created a professional learning community (PLC) where they participated in part of the Integrated Science Literacy Enactments (ISLE) Project, a project designed to teach science while integrating elements of literacy in urban schools. Elementary students and their teachers alike learned science content while enhancing their writing skills, a form of reform-based instruction (Avraamidou, 2014a), further moving the needle toward more equitable science teaching practices (Rivera Maulucci & Fann, 2016). Despite teachers having opportunities to learn and enact science content in their classrooms through PLCs, this was not enough to fully shift some of the teachers' identities as science teachers. For example, one teacher, Jennifer, explained that she experienced difficulties in teaching when students asked questions to which she had no answer. Although she recognized her emerging role as a facilitator rather than director of students' science knowledge, she reverted to her role as director during times when she was unsure of an answer, likely related to issues of confidence and self-efficacy (Chen & Mensah, 2018).

Understanding the relationships between a teacher's approach to professional development, teaching, and learning, Mensah (2008; 2016) argued for studying science teacher identity through a positional identity (positionality) lens. More specifically, this positional identity can contextualize sociocultural factors (e.g. race, ethnicity, economic status, etc.) that impact a teacher of color's various identities. When applying a positional identity framework to understanding the science identity development of preservice teachers of color (PTOC), these various identities intersect and ultimately allow one to understand their "science identity, science teaching, and relationships" (p. 50). Typically, secondary science teachers view their science identities through the lens of their subject matter training (e.g. a biology teacher considering themselves a biologist), whereas elementary PSTs often view themselves as non-scientists due to their construction of a science identity which is informed by their personal science experiences (Mensah, 2011b). These experiences are usually stereotypical in nature, with the science teacher being a White male in a lab coat conducting experiments, which ultimately inform their science teaching, resulting in practices that directly contradict reform efforts (NRC, 2012).

Understanding one's positionality is greatly influenced by personal narratives (Mensah, 2008; 2019). These personal narratives were instrumental in studying PTOC, as this is a limited area of current research. Mensah's (2016) study was conducted as a yearlong study with 10 PTOC (all female) who participated in a science methods course. The findings from the study directly support others (Chen & Mensah, 2018; Forbes, 2009; 2013; Gunning & Mensah, 2011; Mensah, 2011b) recommending that PSTs engage in numerous opportunities to teach because this allows them to develop confidence in their capacity to teach science, supporting their identity development.

While these opportunities may be helpful in shaping some PSTs science identities, it is worth mentioning this is not guaranteed. For example, Mensah (2016) noted some of her student participants reported feeling "inexperienced" and "uncomfortable" at the end of the course despite serving as interns in elementary schools and microteaching several connected lessons throughout the semester. In other cases, there is a disconnect between what is taught in teacher preparation programs and what happens in classrooms, which can discourage beginning teachers from teaching in socially just ways or recognizing students as capable doers of science (Carrier et al., 2017). Further, although positionality is a useful framework to study PSTs, there is no research examining how in-service teachers' positionalities inform their science teaching identities in a reform-driven and high stakes testing environment, a gap which this study seeks to explore.

Science Curriculum Reform

Science for All Americans

The American Association for the Advancement of Science (AAAS) developed its initiative, Project 2061, in the late 1980s to increase the science and mathematics literacy of all Americans. This initiative generated several reports which have been fundamental to understanding science reform efforts. Its first publication, *Science for All Americans* (Rutherford & Ahlgren, 1990) echoed many of the claims from the *Nation at Risk* report (NCEE, 1983), but the central claim was that scientific illiteracy was the crux of these issues. Students were inadequately prepared to learn science beginning with elementary teachers who were virtually incompetent in their own science and mathematics instruction (Rutherford & Ahlgren, 1990), who themselves were underprepared by their degree-bearing undergraduate institutions. As a result, Rutherford and Ahlgren proposed recommendations for scientific literacy aimed at producing a more scientifically literate population who would not only increase our global standing on international assessments but be prepared to address the serious global problems of their time.

Science for All Americans intended to provide recommendations such that all students have adequate access to science instruction that promotes scientific literacy. Science instruction should provide students with meaningful opportunities that do not utilize the "mile wide inch deep" practice, where students are expected to know generalized factoids on a broad range of topics. The recommendations were also significant, as they explicitly claimed to address ethnic and language minorities and girls, making it the first science curriculum framework developed with these populations in mind.

National Science Education Standards

The National Science Education Standards (NSES) were developed in 1996 and continued the same calls for scientific literacy referenced in the *Benchmarks for Scientific Literacy*, another product of Project 2061 (AAAS, 1993). These standards precede the NGSS and were influential in their development, so I briefly review them to provide a contextual understanding for the NGSS. The NSES also aimed to "apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science" (p. 2). While *Science for All Americans* promoted scientific literacy, the NSES extended this argument to include inquiry-based instruction. Students who engaged in inquiry science instruction would have "hands-on" in addition to "minds-on" experiences (NAP, 1996), such that they developed the critical thinking skills needed to effectively evaluate and communicate scientific explanations to others.

The NSES provided the first explicit expectations for science learning, arguing for students to learn science as a process incorporating aspects of the nature of science (NOS). As such, students would learn how science contributes to culture and teachers would develop inquiry-based instruction with their students in mind. Teachers would not rely on the offerings of content-laden textbooks and would collaborate across disciplines to ensure their students could make connections to improve their scientific literacy. Because of a lack of concrete standards for teachers to follow, this recommendation resulted in various interpretations of inquiry-based instruction and closely mirrored traditional instructional approaches to science teaching that positions the teacher as the purveyor of scientific knowledge.

Although these standards proposed recommendations for science teachers aimed to address marginalized communities (e.g. English Language Learners, women, students of color), there was an underlying assumption of what science teachers knew regarding their students' funds of knowledge. For example, inquiry-driven teaching assumed "teachers are of and understand common naïve concepts in science for given grade levels, as well as the cultural and experiential background of students and the effects these have on learning" (p. 31). In addition, these standards emphasized the significance of teachers planning for instruction with these considerations in mind.

While I agree these are critical tools to ensure equitable science learning opportunities for all students, these standards implied a rather significant cultural understanding on the part of the teachers, which, like inquiry, led to multiple interpretations of what was considered "culturally responsive teaching." This indicated a need for understanding the teachers' positionalities (Mensah 2008; 2016), as it helps uncover how teachers understand the intersections of these recommendations of inquiry-driven teaching. Further, *scientific inquiry* was conceptualized as the way scientists come to understand the world, with inquiry categorized as a stepwise process reminiscent of the scientific method.

Next Generation Science Standards

The NGSS represent a marked shift in rhetoric regarding all students, particularly those from marginalized backgrounds in science education. Rather than focusing on the science content while attending to scientific literacy (*Benchmarks*) or the science content juxtaposed to scientific literacy and inquiry (*NSES*), the NGSS presents science learning in a three-dimensional context with the goal of developing a scientifically literate society. The dimensions *(Science and Engineering Practices*, *Disciplinary Core Ideas*, and *Crosscutting Concepts*) are organized such that students are presented with the content in meaningful ways that serve as adequate opportunities to learn science (NRC, 2012). This is significant because the previous reform efforts have recognized the gaps in science access for underrepresented students but failed to provide recommendations for how to meet the needs of these groups. While the NGSS are informed by the NSES and Benchmarks, they recognize how inequities are perpetuated through an instructional and systems approach, highlighting the effects of structures such as tracking, literacy, and mathematics courses have on marginalized students' opportunities to learn science.

Although the Benchmarks claimed students were expected to understand and recognize cultural values within the science classroom (AAAS, 1993), the NGSS recognizes science as the incorporation of one's culture. In other words, these standards centers student experiences. Students are viewed as knowledgeable individuals who develop scientific understandings of their world throughout their daily interactions, a view that should influence teachers' instruction.

Perhaps one of the most explicit ways in which the NGSS have made science instruction more accessible is through the inclusion of engineering, which has largely been reserved for males and college-aged students. The marginalized student groups (e.g. students of color, women, and English language learners) are regarded as accountability groups listed in the NGSS appendices (see NGSS Appendix D, NRC, 2013). In the following sections, I will briefly describe how the NGSS aim to meet the needs of each of these groups through a series of proposed strategies.

Students of Color. Referred to as *Students from Racial and Ethnic Groups* in related literature, the NGSS provide four strategies to engage students of color in science: culturally relevant pedagogy, community involvement and social activism, multiple representation and multimodal experiences, and the inclusion of mentor/role models of color. Culturally relevant pedagogy aims to incorporate students' experiences in an intentional manner such that students are positioned as capable members of the scientific community. This recommendation works in tandem with community involvement, as students can leverage their scientific knowledge in ways to promote activism. Providing mentors of similar identities as students are yet another manifestation of culturally relevant practices and allows students to view themselves as scientists by recognizing their cultural contributions to the various science disciplines.

Women. Strategies to engage girls in science include changes to instruction, curricula, and school structure (NGSS Appendix D). Because science has historically privileged men through its practices, it is critical to center the contributions of women. The inclusion of the Engineering Practices (also referred to as the Scientific and Engineering Practices) has been proposed as one curriculum practice to specifically engage girls because it allows them to incorporate problem-solving skills in more meaningful ways. Like the recommendations provided for engaging students of color, curricula should be revised to include meaningful representations of women in STEM.

English Language Learners. Effective strategies proposed by the NGSS for students who identify as English Language Learners (ELL) highlight five areas which include: literacy strategies with all students, language support strategies with ELLs, discourse strategies with ELLs, home language support, and home culture connections" (Appendix D, Case Study 4).

Although the NGSS provide the best opportunity to support all students in science education, for the needs of these three groups to be adequately addressed, structural changes must occur to reposition science in both K-16 and the scientific enterprise writ large. I argue for transformative change to occur, we must understand how the reform-based science curriculum gets taken up in schools and how this intersects with teachers' and students' science identities. In this study, the teacher utilized the FOSS modules, which were purportedly aligned to the NGSS. It is important to note the FOSS modules were not developed in response to the NGSS; rather, they preceded the standards by decades and have been adapted throughout the years to address many recommendations of the various reform movements. This indicates a need to understand how this curriculum functions to address issues of equity per the NGSS (NRC, 2012).

Given our understandings of elementary teacher science efficacy (Chen & Mensah, 2018), we must also understand how the teacher positions herself as a science teacher, how she views her students as science learners, and how this positioning influences her science instruction. In addition, the NGSS call for teachers to utilize students' funds of knowledge throughout their instruction, which requires us to understand how students communicate their science knowledge and position themselves as scientists, an area this study attends to.

CHAPTER 3—METHODS

The purpose of this exploratory study is to examine how elementary students of color reconcile their multiple identities (as a student, a person of color, and a scientist) within the science classroom while adhering to the sociocultural and sociopolitical practices of learning—their identity work. This learning is occurring during a time in which an equity-drive science reform is taking root within their school, and as such, this study centers the identity work of students in addition to the role of their teacher and the science curriculum on the development of their science identities. The research questions guiding this study are:

1. How do elementary students of color construct their science identities in classroom spaces?
   (a) How does the curriculum support elementary students of color's science identity development?
2. How does an elementary teacher's positionality inform her science instruction within a diverse classroom?

In the following sections of this chapter, I introduce the participants, detail the methods employed to address these questions, and conclude with positioning myself within this work.

Research Design

In her comparative ethnographic study, Carlone (2012) used an adapted descriptive question matrix to generate a baseline understanding of what constituted "good science" in two different classrooms. Upon gathering this understanding, Carlone generated cards with various declarative statements representing classroom norms or values of a "good science student," where students were expected to sort the cards into three categories: "yes," "no," and "maybe." Students were subsequently interviewed to understand their rationale behind arranging the cards in the various categories to better understand the relationship between a students' access to science and the institutionalized ways science has been either inclusive or exclusive of one's values.

Varelas, Martin, and Kane (2012) recommended exploring students' identities-in-practice coupled with opportunities for students to reflect on their emergent identity domains. As such, I designed a multi-part study to explore these areas because it provides an in-depth understanding of one's narrated and practiced identities and is the best means of understanding one's overall identity as the students' voices are at the center of this work. The study is divided into three phases; the first phase consisted of an identity mapping task, which utilized questions from Varelas, Martin, and Kane's (2012) *Prompts for Tasks Aimed at Identities-in-Narratives* (see Appendix G), Carlone's (2012) *Norms and Values* assessment, and Seller et al.'s (1998) MMRI to understand the students' identities-in-narratives across the disciplinary, academic, and racial identity domains. The second phase of the study included classroom observations and videoed science lessons to capture students' identities-in-practice. The final phase of the study involved the selection of video clips for each participant in which they were provided the opportunity to reflect on their identities through their participation in a semi-structured interview. I provide a detailed description of each phase in the *Data Collection* section.

Participants

The recruitment criteria consisted of individuals who were in the fifth grade and considered a person of color. Additional criteria excluded students who did not have Elizabeth (the teacher) for science instruction. Overall, there were a total of fifteen individuals who agreed to participate in the study. Fourteen fifth graders, all identifying as persons of color, and their respective science teacher, Elizabeth. To provide all with a space to represent themselves throughout this document, I allowed each participant to choose their own pseudonym, and because the students' voices are central to this work, I will introduce them first. This introduction consists of the students' self-reflections coupled with my own ways of coming to know each person in the space below. Additional contextual information (e.g. research setting) intentionally succeed these introductions because for me, it is important that the reader understands who each person is absent of the inevitable implicit positioning of their identities that can occur when understanding these students through the lens of their classroom environment.

Alexis

Alexis positioned herself (and was positioned by her teachers) as someone who was very quiet and shy. She self-identified as an African American female who enjoyed writing and playing with her friends. She desired to become a pediatrician in the future because she enjoyed helping others. During our individual interviews and classroom observations, it was rare for Alexis to offer more than a one- or two-word verbal response to questions or classroom discussions, although her notebook deeply reflected her content understanding. She received small group instructional support in reading and mathematics, which was provided by a special education teacher who pushed into the classroom to support students.

Anna

Anna was a self-identified African American female who frequently participated in class discussions and was a strong advocate for her education. She would be the first to speak out whenever she did not understand a problem or concept and prided herself on her science performance. Having worked with Anna during her fourth-grade year, I came to know her as an individual who carried a serious demeanor in formal spaces, but quickly "turned off" this persona whenever allowed time to interact with her friends in common areas. During fourth-grade, Anna expressed to me that she wanted to become a doctor in the future, but this desire changed as she entered fifth grade because she out-performed her peers on the state science test and thus, wanted to become a scientist.

Anthony

Anthony was a lively student who self-identified as a Latinx male. He described himself as one who was "kinda good, kinda bad" but nonetheless has a great life and a lot of friends. He enjoyed making spinning tops, commonly known as referred to as Beyblades, which were spinning toys composed of Lego pieces designed to shatter upon impact with another Beyblade. During free time, he engaged in Beyblade battles, where students would compete with one another in a tournament-style competition where the Beyblade that could either withstand the most collisions while remaining intact, was the last to stop spinning, or both, won. He was frequently re-directed by Ms. Elizabeth and was subsequently positioned as a student whose behavior determined his access to various learning opportunities.

Blue

Blue was a student who oftentimes assumed extra responsibilities within the classroom and her family. She identified as an African American female who was the eldest of her siblings who attended Central Elementary. As such, she was frequently held responsible by adults throughout the building for her siblings' actions. This positioning by her family and others seemingly contributed to her compassionate nature. She often expressed a "can do" attitude of persistence and welcomed failure because for her, it made her stronger. She enjoyed drawing and spending time with her friends and family, as they were a tight-knit group.

Charlotte

Charlotte was another student who participated in the pilot study as a fourth grader. She identified as biracial, describing her mother as White and her father as Black. Although quiet and reserved, Charlotte enjoyed doing gymnastics and playing with her friends outside during recess. She also described her career interests in fourth grade as wanting to become a paleontologist, but at the time of the study, she desired to become a police officer instead to help prevent children from being kidnapped by predators. She also actively sought to participate in what she referred to as "boy sports," such as basketball, but she typically played with other girls because she felt that boys never took her seriously and rather than start an argument with them, she preferred to disengage. In class, she offered insightful perspectives whenever she participated in discussions and pushed herself to overcome her shyness by performing a rap song she wrote with a classmate in front of the entire school at the school's annual chorus performance.

Jaena

Jaena was a student who actively participated in class discussions and was frequently delegated leadership tasks by Ms. Elizabeth (e.g. class pencil sharpener, table leader). She enjoyed playing with her friends and was seldomly reprimanded for talking in class, as Ms. Elizabeth often overlooked this, likely due to her positioning by others. She desired to pursue a career in medicine as an adult and enjoyed science because it was fun for her. She self-identified as an African American female, and while she was a vocal participant throughout class discussions, she would often disengage from her group if she felt as though her ideas were not acknowledged.

John

John was a student who was perceived as boisterous by many within the school. He self-identified as an African American male and described himself as “active.” He enjoyed playing video games, playing with friends, and traveling. He intended to pursue a career in professional basketball, and desired to attend the University of California, Los Angeles because his favorite basketball player, Lonzo Ball, attended the same institution. John acknowledged his need to “yell out” as an area he needed to work on, but otherwise considered himself a good kid. His self-described areas of improvement were likely attributed to his being positioned as a student who required much redirection from the teacher. He considered Anthony one of his close friends and often partnered with him to solicit my help with practicing supplemental math instruction on the classroom whiteboard.

Nguyet

Nguyet described herself as a recent immigrant from Southeast Asia. She took pride in her quick learning of the English language and attributed this to her capacity to meet friends and show her thinking to her teachers in ways that empowered her. She was positioned by Ms. Elizabeth as being one of her “strongest” students, and as such, she was one of the most vocal participants in class. Although quiet outside of class discussions, she came to life during recess. She associated with a core group of friends, namely Jaena and Rebecca, and these three would often chase one another around the playground and play various games until being called to return to the building.

Nick

Nick self-identified as an African American male who enjoyed science because it was "fun." He, like John, was active in class, but was reprimanded much less for his behavior. He received small group instructional support in math and positioned himself as a smart student. In class, he thrived when recognized for his efforts and would frequently ask an adult if he were "doing a good job." He actively engaged in activities when he was allowed an opportunity to work with friends as this allowed them a space to support one another's learning.

Pro

Having worked with him in fourth grade, I came to know Pro relatively well. He identified as a Black male who recently immigrated from a country in Central Africa. He desired to become an engineer as an adult and enjoyed working with friends who shared similar interests. Pro was positioned by Ms. Elizabeth and friends alike as a bright student who was always willing to participate in class, and only contributed to the discussions if he felt confident in his ideas. Whenever uncertain about an idea, response, or to quickly divert attention from himself, Pro would rely on the phrase "I don't know." His engineering interests were supported by his family, as he had an older brother pursuing an undergraduate degree in engineering at a nearby university and parents who regularly purchased games and puzzles for him engage with.

Rebecca

Like Pro and Jaena, I worked with Rebecca as a fourth grader. She identified as a female who recently immigrated from Southeast Asia and while quiet and reserved during her fourth-grade year, she was much more vocal and comfortable participating in class as a fifth grader. Although she participated more in class, she preferred advance notice if called upon; otherwise, she would smile slightly and look down until the teacher acknowledged a different student. She enjoyed drawing and desired to please her parents by pursuing what she termed a “respectable” profession (e.g. medicine, education) as an adult, despite her personal interests in visual arts.

Seth

Seth identified as an African American male who enjoyed playing video games and closely followed professional wrestling. He was positioned by adults as a student who would regularly have times where he would either miss school or wander the hallways prompting interventions by the administrative staff. Despite this positioning, he appreciated times in which his peers validated his ideas or allowed him to occupy leadership roles during science instruction. In addition, he frequently asked for permission to spend time with me at lunch or during Enrichment, as he enjoyed individualized opportunities to engage in dialogue outside of the classroom.

Terrance

Terrance self-identified as an African American male who oftentimes occupied an observer role within the classroom. He enjoyed helping his classmates whenever prompted and frequently ran errands for adults throughout the building. In fact, he worked with the swimming teacher to monitor younger students during their swim classes. He was a student who typically flew under the radar and was assigned to sit with a student who frequently missed school. As such, he often sat by himself throughout the school day. He cited his family as being critical in shaping his identity and because he had younger siblings at the school, he felt the need to be a role model for them.

Westpaul

Westpaul identified as a first-generation Asian American male. Although quiet, he enjoyed playing with his friends and described himself as “nice, helpful, and kind.” He, like Terrance, often went unnoticed in the classroom but enjoyed science and mathematics classes because he could use manipulatives (in mathematics) to solve problems. He desired to pursue a career in education or law enforcement as an adult, and while seldomly called upon in class, he actively contributed to class discussions vis-à-vis his science notebook.

Setting

Central City

This work was conducted in an urban elementary school in Central City (pseudonym), a Northeastern US city. Formerly an industry-driven city, Central City is known for its high poverty rates for residents who reside within the inner city. The major local employers consist of local hospital or university employment, and in recent years, Central City has reported an unemployment rate on par with the national average. Despite this reported low unemployment rate, the City reports the highest concentration of poverty for Black and Hispanic-identifying residents in the nation.

Surrounding Central City are various suburban communities where the median household income dwarfs that of the inner-city residents, despite a major research university and research hospital residing in the center of the city. The city has a history of segregation, and perhaps the largest reminder is the physical barrier, the local interstate, which separates the mostly white university from the predominately Black community. Despite the segregation which defines Central City, it has a rich cultural history that played significant roles in the abolitionist and civil rights movements and is constructed on the ancestral lands of indigenous peoples whose contributions to the local university and community are often overlooked. In addition, it has frequently been referred to formally and informally as a "sanctuary city," a city which welcomes immigrants despite resistance from the federal government. The local government chooses to enact less strict immigration policies allowing undocumented immigrant families to enroll their children in local schools without fear of deportation.

Central City School District

Central City School District (CCSD) is a diverse school district which educates approximately 21,000 students in grades pre-Kindergarten-12th grade. Of this total enrollment, approximately half of the student population are elementary students in grades pK-5. Approximately 30% of the elementary students within the district are identified as "chronically absent," with Black/African American students comprising most cases. Due to the city's sanctuary status, the district supports 70 different spoken languages with students from 60 countries. The 4-year graduation rate for students within CCSD is 60%, approximately 20% below the state average, with students identified as American Indian, Latinx, English Language Learners, students with disabilities, or economically disadvantaged reporting graduation rates below the district average. Due to a partnership with the state, each student within the school district are provided free breakfast and lunch, with various schools serving as community hubs who continue to provide meals for students and families throughout the summer months.

Central Elementary

Within walking distance of the local university community resides Central Elementary. The school is a reflection of the demographics of the community, supporting approximately 80% students of color (American Indian or Alaska Native—1%, Black or African American—48%, Hispanic or Latinx—15%, Asian or Native Hawaiian/Other Pacific Islander—8%, and Multiracial—9%) (State Department of Education, 2017). Most of the students at Central Elementary are classified as economically disadvantaged (90%), which is slightly higher than the district average with approximately 20% of the teaching faculty having fewer than three years of teaching experience (State Department of Education, 2017). Approximately 30% of the students at Central Elementary are identified as ELL, which is approximately 10% higher than the district average.

Although much of the student body consists of students of color, at the time of this study, the entire fifth-grade faculty identified as White (1 male, 5 females). Unlike other grades, the fifth-grade faculty were departmentalized, with two teachers responsible for teaching English/Language Arts and social studies, two teachers teaching mathematics and science, and two special education teachers who primarily worked with students identified as having a learning disability. Elizabeth, the teacher participant within this study, has taught at Central Elementary for the duration of her career (6 years), and as such, was identified as a leader within the school building. She identifies as a White female whose graduate school experience in a large urban city in the southern portion of the state. She taught science and mathematics to half of the fifth-grade cohort with the other teacher often co-planning lessons with Elizabeth for the remaining two classes to promote consistency.

To accommodate science and mathematics instruction for all students, the department operated on an alternating A-day, B-day schedule, where the teacher would have her assigned homeroom class each morning and alternate each afternoon for mathematics, science, social studies, and ELA instruction. Science instruction was scheduled as the last class of the day, immediately following students' elective (e.g. swimming, physical education, music) courses.

Because of the departmentalization, Elizabeth taught the same group of students every other day, resulting in a maximum of three different science lessons each week. The fifth graders selected for this study reported 53% proficiency on the fourth-grade state science exam during the 2017-2018 academic year, nearly double the school's proficiency from the previous year (State Department of Education, 2017). The school utilized the FOSS modules across all grade levels to support its teachers' science instruction.

At the time of the study, the school was transitioning from being designated as a "priority school," which required adherence to strict state guidelines to ensure the school's improvement. During the 2018-2019 academic year, the school was reclassified as being in "good standing" with the state for meeting the predetermined "accountability designations." Science assessment scores are one such accountability designation, and during periods in which schools are under state supervision, the school must agree to provide extended learning opportunities for all students, which resulted in the incorporation of an enrichment program at Central Elementary. The school's program was described as a Science, Technology, Engineering, Art, and Math (STEAM) enrichment program that provided supplemental activities to all students during the school day. The program was designed to allow students the opportunity to continue exploring many of the concepts learned during science time through the completion of various arts-based projects. The enrichment staff consisted of unlicensed individuals who pushed into the classroom to lead supplemental lessons while the teacher of record participated in various professional developmental activities. The enrichment classes offered a 40-minute gap in the teachers' schedule to accommodate these development opportunities. As a result of these offerings, the school operated on an extended school day schedule, where dismissal was considerably later than other elementary schools in the district.

Central Elementary was described by some faculty members as being one of the “better” elementary schools within the school district, where students were “more behaved.” This characterization of the school was largely fueled by the faculty’s perspectives on the administrators’ approaches to addressing student behavior. A school security officer was always present within the building and was frequently called by classroom teachers to assist in managing undesired student behaviors. Additionally, several teachers served as informal administrators whose purpose in handling student behavior often superseded their role as classroom teachers. In these cases, the teachers were often called on by colleagues to either house displaced “misbehaving” students within their classrooms until their assigned teacher determined it appropriate for them to return, or to leave their classroom during instruction to address student behaviors in common spaces as having been identified as one who was good at “classroom management.”

The school facilities were also recently updated, with each classroom equipped with smartboard technology, hand-held microphones, a laptop cart, and tablets. Because of the relatively large population of English Learners (ELs) at the school, there were representations of geographical diversity (e.g. maps with pins of the home countries of students on the walls, banners with flags of various countries posted throughout the building) to promote a culture of community throughout the school. To remind students of its mission, each morning, students were expected to rise from their seats and recite the school’s pledge—a mantra steeped in affirming language reminiscent of charter schools—shortly after reciting the Pledge of Allegiance. This pledge was to remind students that each of them were an important individual whose school promises to prepare them for the world ahead.

Data Collection

Data collection commenced in early March and ended in late June of 2019. I spent approximately forty hours per week at the school for the duration of the study. The data collection consisted of three phases:

Recruitment. Prior to initiating this study, I spent several weeks (late January-mid February) in the school with the primary goal of building rapport amongst the students, faculty, and staff. I introduced the study to the students and Elizabeth and provided several opportunities for all to ask questions. During this time, I informally observed the classroom and school to gain an understanding of its structure and typical operating conditions. As parental consent forms were returned, I documented their receipt, a process which required digitizing and filing with district administration. All hard copies of files were stored in a locked filing cabinet on campus with only myself and my faculty advisor having access. After students returned signed consent forms, I scheduled individual interviews where I further explained the nature of the study and requested their assent for participation in the study. Upon the students' assent, I followed the same procedures as noted with the consent forms and began phase one.

Phase 1. Phase one consisted of the pre-observation task (POT) (Appendix A) and individual student interview. The purpose of the task was for students to articulate their identities-in-narratives of their academic, racial, and disciplinary identities (Varelas, Martin, & Kane, 2012) prior to classroom observations. Because the CLIC framework does not provide a tool to elicit students' narrations of their academic and racial identities, prompts from Carlone's (2012) *Norms and Values Sorting Activity,* and Sellers et al. (1998) MMRI were incorporated into Varelas, Martin, and Kane's (2012) *Prompts for tasks aimed at identities-in-narratives* (see

APPENDIX G) to construct the task. For the POT, students were provided a set of index cards arranged in the following order:

1. Overall, my race/ethnicity has very little to do with how I view myself as a scientist.
2. Overall, my friends support me being a scientist.
3. Overall, my family supports me being a scientist.
4. Overall, in science class, it is important to talk like a scientist.
5. Overall, in science class, it is important to respect others.
6. My gender is an important part of me being a scientist.
7. Overall, my race/ethnicity is an important reflection of who I am as a scientist.
8. Other: I really wanted to talk about this___.

Students were instructed to read each card and arrange them along an arrow labeled: "not true for me," "kinda true for me," or "very true for me." After arranging the cards in order of least to most significant, they were provided a paper in which they responded to three short-answer prompts:

1. I am good at science because…
2. It's important for me to show my teachers/classmates that I am good at science because…
3. What do you do in science that scientists don't do?

Upon completion of the pre-observation task, students were interviewed to understand their rationale for their responses. The responses were transcribed and subsequently subjected to an initial analysis to note how students were positioning themselves across each of the identity constructions, which informed Phase 2.

Phase 2. The second phase of the data collection consisted of a series of classroom observations and video recordings, reflective post-lesson interviews with Elizabeth, and collection of student science notebooks and teacher lesson plans for content analysis. Assenting students were grouped based on their seating preferences and input from Ms. Elizabeth (see Appendix F for student grouping chart). Three students: Westpaul, Rebecca, and Nguyet assented to audio recording only and were grouped together at table 3 (Figure 2). These students were provided audio recorders to capture their conversations during the science lessons. The video recording software allowed simultaneous video and audio recording of the teacher and students. The recorder was positioned in the rear of the classroom such that it only tracked and recorded the movement and audio of the teacher. For the remaining students who assented to video and audio recording, tablets and audio recorders were positioned at each of their workstations and captured footage synchronously with the teacher for the duration of the lesson.

The recordings spanned a period of six weeks, resulting in twelve non-consecutive recorded lessons. Eight of the recordings included teacher and student video/audio; however, after a month of recording, students expressed their desire to return to their traditional teacher-assigned pairings. I honored their requests and recorded the teacher's instruction for four additional lessons. All videoed lessons were viewed and analyzed for preliminary patterns per the students' narrated identities from the POT. I selected multiple video clips for each participant that best represented their identities-in-practice, and used the clips generate the questions which guided the post-lesson interview (see Appendix C). During this time, identity profiles were developed for each student using the identities in practice analytical guide (See Appendix G). The profiles were created to understand how the students' narrated identities were practiced within the classrooms and were also referenced in the post-lesson interview with the students as a form of member checking.

Upon selection of clips and generation of the questions, Elizabeth and each student participated in a semi-structured post-lesson interview. Student science notebooks were also digitized and stored within a folder created for each participant and subjected to analysis to understand how the students' narrated identities were practiced within their classroom work. The teaching guide which accompanied each module was collected and digitized for content analysis in response to sub research question 1.

For Elizabeth, the post-lesson interviews functioned as a debriefing space for her to reflect on the lesson. Initial guiding questions were used to guide the interviews and eventually, Elizabeth felt more comfortable providing live reflections during the lesson or would initiate the lesson debrief where she focused on two main areas: the purpose of the lesson and how to adjust subsequent lessons based on student understandings.

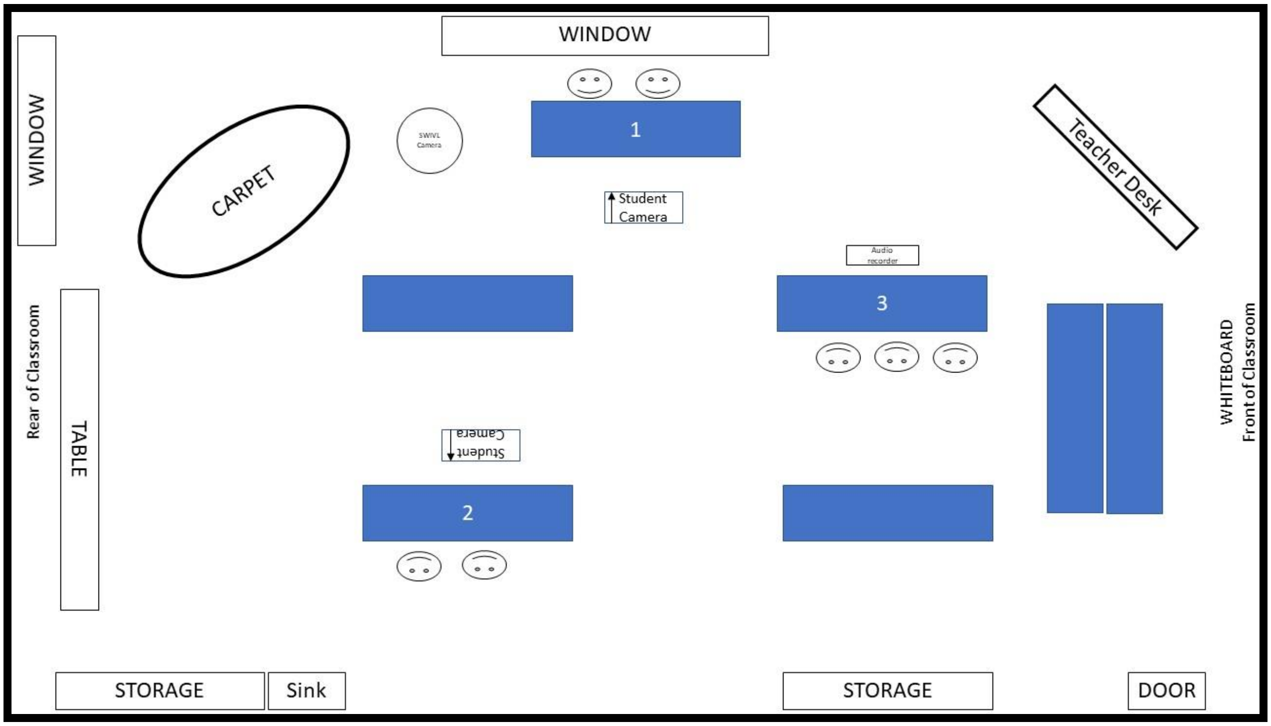


Figure 2: Layout of Ms. Elizabeth's Classroom

Phase 3. After selecting the video clips during phase 2, I interviewed each participant to understand how their narrated identities were practiced within the classroom. Each student watched multiple clips of themselves and Elizabeth during instruction as a recall tool (Clarke et al., 2006) and was asked semi-structured questions designed to elicit their overall reflections of the lesson and how their self-described identities manifested within the classroom and throughout their science work. To support my initial analysis of the video clips, I asked students probing questions to further understand whether my interpretations of the students' actions within the clip aligned with their own reflections of their experience, which served as an additional form of member checking. I followed the same procedure to select video clips for Elizabeth, with the questions serving to understand the nature of her science teaching identity throughout the course of the study.

Data Analysis

Several data analysis methods were employed throughout this study. To illustrate the process, I provide a supplemental diagram (Figure 3) detailing the relationships between the data, the analysis, and the resulting findings.

Prior to commencing full analysis, all interview data were transcribed verbatim. To ensure accuracy of my interpretations of their expressed ideas, all student participants were asked clarifying questions regarding their responses to interview questions, while Elizabeth was provided transcripts of our conversations along with my observer comments and initial analysis for review. In addition, the video clips selected for the second interview were transcribed, as the transcriptions were analyzed to inform the semi-structured questions for the second interview (phase 3).

The data sources (interview/video transcriptions, pre-observation task, student notebooks, and teacher guide) informed the reflexive and analytical memos derived during my time in the field. The reflexive memos documented daily occurrences within the field and coupled with the POT and identities-in-practice analytical guide (Appendix G), informed the generation of individual student identity profiles. These profiles were designed to understand how the students' identity domains manifested within the classroom, and the documents (e.g. student notebooks and teacher guide) were analyzed to understand how the students' identity constructions were elicited within the curriculum. The culmination of these data points subsequently informed the development of the coding system.

Development of the coding system

Implementing Chenail's (2012) qualitative data analysis technique, the interview data and reflexive memos were reviewed and pre-coded for qualitative significance. During this process, I documented notable moments from observational notes and illustrative phrases expressed by participants during interviews or classroom observations for further analysis which informed the first cycle coding process (Saldaña, 2016). In the following sections, I overview each coding cycle and conclude with a coded excerpt of data to illustrate this process.

First cycle coding. During the first cycle codes, the pre-codes were reviewed while all data was coded line by line through open coding. The open codes were descriptive in nature with similar codes grouped together for further analysis. During this analysis, the codes were compared against one another to evaluate their meaning in relation to the data, resulting in the collapsing of similar codes and the generation of sub-codes related to a central category. These codes and associated categories were then used to re-code the data during the second cycle coding.

Second cycle coding. During this phase of data analysis, the revised codes were reapplied across all data to gain further insight into the emergent themes. Analytical memos were generated of the emergent themes and compared to initial memos to observe for patterns or changes in interpretation of the data. Excerpts of the data were shared with colleagues during this phase where they could generate codes and memos for comparison to ensure reliability of findings. To provide a contextual understanding of this process, I overview the “rules” coding system and resulting codes/sub-codes.

One of my initial codes was *rules*, which referred to the way students referenced classroom norms through their actions (e.g. raising hands, following the teachers’ instruction). However, after continued analysis of the data, I realized that rules was a category with multiple interpretations, allowing for the generation of the codes, “class participation,” “engagement in class,” and “behavior management.” Class participation occurred during verbal discussions or through students' writing and one of the ways for students to gain access to the space was through the incorporation of classroom discourse strategies, a sub-code of participation.

The second code, *engagement in class*, referred to the student's reflection of their class participation. This code is different from the class participation code because it represents the students' own positioning of their classroom behavior, which was oftentimes validated by the teacher's acknowledgement. This code was prevalent in phase 3, as students reflected on how their actions were representative of their identities-in-narratives. For example, when reviewing the video of himself during a lesson, Anthony lamented that he did not feel like a scientist during that time (his disciplinary identity), because Ms. Elizabeth was "talking a lot about instructions." In this example, Anthony reflected on his dis-engagement, and linked it to his disciplinary identity. Contrarily, students also reflected on moments where they could interact with their peers, as evidenced in the "collaboration" sub-code.

The *behavior management* code referred to moments where either students or the teacher reflected on the need for others to "act good." In these examples, students would use authoritarian-related language to describe "bad behavior," often attributing such behaviors to themselves rather than questioning the nature of the origins of the rule.

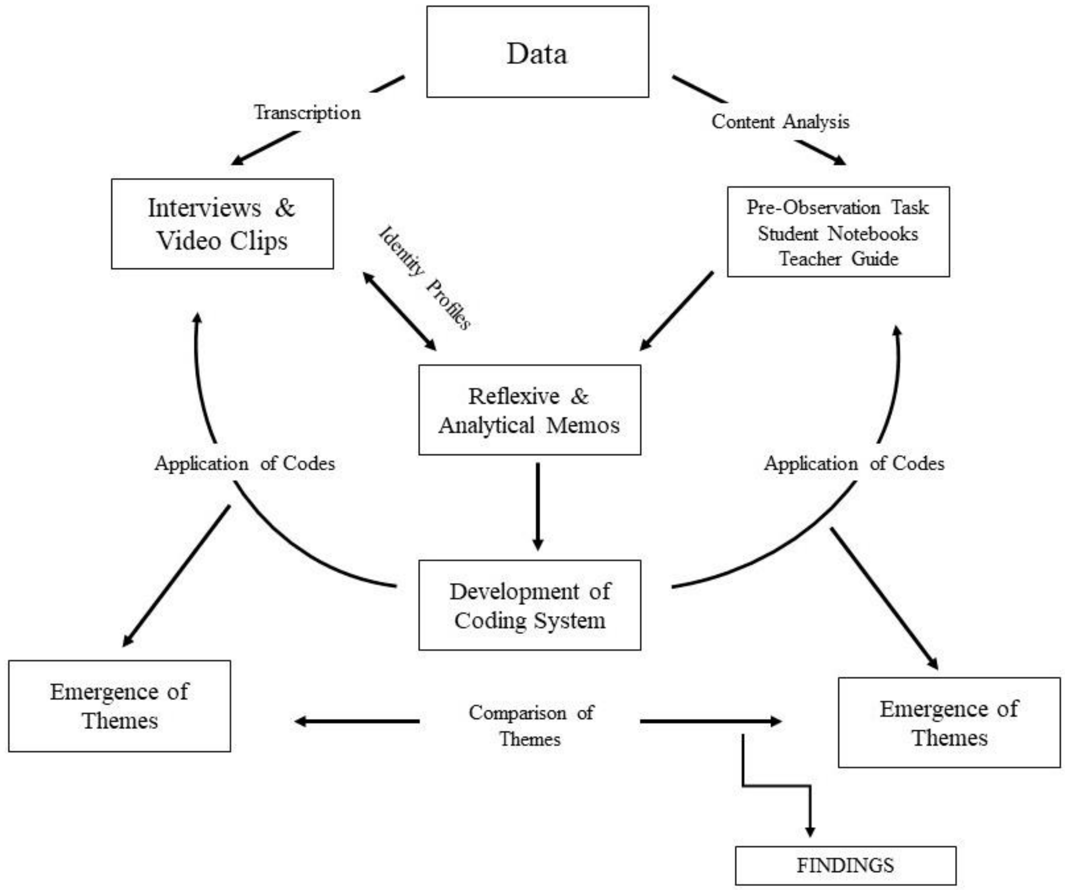


Figure 3: Diagram of data analysis process.

My Role in the Research

As the researcher in the study, I occupied a participant observer role. Throughout my time in the school, it was more important for me to feel as though I was actively contributing to the school and classroom community than being an abstract researcher and as such, I spent as much time in the building as possible. I typically arrived by 8am shortly before the students and departed at 4:30pm after the students were dismissed for the day, 5 days a week. Although there were fifteen participants who agreed to participate in the study, I worked with all students across both classrooms throughout the school day.

To contribute to the community and build rapport with the faculty and staff at Central Elementary, I chaperoned multiple field trips, attended school assemblies, and ate lunch with the fifth-grade faculty daily. Within the classroom, I assisted Elizabeth in any way she deemed necessary, usually resulting in me leading small group lessons during math instruction to provide additional individualized support for students, leading whole-class discussions during science instruction to elicit and build on student thinking, assisting with the setup and disassembling of materials for science lessons, and accompanying students to recess and other extra-curricular classes.

Because of my affiliation with the local university coupled with the fact that I had not previously worked with Elizabeth, I recognized the intrusive and seemingly evaluative nature of my presence. However, I worked to quell these feelings as much as possible, as her comfort with me occupying such space and trusting me as a contributor rather than outsider was of paramount importance. She expressed initial discomfort teaching science when committing to participate in the study, so rather than positioning myself as an evaluator of her science teaching practices, I positioned myself as one who could provide immediate professional development to answer any questions she could have around the central ideas of the investigations, the standard(s) they aimed to address, or assistance with co-planning subsequent lessons based on student thinking.

Additionally, this discomfort was heightened by the expectation of video recording, as it implied a need for Elizabeth to perform, because to her, her instruction was memorialized in video. Initially, there were days where it was apparent the students' access to science instruction was contingent upon the presence of the video recorder, leading to inconsistencies in the recording schedule. However, this eventually subsided throughout our partnership, and I suspect this was partially attributed to Elizabeth's growing confidence with teaching science. In effect, I was an instructional support person with additional responsibilities of a teaching assistant.

While I understood my role as a researcher in one classroom, I was equally aware of my presence throughout the entire building. Because I began working with the school in 2017 and spent the spring 2018 semester in the building, although in a different classroom, the office staff were fond of me and would greet me daily as I checked into and out of the building. I had limited interactions with the new principal, but she reiterated the significance of my presence in the building as well. This significance was not lost on me, as it is highly likely that my identity as a Black male who was not occupying a staff-related (e.g. custodial, cafeteria) role was viewed as valuable to the school administration. In fact, the principal stated as much on my last day at the school, where she and other teachers inquired about whether I would be coming to the school during the following academic year. At their graduation ceremony on the last day of school, students excitedly introduced me to their parents and inquired about if I were planning to follow them to middle school, presuming I would occupy a similar instructional support role. These instances indicate my concerted efforts, and subsequent success with, connecting and building relationships within and across the school.

CHAPTER 4—FINDINGS

In this chapter, I present the findings from the data analysis in which I address each of the following research questions:

1. How do elementary students of color construct their science identities in classroom spaces?
   (a) How does the curriculum support elementary students of color's science identity development?
2. How does an elementary teachers' positionality inform her science instruction in a diverse classroom?

This chapter is divided into three main sections. In the first section, I report findings related to the initial research question. This section is divided into sub-sections describing the findings from the pre-observation task, in which students' responses to the prompts were coded into initial identity markers. These markers were used to observe their classroom interactions, or their identities-in-practice. I report findings from these identities-in-practice across the three domains: the racial, academic, and disciplinary identities, per the CLIC framework (Varelas, Martin, & Kane, 2012). The second section addresses the sub-research question (1a), where I begin with an overview the curriculum. I further describe the lessons observed throughout the study and provide a detailed analysis of the curriculum to understand how the curriculum attends to the students' multiple identities. In the third section, I present findings related to Elizabeth's positionality and the emergence of her science teaching identity, where I conclude with an overview of her attempts to tend to the students' identity domains.

Elementary Students' Identity Constructions

Varelas, Martin, and Kane (2012) offered the CLIC framework as a tool which "strongly emphasizes constructing racial identities simultaneously with disciplinary and academic identities along with disciplinary knowledge" (p. 326) to foster success for students of color in science. As such, we must understand how students themselves position these identity constructions, which I addressed through the creation of the POT (see Chapter 3 for a detailed description). In the sections to follow, I provide a brief reporting on the trends of students' identity positioning vis-à-vis this task, followed by an in-depth reporting of the identities-in-practice to address the central research question.

Pre-Observation Task

From the POT, students positioned their racial and gender identities as insignificant contributors to their science identity (see Table 1). These views were supported through color-evasive[4] rhetoric, where students seemingly espoused views of a post-racial society despite the race-related implications (Bonilla-Silva, 2015) embedded within their stories. For example, when asked about her card sort, Blue, who identified as an African American female, stated:

> *Mr. B.*: Ok, and then right in the middle, [referring to the pre-observation task] you said that your race/ethnicity has very little with how you view yourself as a scientist. Why?
>
> *Blue*: Because, like I said with my gender, now in 2019, there's not much really about race. Like, nobody cares about racism, nobody talks about racism, unless it's one person

[4] Although this term has been colloquially conceptualized as "colorblindness," Annamma et al. (2016) argue for the use of the term "color-evasiveness" as an expansive racial ideology as it "resists positioning people with disabilities as problematic as it does not partake in dis/ability as a metaphor for undesired" (p. 153). Considering this recommendation, I will utilize colorblindness only when referencing the term in its original work.

that really wants to talk about it and really just…really just…and um that's why I put that one right there.

Mr. B.: Do you think that you've experienced or observed instances of racism in school?

Blue: Nods head up and down (affirmative).

Mr. B.: How?

Blue: Because there was this one boy when I was in first grade…that's weird that I still remember this. There was this one boy, he was physically White, and he really didn't like Black people. And he used to bully me because I was the only Black kid in my class (Interview 1, 3/20/2019).

Anna, another Black female, echoed Blue's sentiments in her interview:

Anna: And this one [of the pre-observation task] says "Overall, my race/ethnicity has very little to do with how I view myself as a scientist." It does, because a person can be Black or White…it doesn't…like associate them with being smart or dumb. And this one says: "Overall my race/ethnicity is an important reflection of who I am as a scientist." I think that's not true because if I'm Black it doesn't matter, I just show how good I am as a scientist.

Mr. B.: So when we think about what you said with women not being represented in like pictures or [science] textbooks, do you see scientists that look like you that are in like books or in the things that you see or read?

Anna: Yeah…I think that kinda [*sic*] the world is like over race. Like they know that Black people, men or women, can be scientists and stuff like that so they [Black people] are not heavily embedded in textbooks, but they're there (Interview 1, 3/13/2019).

Table 1: Summary of Collated Student Responses for Pre-Observation Task

Statement	Not True for Me	Kinda True for Me	Very True for Me
1. Overall, my race/ethnicity has very little to do with how I view myself as a scientist.	Charlotte* Pro*	Alexis Rebecca* Anthony Westpaul* Blue Jaena Nick*	Anna John Nguyet Seth Terrance
7. Overall, my race/ethnicity is an important reflection of who I am as a scientist.	Anna Blue Charlotte Jaena Seth Terrance Nguyet John Pro	Anthony Rebecca Westpaul	Alexis Nick Seth
2. Overall, my friends support me being a scientist.		Alexis Terrance Charlotte John Nick Rebecca Seth	Anna Anthony Blue Jaena Nguyet Pro Westpaul
3. Overall, my family supports me being a scientist.	Nick Pro Rebecca	Blue Seth Westpaul	Pro Terrance
4. Overall, in science class, it is important to talk like a scientist.	Blue	Pro Seth	Alexis Anna Anthony Charlotte Jaena John Nguyet Nick Rebecca Terrance Westpaul
5. Overall, in science class, it is important to respect others.			Alexis Anna Anthony Blue Charlotte Jaena John Nguyet Nick Pro Rebecca Seth Terrance Westpaul
6. My gender is an important part of me being a scientist.	Anna Anthony Jaena John Pro Rebecca Terrance	Charlotte Nguyet Westpaul	Alexis Blue Nick Seth

Note. * Indicates participants who misunderstood the meaning of the prompt. In the interview, clarification was provided to contextualize their responses.

Although students positioned their racial and gender identities as insignificant contributors to their science identity, their academic identities were central to shaping their disciplinary and overall science identities, as indicated by the "very true for me" designation. The statement "Overall, in science class it is important to respect others." (statement 5), a statement designed to elicit the positioning of one's academic identity, was noted as "very true" for all students (n=14), closely followed by an emphasis to "talk like a scientist," reflective of the disciplinary identity domain (see Table 1). Students viewed respecting others as a gateway to their science access, as illustrated in the following excerpts:

> *Mr. B.*: Ok, and so the next one you said that "overall in science class, it's important to respect others." So why is it important to respect others?
>
> *Seth*: It's important to respect others because if you don't respect them, then they won't want to work with you. But if you respect them and respect others, then they'll like work with you and like agree to everything that you like—your answers and questions and things (Interview 1, 3/16/2019).
>
> *Jaena:* Umm…also I picked um this one because it is important to respect others because scientists can't be like… scientists can't be like rude to people while they are doing stuff because then that's how anybody's not gonna like you, and then that's how everybody's not gonna like you and they are gonna think that you're a bad person and you're mean (Interview 1, 3/15/2019).

While students acknowledged the value of collaborating with one another in science class, this collaboration functioned as a secondary factor for their access to instruction. In other words, students implicitly understood that in order to participate in science lessons, they must respect one another, an expectation deeply rooted in rule following, which was directly observable in students' practiced identities.

Identities-In-Practice

The identities-in-practice guide (Varelas, Martin, & Kane, 2012) serves as an analytical tool to provide the researcher with a contextual understanding of how students enact their respective identities within the science classroom. As such, various questions rooted in each of the identity domains (see Appendix G.) guided the observational analysis to understand these identity constructions.

Disciplinary Identity Constructions

Analysis of the disciplinary identity construction, linked to one's ability to 'do' science, fit within three categories: classroom rules, validation, and classroom discourse. I provide brief illustrations of each sub-domain in the sections to follow.

Classroom rules. Students whose disciplinary identities were reflective of classroom rules referenced the notion of "being good" as a measure of their science identity. This was especially evident in observations of both Blue and Anthony. While Blue positioned herself as someone who was a scientist despite making mistakes, she also attributed her attitudes toward science as being indicative of her behavior. For example, in one lesson of the *Mixtures and Solutions* module, students were exploring the focus question: "What is the difference between dissolving and melting?" This lesson succeeded an introductory investigation designed to engage students in scientific modeling and the central idea was for students to subject a cup containing four different objects (a pebble, a cube of margarine, a segment of a birthday candle, and a chocolate chip) to a basin of warm water and make observations. Blue, Terrance, and Jaena were grouped together, and during Ms. Elizabeth's instruction, both Blue and Jaena awaited permission to begin the investigation while Terrance began placing the cup containing the four objects into the warm water, causing Blue to swat at Terrance's hand, shouting "No!" Terrance then placed the cup back on the table and proceeded to raise his hand to ask for permission to continue to the next step. As Blue watched the video clip of this lesson, she mentioned that she became frustrated with Terrance because she knew the teacher "was going to get mad" at them for failing to follow her instructions. She further attributed this interaction to her self-described "anger issues," stating that it was something "she needed to work on because people are held accountable based upon their choices."

Anthony, like Blue, viewed his disciplinary identity through the lens of his behavior. In his case, he was frequently separated from his peers for talking at inappropriate times or exhibiting other undesired behaviors. He described himself as one who was "sometimes good and sometimes bad," with the instances of his self-described "bad behavior" being attributed to himself, even if his actions were in response to his feelings of being singled out in front of his peers. He actively sought validation of his behavior from the teacher through the frequent asking of "Did I do good today?" to affirm his disciplinary identity.

Classroom rules also shaped students' disciplinary identities as emergent knowers of science, as illustrated in Blue's articulation of why she positions herself as a smart in science:

> First, I wrote what she told me to write. I did the date…everything. I did the right um diagram. I split it up by temperature and stuff and I—first of all, I showed pictures. I split it up, I showed pictures on each one—on dissolving and melting. I wrote all the notes that's important like she told me to (Interview 2, 5/28/2019)

Although the teacher set academic and behavioral expectations of her students, students implicitly seemed to place greater emphasis on wanting to please the teacher through their positive behavior. Within their academic work, these behaviors manifested as following the teacher's instructions, as evidenced in Blue's account. Anthony described the action of raising his hand to answer a question as a manifestation of his disciplinary identity. In his case, he felt those instances directly contradicted what was considered his "normal" behavior; thus, he positioned himself as a scientist.

Validation. While following classroom norms were expected of students, it is possible these norms allowed students entry into the learning space where they could compete with one another for the validation of their ideas. For example, Seth was positioned by adults within the school as a student who exhibited unpredictable behavior and "struggled in reading." Although these were designated identity markers (Sfard & Prusak, 2005) for him in other disciplines, Seth actively asserted himself in science class to position himself as both a doer and knower of science. During our second interview, upon reflecting on the video, he mentioned that he felt the need to take a leadership position during the investigation because he had already worked through the investigation on his own and knew the answers. Rather than completing the investigation on their own, he expected his groupmates to adopt his rationale and duplicate his answers. Seth prioritized this need to show others his science abilities because he suspected they would "give him good comments instead of bad comments." Because of his designated identity in other academic disciplines and the school writ large, Seth may have felt the need to prove to others his science competency, leading to frustration whenever these assertions were not acknowledged. These frustrations sometimes resulted in Seth repositioning himself as someone who was not "good enough" in science.

For example, during a lesson within the *Living Systems* module, students were provided 15 informational cards with various organisms inhabiting the kelp forest ecosystem. Seth was grouped with Terrance, Jaena, and John, who were all instructed to divide the cards amongst one another, study their contents to become experts on their assigned organisms, and generate a food web for the kelp forest. Roughly halfway through the lesson, Seth became visibly frustrated with his groupmates as they actively ignored his arguments for the construction of their food web, stating emphatically: "Ugh…see, this is why…" After this expression, he appeared visibly upset and began to retreat from the whole group discussion and returned to drawing in his notebook.

On a typical day in class, Seth would usually either completely engage with the lesson or leave the classroom altogether, resulting in administrative actions. It is likely this expression was his articulation of providing evidence to support his disengagements from lessons. Further, when asked to recall his feelings during this exchange, he expressed that he felt "disrespected because he listened to them [his groupmates], and they didn't listen to me" (Interview 2, 5/29/2019). He also mentioned that during these instances, he sometimes changed his ideas around science because no one listened to them.

The validation of their ideas authenticated science as a process for the students. In the teacher's instructional practices of acknowledging students' ideas as correct, they considered this work as part of "real" science. Nick's disciplinary identity was reflective of this as he made mention of feeling like a scientist when assignments were "fun" and he "gets them right." Jaena viewed her class participation as a validating space for her ideas as evidenced in this excerpt from our first interview:

> *Mr. B.:* Ok. So here, [referencing the pre-observation task] you said that "It is important to show my teacher/classmates that I am good in science because…"

Jaena: Um…because they could pick on me…like if I was good. Because if I'm not a good scientist, they would probably think that I don't know like the answers, so, like I want them to pick on me. I want them to know that I am a good scientist, so I have to show them that I know how to be a good scientist.

Mr. B.: Ok, so you said that they would pick on you if you were a good scientist?

Jaena: Yeah.

Mr. B.: Ok, so tell me why you think they would pick on you.

Jaena: 'Cause if I wasn't one, they would probably be like "Oh, she doesn't know what this is about." But if they see me working hard, they would probably be like "She knows what she is doing."

Mr. B.: So, is picking on you a bad thing? Or like, do you mean tease you or making fun of you?

Jaena: No, like picking on me for questions (Interview 1, March 15, 2019).

During whole-class discussions, Jaena was usually the first student to raise her hand to participate, indicating her attempt to position herself as a scientist as evidenced in her notion of being "picked on". In her interview, she mentioned the need to show others this identity as it would increase her chances of being selected to participate. Inherent in Jaena's bids to assert her disciplinary identity were also indicators of how she followed the classroom rules (e.g. raising her hand to speak) allowing her access into the classroom space. She, unlike Anthony, did not position herself as a "kinda good, kinda bad" student, which was reflected in her interactions with her teacher subsequently allowing her to experience more science learning opportunities.

Classroom Discourse. While following classroom rules provided students with a sense of validation of their identities, implementing the classroom discourse norms through talk and writing were also common practices amongst students as a space to assert their disciplinary identities. Ms. Elizabeth focused on providing students with sentence starters she required them to use to communicate their ideas with one another in class. Her teaching philosophy was one that positioned students as “owners” of their learning, (Interview 1, 3/22/2019), and as such, she hoped students would come to value learning by developing a genuine interest in the content rather than viewing their classwork as a requirement. The sentence starters (e.g. “I disagree with ___ because of ___; “I agree and would like to add on ___”) were designed as a tool allowing all students to access one another’s ideas during classroom discussions.

John, one of her students, was designated as a student who was "low" in his math and writing skills. Although considered a "strong" reader, Ms. Elizabeth felt that he struggled with reading comprehension and writing. However, like Seth, John used science to assert a disciplinary identity through his implementation of the classroom discourse practices. For example, when describing himself, John quickly noted: "I have a hard time with outbursts in class and that's something that I need to work on" (Interview 1, 4/25/2019). During periods where students could share their ideas with one another, John would oftentimes excitedly share his ideas out of turn, usually leading to redirection from the teacher. Although out of turn, he would continue abiding by the discourse rules through the incorporation of sentence starters in his responses. He noted as much in an interview where he referred to his use of the phrase “I kindly disagree” and “words on the whiteboard” (Interview 1, 4/25/2019) as evidence of his disciplinary identity. John also viewed his participation in science to be a measure of his future self, as he alluded to the idea that he must do well in science because “it'll reflect on your future,” in his first interview.

Students also positioned themselves as scientists through their writing. These students were typically ones who were self-described as shy or those who resided along the margins of whole-class discussions. Four of the students: Westpaul, Rebecca, Nguyet, and Charlotte all actively used their science notebooks to indicate participation in the classroom community, often writing well beyond the teacher’s specifications. For example, Charlotte, a student who often visibly retreated from classroom discussions, described her science writing was a way to let her teacher see that she’s “done a good job.” Charlotte also viewed her work as being validated by the teacher as she “did not ask her to revise any of her ideas.” In a written reflection, she described her science identity by stating that the lesson made her feel like a scientist because she “had to draw a model and scientists also draw models. Also, scientists discuss their ideas with other scientists and our group discussed with our group [*sic*] mates” (Science notebook entry 3/9/2019 p. 28). This notebook entry is significant because it demonstrates how students utilized the practice of writing as a form of agency. Further, it served as a paradigm shift in which there is a partial balance between one’s disciplinary identity (as referenced by modeling) and academic identity (as noted by idea revision). Charlotte’s quiet demeanor in class sometimes resulted in a sense of being forgotten or excluded from the classroom community. However, through her writing, she actively participated in equally significant ways without having to make bids for her classmates to “pick on her,” as was the case with Jaena.

Students who were identified as having speech or language acquisition limitations utilized writing to illustrate their science competency. Rebecca, an identified EL who recently immigrated from Southeast Asia, incorporated the classroom discourse practices into her writing to communicate her disciplinary science identity. For example, Rebecca mentioned her notebook is a place where she can draw detailed pictures of what she observed and write about them. In the third investigation of the *Living Systems* module, students were provided a notebook entry detailing a scenario depicting the ideas of two students having a conversation about a woodland ecosystem food web. The food web was drawn with errors designed to assess students' conceptual understandings of the transfer of energy from one organism to another. The prompt of the task asked students to imagine that they were the third student in the conversation between the two students where you needed to incorporate your knowledge of food webs to assess the students' argument. Ms. Elizabeth required students to write one 5-sentence paragraph using five key science vocabulary words in their responses to the students in the story. In her assessment of the food web, Rebecca pointed out:

> If I were a third student, I would tell the other student that I disagree with the arrow because like for example the rabbit is transferring the energy to the wildflower which isn't right because the wildflower can't eat the rabbit. …And I would like to add on that I disagree with the second person who said that they are missing consumers, and producers because the hawk, snake, rabbit, mouse are consumers, and the wildflower and the grass are the producer so I disagree with the other student (p. 38).

Rebecca's notebook entry comprised multiple paragraphs spanning beyond a full page, which was well beyond the teacher's 5-sentence paragraph requirement. In her response, she incorporated several of the classroom discourse talk phrases (e.g. "I would like to add on…" "I disagree with…") as though she were participating in an oral class discussion. She underlined the key science vocabulary terms students were studying in class, an indication of Rebecca following the rules set forth by her teacher while also utilizing the space to communicate her science knowledge. Although Rebecca referenced her notebook as a part of her disciplinary identity "because it's filled with lots of writing," her writing served as an illustration of her agency as one who was typically reserved during class discussions.

Racial Identity Constructions

"The World is Over Race." In classroom observations, students' racial identities were not positioned as a central contributor to their learning. To support this claim, students narrated racial identities steeped in color-evasive rhetoric. This rhetoric was seemingly influenced by the notion that we live in a post-racial society, as evidenced in Anna's claim that "the world was over race," indicating little need to talk about race. Despite students recognizing the lack of persons of color depicted in stock scientist photos, their discourse reverted to phrases such as: "It doesn't matter what you look like," or "I don't see color; anyone can be a scientist," indicative of implicit messaging of meritocracy communicated throughout the school. As observed in the POT, Blue claimed to live in a post-racial society despite encountering instances of racism in previous years. When asked to reflect on these experiences in the second interview, she reverted to similar color-evasive rhetoric, effectively dismissing the multiple previous experiences she deemed racist in nature.

> *Mr. B.:* The last time we talked, you were mentioning—and I kept thinking about it—you were mentioning the incident when you were in first grade with the paint. So what does being Black or African American mean to you?
>
> *Blue:* Well…I mean…(long pause) I dunno. I guess it means…like you gotta be who you are. Like don't judge each other. Like we can't like always—I mean we can depend on people, but we can't always depend on people because sometimes you need to get your

stuff together, and you can't always depend on people.

Mr. B.: Hmm…and is that for African Americans in general or people in general?

Blue: People (laughs) just people in general. See, I don't see color, I see personality. I see face. I see…everybody. I don't see color. Color is not like…color is not everything.

Mr. B.: Can you say more about that?

Blue: I feel like color is not everything because sometimes you can just be Muslim, no offense, and people just turn you down because the way you look, or the way the color of your skin is. I don't judge people on the color of their skin. I judge—I don't even judge…I judge people sometimes on their personality and some of the choices. I—matter of fact, not even their personality, but on the choices that they make…(Interview 2, 5/28/2019).

In our first interview, Blue categorized her racial and gender identities as being unimportant regarding her consideration of herself as a scientist because of her perceived post-racial nature of our society. However, when pressed on these beliefs, she offered an experience which contradicted this assertion by recounting her experience with racism as a first grader. She mentioned that the incident was significant enough that her parents decided to remove her from the school and enroll her in Central Elementary. Despite this traumatic experience, Blue continued in the second interview to define her African American identity as "being who you are" and that "color is not everything." She hedged by her mentioning of the phrase "no offense" when referencing a Muslim individual, likely illustrative of the unspoken rule of ignoring racial identities, religious beliefs, gender expression, or any other identifiers which signify differences amongst students in school conversations where students know adults may overhear their interchange.

The color-evasive racial identity was also espoused by students who identified as recent immigrants. For Nguyet, her racial identity did not seem to matter if one persevered, which, for her, was learning to read and speak the English language.

> *Mr. B.:* You also said that your race/ethnicity wasn't important in you being a scientist. So for you—and you mentioned that your family immigrated from Southeast Asia, right? So one of the things that I'm interested to know more about from you is what does it mean to you to be Asian?
>
> *Nguyet*: I think that it doesn't mean much like how you look like…Like you have black hair, black eyes…you can be mixed and like if you're Asian, you can speak the language and communicate with other people that are Asian that is in the same country.
>
> *Mr. B.*: Mmhmm (affirmation). Do you feel like there have ever been moments that you've been treated unfairly because you identify as Asian?
>
> *Nguyet*: Um…when I first came here [to the US] some people maybe thought I was like dumb because I can't speak English, so they would also look at me and ask if I'm Chinese.
>
> *Mr. B.:* Hmm…and how did you feel about that?
>
> *Nguyet*: I'm feeling a bit…um sometimes upset. But I got over it.
>
> *Mr. B.:* And what would you say to another student that was facing the same challenges that you faced when you first got here?
>
> *Nguyet:* I would say to that person that um he or she just have to work hard and prove the people that judge you wrong and um…yeah (Interview 2, 6/6/2019).

Although Nguyet referenced her frustration with experiences of racism during her attempted assimilation into the US culture of schooling, she echoed similar sentiments as Blue regarding her claim that "it doesn't matter what you look like." Here, she has experienced a critical moment where her perceived academic ability was linked to her mastery of the English language. For her, mastering English was a way in which she could "prove others wrong," validating her access to the learning space, a practice illustrative of what Kendi (2017) termed *uplift suasion*, a phrase he conceptualized as "the idea that White people could be persuaded away from their racist ideas if they saw Black people improving their behavior, uplifting themselves from their low station in American society" (p. 124). While working to prove her worth to others, she was also forced to educate them on racist stereotypes regarding Asians (hence, her reference to individuals questioning if she were Chinese). Rather than these experiences serving as moments where her racial identity was salient, she dismissed them, likely due to the expectations of full assimilation that plagues many immigrants who arrive in the US. The need to blend in through academic achievement may be more important than acknowledging one's ethnic identity, leading to an emphasis on developing a strong academic identity.

Despite their color-evasive rhetoric, students indicated an awareness of their racial identities; however, their racial identities were viewed through negative stereotypes, likely fueling their meritocratic and color-evasive rhetoric. For example, John, an individual who identified as a Black male, associated his Blackness with the possession of material objects which would reflect his socioeconomic status. In the following exchange, I asked John about a conversation I overheard him and a group of students having around the use of the n-word. During the discussion, one student who presented to me as a White male was attempting to defend his use of the word to the dismay of his Black peers.

Mr. B.: Ok…And one of the things that came up yesterday at the end of the day was the discussion that I overheard you having with another student regarding using the n-word; do you remember that?

John: Mmhmm (affirmative)

Mr. B.: So one of the things that he said was that he was…well in his words, he is "mixed" and because of that, he can say the word.

John: Yeah…

Mr. B.: So, for you, what does it mean to be Black?

John: Well, like back in the old days, White people would call us that all the time, and I just feel like he was lying [about his racial identity], and he shouldn't say the word and that's it.

Mr. B.: So how does it make you feel to hear somebody say that?

John: I was just shocked.

Mr. B.: And so outside of that, in general for you, what does it mean to be Black?

John: Well, I got a good life, so I really don't know.

Mr. B.: Ok. So what is it about your life that you think is really, really good?

John: So I got a lot of stuff, I got Fortnite [videogame] skins, I got a big house, I got a lot of bathrooms, and a lot of bedrooms. I got a game room, I got a PS4—well in fact, I got 3 PS4s [videogame cosoles], actually. And I got a lot of friends…yeah.

Mr. B.: So because you have those things you think that being—how do those things then allow you to not know what it means to be Black?

John: Because like there's still some kids out there who don't get the same treatment that others do in America.

Mr. B.: So you think that you get the same treatment?

John: Yeah. And I don't know how that feels [to be treated differently] (Interview 2, 5/29/2019).

While John mentions his reported "not knowing" the meaning of his Blackness, he referenced it during his articulation of why he was offended by his classmates' use of the n-word (through his use of the word "us"), illustrating a racial awareness. However, he likely has not yet begun to view the intersection of his racial identity with other identities (e.g. being a Black scientist, a Black student, etc.). Like others, he alluded to a post-racial society ("Back in the old days"), and seemingly associated being Black with being treated differently, which fits within the color-evasive paradigm, as he asserted not experiencing differential treatment based on his racial identity.

Academic Identity Constructions

Overall, students were positioned as knowledgeable by their teacher and other adults throughout the building from the confluence of their performance on state tests and their behavior within the classroom, sometimes presenting varying interpretations of this domain. For example, several students (Seth, Terrance, John, Anthony) were positioned by adults as students who were "difficult" to deal with because of their behavior and/or reading and math skills, which greatly influenced how they were viewed by others as knowledgeable.

Much like how students positioned themselves as scientists whenever they followed classroom rules, they also positioned themselves as knowledgeable when adhering to classroom norms, indicating very little distinction between the two domains. This was articulated in both individual interviews and the analysis of student work, as students associate being "good" in science with "raising my hand to answer a lot of questions." For example, consider Anthony's—a student who frequently received fragmented individualized instruction due to his behavior—articulation of the significance of showing his teacher and classmates his science understandings: "If I don't show my teachers [that I am good in science] they are going to think that I am a bad kid. Also, my classmates are going to think I am a bad friend" (Interview 1, 4/12/2019). Anthony also considered himself a scientist when his efforts were recognized by his teacher as noted in the interview excerpt below:

> *Mr. B.*: Ok. And one of the things you said earlier was that you showed your teacher that you were a scientist because you raised your hand to answer questions. And that you did your work, so what do you think your teacher thought about you being a scientist?
>
> *Anthony*: Um when I was over there, I asked her "did I do good today? Did I do a good job?" and she was like "Yeah. You answered and you raised your hand and you moved around and took good notes." Yeah (Interview 2, 5/30/2019).

For Anthony, he emphasized his behavior in the articulation of his academic identity. He described himself as one who was sometimes a "bad kid" and was frequently positioned as such by the teacher through her disciplinary actions. These actions sometimes resulted in Anthony being separated from his group or being placed in another teacher's classroom, affirming the role student behavior played in determining which students had access to learning opportunities.

Identity Contradictions. Although authority figures regularly positioned students as knowledgeable based on their behavior and test scores, students sometimes positioned themselves in ways which contradicted their teacher's positioning, indicating the work students who are positioned from a deficit lens must do to reposition themselves as knowers. Students who illustrated this repositioning would typically appear "assertive" in science class, as illustrated by John. John was viewed by his teacher as a student who was "low" in his math and writing skills. In addition, during what she considered as a "rough day," Elizabeth stated that John would likely have a difficult time in middle and high school if he could not manage his behavior and would likely not attend college. Although this positioning influenced the usually tense interactions with his teacher, John viewed himself as knowledgeable in science because of the agency it afforded him, as evidenced in the following excerpt.

> *Mr. B.*: So how do you think this lesson allowed you to show your science skills?
>
> *John*: Because I kind of knew everything about the animals. I read the flash cards…and everything.
>
> *Mr. B.*: So how did it make you feel that you knew everything?
>
> *John*: I felt pretty great because I went home and taught my um my dad something.
>
> *Mr. B.*: And what did your dad think?
>
> *John:* (excitedly) He said that it was good! (Interview 2, 5/29/2019).

Despite being a "strong" reader, Ms. Elizabeth felt that he struggled with reading comprehension and writing. She further mentioned that perhaps the reason why he was more assertive in science was because he felt more comfortable with the material. However, Elizabeth was not critical of her deficit-oriented assertion of John's academic identity, which oftentimes discounted the work (e.g. taking what he learned in school home to educate his parents) as a true measure of one's reading comprehension.

Like John, Seth was another student who worked against this deficit positioning. However, he felt the need to prove to others his knowledge as he wanted to "receive good comments instead of bad comments" (Interview 1, 3/16/2019). An example of this claim was evidenced in Seth's articulation of his practiced academic identity.

> I showed my teacher and groupmates that I was like other scientists because I made my own food web and I helped everybody make their diagram in their book like for their foodweb. And we had put the cards on this big piece of paper for everybody and then we all drew lines to like what eats what, so my diagram and having them copy it helped everybody like get the cards placed in order (Interview 2, 5/29/2019).

Throughout my time in the building, I came to know Seth as a student who valued individual interactions with adults and would thrive in conversations where he was given the floor. However, this was a rare occurrence. Typically, Seth's name was blaring across the walkie talkies of adults throughout the building due to his violation of one (or several) of the school's "undesirable behaviors." As such, he was viewed through the lens of his behavior rather than through his scientific knowledge, leading to a failure of Seth's articulation of his identity to be taken up by his teacher.

When considering the significance of how students' funds of knowledge are evaluated, it is critical to examine the curriculum to understand how these identities are acknowledged, leading to the sub-research question: How does the curriculum support elementary students of color's science identity development? To address this question, I provide an overview of the FOSS modules used during the study and analyze their attention (or lack thereof) to students' multiple identities through their purported alignment with the NGSS.

Overview of FOSS Curriculum Modules

The two FOSS modules observed during this study were entitled "Mixtures and Solutions," which was a physical science-based unit, and "Living Systems," a life science-based unit. The instructional materials were designed to provide students with an "active investigation," incorporating core elements of technology, science-centered language development, reading materials, technology, science notebooks, formative assessments, and outdoor engagement (FOSS, 2019). These elements were incorporated into multiple investigations aligned with one (or several) of the NGSS, as indicated below.

Mixtures and Solutions Module. This module was comprised of five multi-part investigations designed around the central idea of exploring matter. The investigations were purportedly aligned to the standards 5-PS1-1, 5-PS1-2, 5-PS1-3, and 5-PS1-4. Due to time restrictions, the teacher was expected to cover three investigations within this module; thus, only addressing standards 5-PS1-1 and 5-PS2-2 (See Appendix J). Ms. Elizabeth focused on Investigation 2 of the module, entitled: *Developing Models,* teaching lessons from two of the three-part investigation. Part 1 of the investigation, entitled: *Black Boxes,* centered around the idea of developing models to describe particles too small to be seen with the naked eye (5-PS1-

1). Part 3 of the investigation, *Models for Change in Properties* was designed to engage students in measuring and graphing phase changes to show the law of conservation of matter (5-PS1-2).

Living Systems Module. This module consisted of four multi-part investigations. The overarching idea guiding the lessons within this module was exploring systems on both macro and micro scales. The module aligned with multiple standards from the physical, life, and earth sciences: 5-PS3-1, 5-LS-1-1, 5-LS2-1, 4-LS1-2, 5-ESS2-1 and 5-ESS2-2 (Appendix J). Ms. Elizabeth focused on Investigation 1 of the module, entitled *Systems*, teaching each lesson of the four-part investigation. The focus question initiating instruction within this unit is "How can you identify a system?" Although Ms. Elizabeth taught four lessons, part one will be the focus of the analysis, as instruction extended beyond the duration of this study.

Analysis of Curriculum Materials

Regarding the research question, although the curriculum materials provided instructional supports for the teacher, it failed to tend to students' multiple emergent identities. More specifically, the curriculum was scripted in ways which reinforced the value placed on students' academic identities. As written, the NGSS explicitly attend to issues of equity within science instruction. Because the FOSS teaching guides purportedly meet these demands through their alignment with the standards, it is critical to examine what is considered equitable science instruction per the curriculum materials.

Windschitl, Thompson, and Braaten (2018) offered what they referred to as the *Ambitious Science Teaching* (AST) framework to attend to issues of access and equity within science instruction. They presented four core instructional practices: "planning for engagement with big science ideas, eliciting students' ideas, supporting ongoing changes in students' thinking, and drawing together evidence-based explanations" (p. 4). These practices further consist of various research-based strategies designed to explicitly engage in equitable science instruction. In addressing equity, these scholars contend that merely providing all students with the same investigations is not enough; rather, teachers must "*provide[s] the means by which all groups of students can take advantage of situations that are designed to support learning*" (p.10).

In addition to the curriculum's emphasis on developing students' academic identities, the central ideas addressed through each investigation are fragmented and accompanied by instructional exemplars which are laden with cultural assumptions of students' experiences, ultimately preventing them from building ideas for conceptual understanding. In the sections that follow, I provide excerpts from the teaching guide as illustrations of the curriculum's attention to the students' developing identities.

Emphasis on academic identity. Although the Black Box lesson engaged students in the process of developing models, the overall investigation did not adequately create a space in which students could actively demonstrate their understanding of modeling, failing to adequately address the standard. The NGSS (NRC, 2012) classifies models into two categories: *mental models* and *conceptual models*. Mental models are defined as "internal, personal, idiosyncratic, incomplete, unstable, and essentially functional [with the] purpose of being a tool for thinking with, making predictions, and making meaning of experience" (p. 56). Contrarily, conceptual models "are explicit representations that are in some ways analogous to the phenomena they represent allow[ing] scientists and engineers to better visualize and understand a phenomenon under investigation or develop a possible solution to a design problem" (p. 56). When referring to *scientific modeling*, it is understood to mean conceptual models, as they represent the "external articulation of mental models" (NRC 2012, p. 56). Modeling is explicitly addressed as the focal scientific practice for the NGSS 5-PS1-1, the standard to the which the Black Box investigation is purportedly aligned.

According to the Science and Engineering Practice (SEP) of the standard, students “use models to represent events and design solutions” (NGSS, 2015). However, the leading focus question of the investigation assessed if students could recount the “steps” of creating a model, upholding traditional science instructional practices (Windschitl & Calabrese Barton, 2016), rather than using the model to represent and understand phenomena. For example, consider the focus question: “What is the process to develop a model of the black box?” (FOSS, 2015). According to the teaching guide, students who met the lesson objective could “incorporate the terms *analyze, collaboration, consensus, construct, model,* and *revise*” into their response to the focus question (p. 162). The teaching guide listed these terms in boldface and encouraged the teacher to review the process students should have followed to produce their black box models across multiple lessons.

This “process” was reminiscent of the scientific method, presenting science as an inauthentic linear process (Windschitl, Thompson, & Braaten, 2008) beginning with one step and concluding with the obtainment of the “correct” answer. This notion directly undercuts the intention of the standards as they aim to dismantle the practice of the scientific method through its incorporation of the SEP (NRC, 2012). The investigation itself failed to provide any phenomena for students to model. As such, the black box was not representative of any scientific phenomena and thus, students were engaging in constructing unexplanatory replicas rather than models.

In addition, the focus question guiding the investigation was closed-ended and low cognitive demand in nature (Windschitl, Thompson, & Braaten, 2018), privileging learning through repetition rather than allowing the teacher to teach and assess students' conceptual understandings of modeling. These types of questions fail to display student learning and stifle classroom discussions, preventing students from actively enacting their disciplinary identities as doers of science. Instead, they implicitly communicate one right answer to students and coupled with the procedural nature of the mastery indicator, explains why students positioned themselves as scientists whenever they followed instructions. Because students were not provided an opportunity to engage with models representative of scientific phenomena, they were subjected to instruction which elicited the rule-following academic identities espoused in their writing.

Further, the focus question provided no space for the displaying of diverse ideas and privileges one answer, resulting in a manifestation of inequity as evidenced by Nguyet's notebook entry (Figure 4). The assessment for the Black Box investigation argued that students have mastered the standard if they can accurately answer the focus question where they "Write something about each of the four processes in the description of how they developed their models: observing, constructing, analyzing, and revising." (p. 163). When examining Nguyet's notebook entry, she has effectively illustrated her ability to recount the process of developing a model through her underlining of the key processes, demonstrating an understanding of the focus question. However, because the box itself does not represent any scientific phenomena, we are unsure if she truly mastered the standard despite having met the lesson goals as communicated by the teacher's guide. In fact, when comparing Nguyet's response to the expected learning outcomes of the standard, which states that students who demonstrate mastery should be able to "develop a model to describe a phenomenon that includes the idea that matter is made of particles too small to be seen" (NGSS, 2015), her response does not align with the standard at all. As an EL, because she was not truly engaging in the SEP, Nguyet was not provided an opportunity to do science, limiting her language acquisition (Lee et al., 2019) and stifling her disciplinary identity. If left unchecked, this develops a false sense of content mastery for students, which can be as damaging as forgoing science instruction altogether.

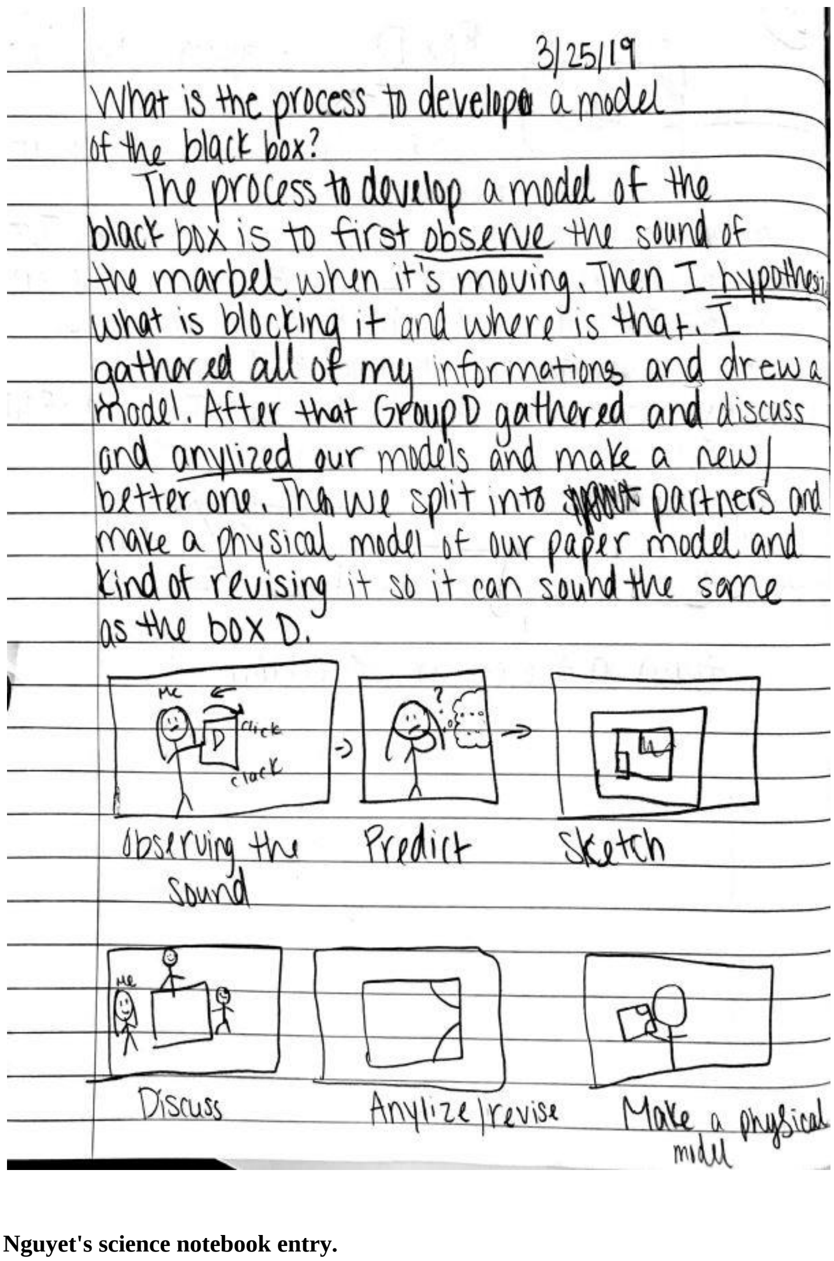
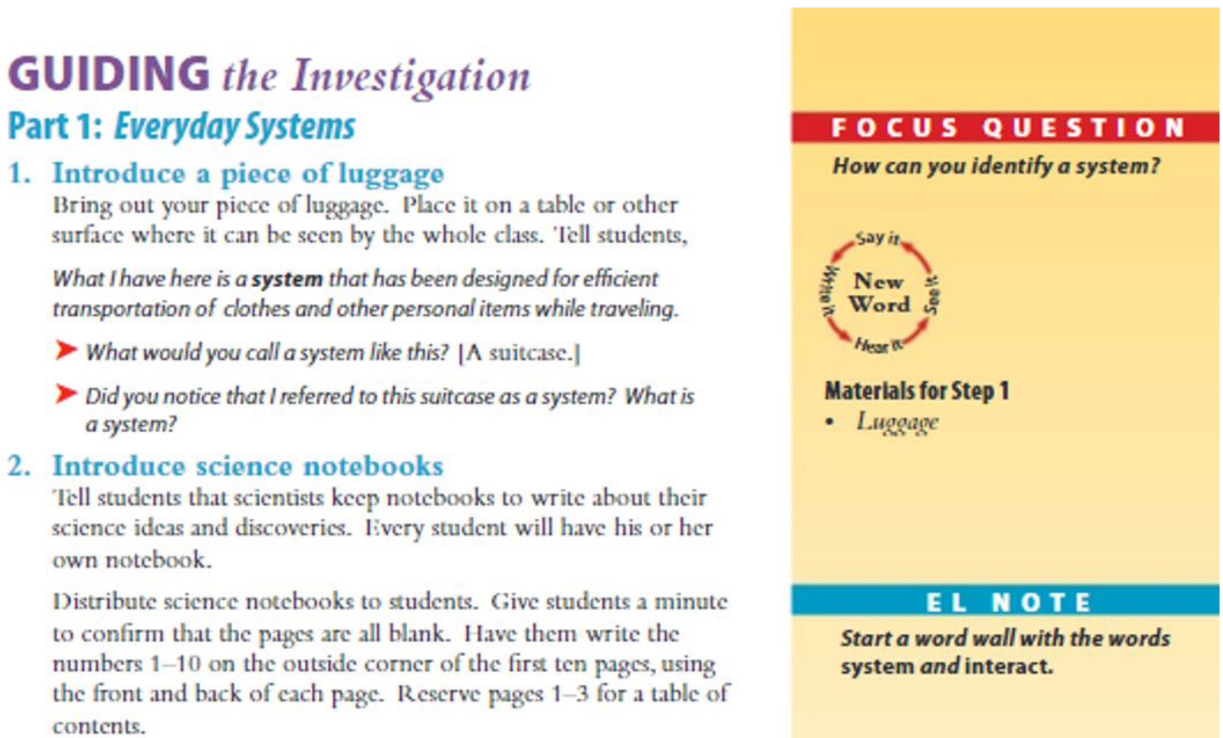


Figure 4: Nguyet's science notebook entry.

Assumptions of students' lived experiences. The design of the lessons implicitly upheld notions of students' lived experiences, that when unpacked, were quite problematic. For example, the introductory lesson for the Living Systems module instructed the teacher to provide a piece of luggage for the class to investigate as they begin learning about systems. The guide (Figure 5) instructs the teacher to read the following introductory script: “What I have here is a **system** that has been designed for efficient transportation of clothes and other personal items while traveling” (p. 93) which, generously speaking, arguably served as the *anchoring event* for the unit, although the example was not representative of any scientific phenomena (Windschitl, Thompson, & Braaten, 2018).



GUIDING *the Investigation*

Part 1: ***Everyday Systems***

1. Introduce a piece of luggage

Bring out your piece of luggage. Place it on a table or other surface where it can be seen by the whole class. Tell students,

What I have here is a ***system*** *that has been designed for efficient transportation of clothes and other personal items while traveling.*

- *What would you call a system like this?* [A suitcase.]
- *Did you notice that I referred to this suitcase as a system? What is a system?*

2. Introduce science notebooks

Tell students that scientists keep notebooks to write about their science ideas and discoveries. Every student will have his or her own notebook.

Distribute science notebooks to students. Give students a minute to confirm that the pages are all blank. Have them write the numbers 1–10 on the outside corner of the first ten pages, using the front and back of each page. Reserve pages 1–3 for a table of contents.

FOCUS QUESTION

How can you identify a system?

Materials for Step 1

- *Luggage*

EL NOTE

Start a word wall with the words **system** ***and*** **interact.**

Figure 5: Excerpt from teaching guide for Living Systems module for Investigation 1 part 1, entitled: “Everyday Systems.”

As designed, this activity assumes students understand what a system is within this context and are familiar enough with luggage to recognize it as such and have traveled beyond their communities requiring such an item. The possession of luggage has socioeconomic implications suggesting that students travel regularly, which can exacerbate gaps between the haves and have-nots within a classroom discussion. In addition, the school district is comprised of approximately 10% of students who were classified as homeless (State Department, 2017). As such, it is plausible that some students may associate luggage with traumatic experiences, effectively alienating them from instruction. Additionally, as illustrated in John's association of his Blackness with his socioeconomic status, race and class often intersect. Because of this assumption, it is clear that the modules, although purportedly aligned with the standards, were not developed to position students as viewing themselves within the curriculum, ignoring their racial and disciplinary identities.

The curriculum also ignores EL students, as it merely implies that by creating a "word wall" coupled with the strategies *say it, write it, hear it,* and *see it* (Figure 5), ELs will be able to access the curriculum. This type of instruction privileges the traditional register (Lee et al., 2019) by focusing on introducing ELs to key terms first before engaging them in the SEP, which were designed to "provide opportunities for purposeful language use" (p. 322). Given that the standards encourage teachers to view science learning as a cultural process incorporating students' funds of knowledge, (Calabrese Barton & Tan, 2008), this lesson's assumptions result in inequitable instruction, further perpetuating the cultural and historical marginalization experienced by students of color in science. While this is a critique of a specific example and its socioeconomic implications for students, I further argue there are ways for teachers to engage students in conceptualizing systems while prioritizing their funds of knowledge in culturally responsive transformative ways (Mutegi, 2011).

Fragmented lesson design. Rather than planning investigations that built upon one another, the lessons were designed to address a specific standard or portion of the standard without making connections to how the central ideas within the lesson aligned with ideas from other lessons. This was evident in the organization of the lessons within each module. For example, modeling, one of the central ideas of the Mixtures and Solutions module, cut across each of the three modules teachers were expected to cover throughout the year. According to one of the performance expectations for standard 5-PS1-1, *Matter and its Interactions,* which the Black Boxes investigation addresses, by the end of the unit, students will "develop a model to describe a phenomenon that includes the idea that matter is made of particles too small to be seen" (NGSS, 2015).

The Black Boxes investigation, however, explored the practice of constructing a model of an *object* rather than a *phenomenon*, never truly meeting the expectation of the standard. In fact, to constitute a model, the phenomenon under investigation must explicitly connect to the idea of particles, another shortcoming of the luggage example referenced in the teaching guide. While the matter which constitutes the luggage is made of particles, as would the materials that can go inside, realizing that all matter is made of particles is an *outcome* of the unit, not the starting point. As a result, teachers would need a phenomenon that engages students' wonderings about particles to drive this need for modeling.

Additionally, the entire Black Box investigation was originally part of an identical preexisting FOSS unit, entitled *Models and Designs,* dating back to 2005, which were originally marketed as being aligned with the National Science Education Standards, the standards which directly precede the NGSS. This likely explains why the content of the investigation has nothing to do with mixtures and solutions. Ms. Elizabeth, while recognizing the centrality of these big ideas (e.g. modeling), was unsure of how to best align them to maximize student learning. In the following excerpt, she reflected on the learning modules:

> Yeah, and that's one thing too that makes me think like of just about your example from Anna saying, "You know, I didn't understand what the lesson was." As teachers

> nowadays, we say like "Oh, we have to do the teaching point" instead of them [students] sort of discovering what it [the phenomena] is about, which I try to do a little more in math, but maybe next year I need to make it a little more explicit on what a model is. It also is a little confusing probably to them that we did the Earth Systems [module] first. Yeah…because I'm even thinking—modeling is a super hard concept to understand, but we did Earth Systems first, which is all about modeling (Interview 1, 3/21/2019).

Despite engaging in lessons unrelated to the learning standard, there were students who managed to generate models to describe the phenomena of the performance expectation, namely representing the "idea that matter is made of particles too small to be seen" (5-PS1-1) through their explanations of the differences between dissolving and melting. Two students, Blue and Rebecca, incorporated similar diagrams in their notebooks to represent the same phenomena, indicating a mastery of the standard despite the curriculum's failed instructional attempts.

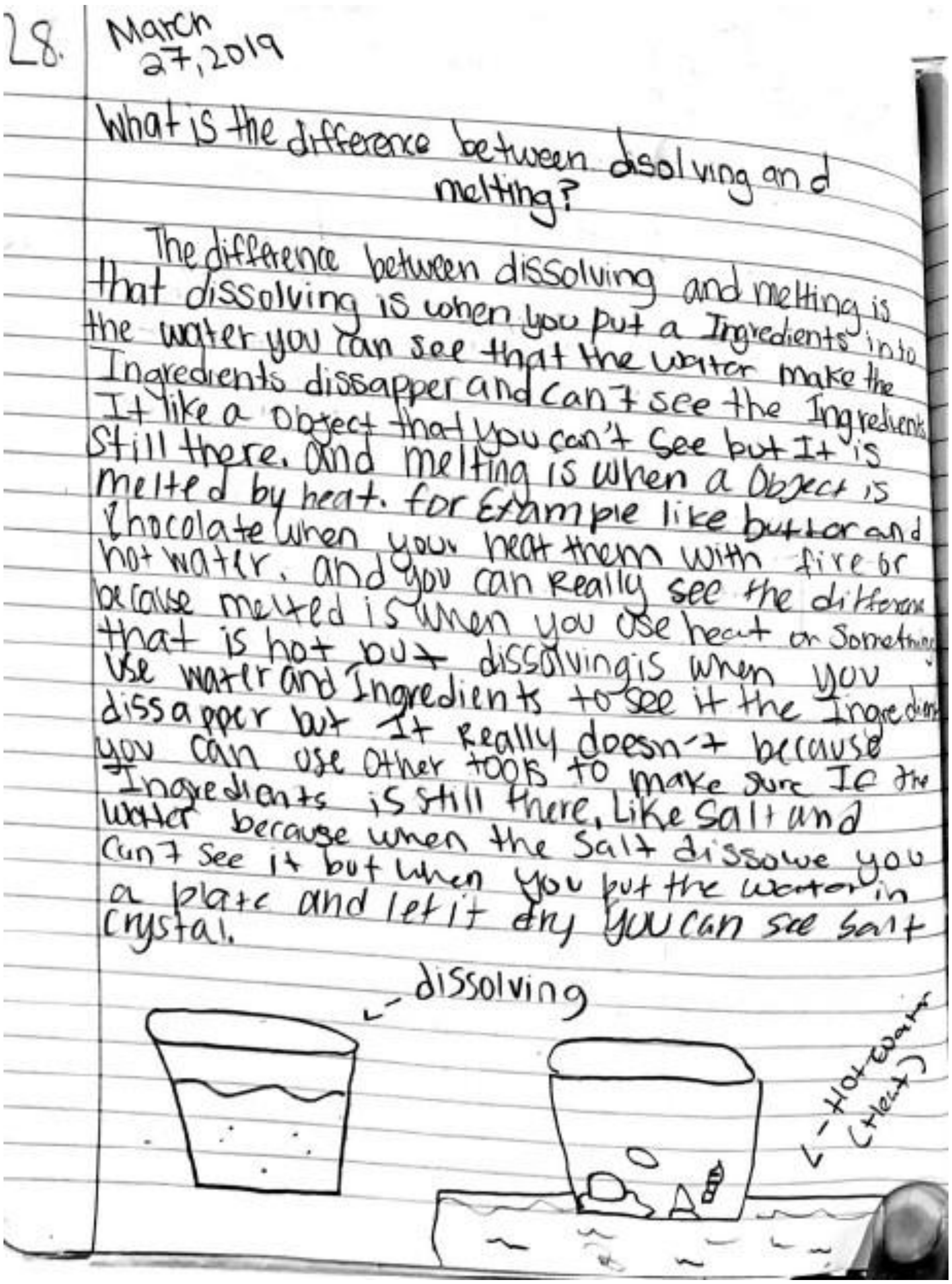


Figure 6: Rebecca's notebook entry for Mixtures and Solution investigation, 3/27/2019.

In her articulation of the difference between dissolving and melting, Rebecca (Figure 6), asserted that dissolving is "when you put a [*sic*] ingredients into the water you can see that the water make the ingredients disappear and can't see the ingredients. It's [*sic*] like a [*sic*] object that you can't see but it is still there" (p. 28). Blue (Figure 7) echoed Rebecca's argument regarding disappearing substances but added: "but when you let it dry use [*sic*] the [*sic*] microscope you can see it." Both diagrams show matter being dissolved (represented by dots) into a solvent, and although it is no longer visible to the naked eye, the solute is still present, meeting the performance indicator of the standard.

One of the lessons of the preceding investigation, entitled "Separating Mixtures," introduced students to the law of conservation of mass through investigating where salt goes when it dissolves in water. After observing the individual behaviors of salt and water, they combine the two substances and generate predictions of what happens to the salt after it has dissolved in water. Students typically develop particle models which consist of drawings of water with dots to represent the salt dissolved within the solution. While this occurs in the first investigation, the subsequent Black Box investigation does not reference this knowledge, illustrating the discrepancy between the implicit deficit-oriented assumptions of student knowledge embedded within the curriculum and students' complex understandings of phenomena. Stated differently, the curriculum is developed in accordance with the hegemonic structures of what elementary students are "incapable of." As such, they develop rather rudimentary lessons which fail to connect to the complex phenomena they were designed to address. However, in this case, both Rebecca and Blue utilized their understandings of modeling to assert their disciplinary identities despite the curriculum's tradition of privileging students' academic identities in deficit-oriented ways.

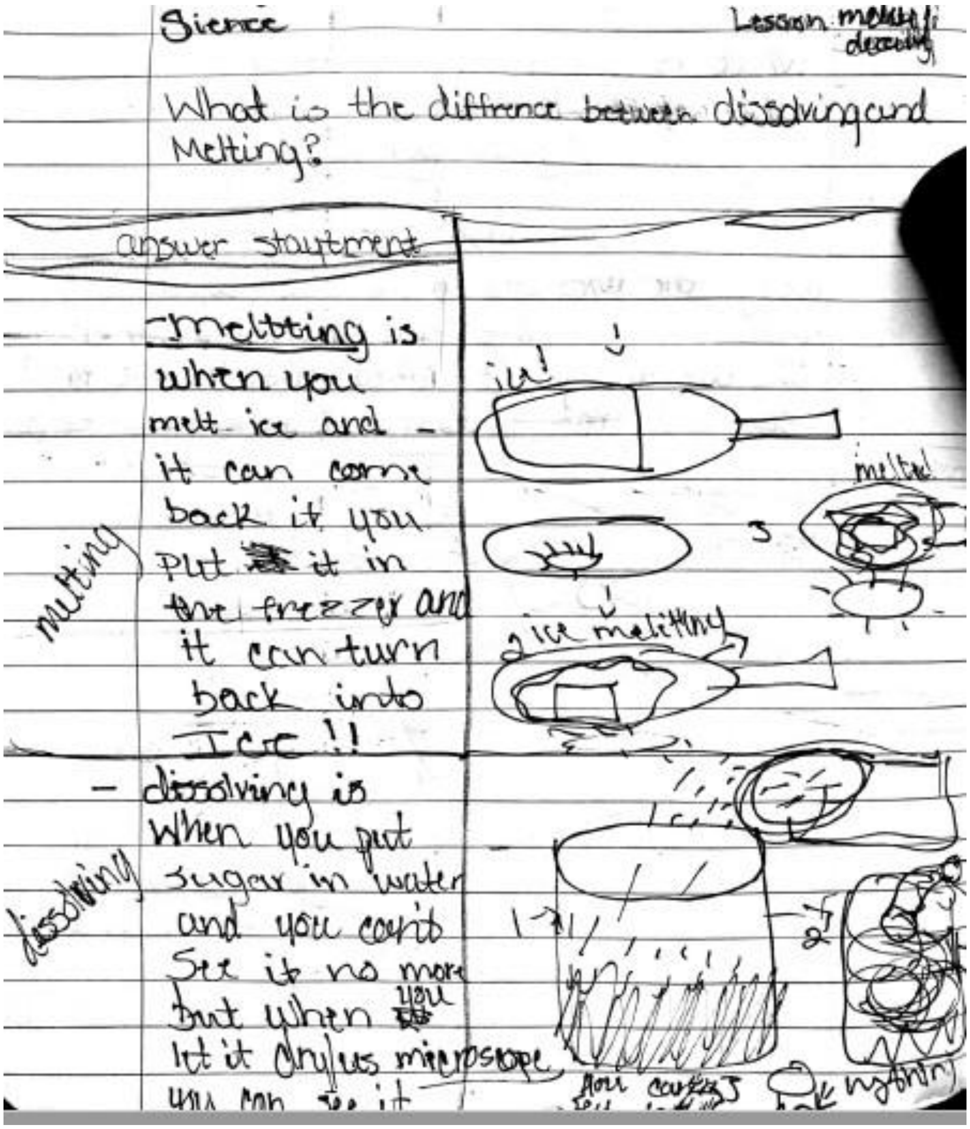


Figure 7: Blue's notebook entry for the Mixtures and Solution investigation 3/27/2019.

In their purported alignment with the NGSS and its attention to equity, there were selected investigations for students to engage with one another through classroom talk. These engagements typically resulted in the establishment of talk parameters as evidenced in the Living Systems module. For example, in the first investigation after students have discussed the systematic components of the luggage example, they were presented with another challenge. According to the teaching guide (Figure 5), the teacher was directed to "Ask students to call to mind a railroad. Tell them, *'A railroad is a transportation system. Railroad systems transport* *people and heavy market products.*"'Aside from the underlying assumptions (e.g. recognizing railroads as a form of transportation) made of students in this example, the students were instructed to consider the parts of the railroad that constitute a system. This narrow example and the established parameters may not be accessible for all students, limiting who can participate in the discussion, another illustration of instructional inequity.

Teacher Positionality

Background of Ms. Elizabeth

Ms. Elizabeth was considered a veteran teacher who had been teaching for six years, four of which were at Central Elementary. During her time at Central, she has exclusively taught fifth-grade mathematics. In fact, in one of our conversations, she mentioned that she was hired to do such. She identified herself as a White female who grew up in a rural area in the northeastern US and attended graduate school in a large city. She was considered the math leader within the building, and frequently devoted her planning time to supporting other colleagues' mathematics instruction across grade levels. As such, she was also positioned by her department colleagues as a leader who took pride in the continual improvement of her mathematics pedagogical practices.

Describing her teaching philosophy as "having kids own their learning [through] trying to create experiences that are truly enriching for them" (Interview 1, 3/22/2019), Ms. Elizabeth centered her math instruction around providing multiple opportunities for students to engage with one another through dialogue. She encouraged participation from all students through discourse strategies along with small group instruction. She also believed in setting high expectations of her students (e.g. explaining their thinking through writing and classroom discussions, utilization of subject-related vocabulary) as "they will rise to meet it [high standards].” (Interview 1, 3/22/2019). This positioning of students arguably broaches the provision of equitable instruction, as Ms. Elizabeth credited small group instruction and questioning as ways she attended to the individual needs of her students. As an illustration of this equitable practice, she claimed:

> You know, they do this big thing in the District, where the push is like personalized learning, and too many people—I look at personalized learning as more of a philosophy that where just because I’m not teaching them something different in my group, doesn’t mean that it’s not personalized. Like, you can see that what I teach one group, I teach the other group based on what they need—the types of questions I ask… so to me as a teacher, it’s important for me to understand the content of the math well enough for me to be able to adjust my questions to meet their needs (Interview 1, 3/22/2019).

Although Elizabeth developed equitable mathematics instructional practices, she admittedly struggled to integrate those practices into her science instruction. However, throughout the duration of the study, her science teaching identity shifted from one who was visibly uncomfortable teaching the content, to one of growth, where she developed a more critical lens of the curriculum, often deviating from the prescribed lessons to better meet the instructional needs of her students.

Elizabeth’s Initial Science Teaching Identity

At the beginning of the study, Elizabeth positioned herself as one who was semi-comfortable teaching science, stating that “I would say [regarding comfort teaching science] I’m like a 5 or 6 [out of 10]” (Interview 1, 3/21/2019). Originally hired as a mathematics teacher, Elizabeth attributed this discomfort with teaching science to her content knowledge, teaching science on an “as-needed” basis. As such, she seemingly relied on the FOSS teacher guide as a teaching script with little deviation from the prescribed lessons. She openly acknowledged the sparse science professional development opportunities offered by the school and district, further contributing to her perceived low content knowledge. During initial weeks of the study, Elizabeth would sometimes ask if I were recording her instruction for the day, becoming visibly relieved if my response was “no”. As the researcher, it seemed as though students’ access to science instruction was contingent upon my presence, which slowly began changing throughout my time in the school.

Elizabeth openly expressed her discomfort with teaching science, as was evident in her lesson observations. As expected, this discomfort was shared by her colleagues, yet because she taught science the previous school year, Elizabeth was also positioned by her colleagues as an instructional leader in science. Despite this positioning, her discomfort with science content manifested as a reliance on the curriculum materials akin to the way an inexperienced cook follows a recipe. For example, during the Black Box lesson introduction, she frequently referred to the teaching guide to ensure that she was mentioning the boldface key terms. In this lesson, she stood at the front of the room with the guide positioned on an adjacent desk for ease of access. She began the lesson by stating, “What we’re going to actually create today is called a physical model. Everyone say, *‘physical model.’*” After students repeated the phrase, she looked down at the teaching guide as if searching for affirmation, looked up and continued, “And you can analyze and evaluate the behavior of this model. Now a physical model means something that you can actually touch and work with.” She projected a slideshow with the key terms for the students’ reference as she lectured. “Now what you all have done so far…this investigation has been a process. What do I mean when I say *process*?”

Through her constant referencing of the teaching guide, emphasis on vocabulary and talking points, Elizabeth illustrated her unwillingness to deviate from the prescribed guide. Given the aforementioned analysis of the inequities perpetuated within the curriculum, this demonstrates a need for increased content learning opportunities for teachers. As she repeated the misinformed interpretation of modeling, she effectively believed she was meeting the central idea of the standard, which required students to "develop a model to describe that matter is made of particles too small to be seen" (NGSS, 2015).

In addition to her utilization of the teaching guide, Elizabeth would oftentimes reflect on lessons in which she implicitly sought my approval of her instruction. There were several instances during the lessons where she would make anecdotal statements such as, "Do you think that was ok? I'm not sure if I said the right thing." These moments usually occurred as Elizabeth negotiated the juxtaposition of her students' ideas with the lesson objectives espoused in the teaching guide. She relied on the bolded words within the guide to know what to emphasize, as she did not yet have sufficient command of the material to know that "physical model" was not representative of a key scientific construct. However, her reflections in which she began questioning the teaching guide were significant because they began to mark a shift in her science teaching identity as these uncertainties represented deviations from the teaching guide.

For example, approximately one month after I began supporting her instruction, Elizabeth began teaching investigations from the third and final module of the year, entitled, *Living Systems*. In this investigation, students were working with cards which contained the names and descriptions of organisms living in the woodland ecosystem. The goal of the lesson was to have students recognize the relationships between the various organisms within the system to ultimately "develop a model to describe the movement of matter among plants, animals, decomposers, and the environment" (NGSS, 2015). The teaching guide instructed the teacher to have students study and arrange the cards based on feeding pairs. However, Elizabeth deviated from the guide and instructed students to come up their own classification scheme for the ecosystem cards. After sorting their cards, students participated in a *gallery walk*, where they walked around the classroom to observe other groups' classifications, noting similarities and differences. Elizabeth's rationale for this instructional choice was guided by her desire to see if students would independently sort the cards based on feeding relationships without prompting.

After visiting various groups' work, students were redirected to their seats for a whole-class discussion in which they discussed their rationales for the card arrangements. This deviation proved fruitful, as it resulted in multiple interpretations of arrangements for the cards which generated a lively discussion amongst the students. One group stated that they sorted the cards based on the ecosystems' food chain, which was the purpose of the lesson (see Figure 8). However, other groups sorted the cards by classifying organisms into *producers, consumers,* and *decomposers*. As the students discussed their ideas, Elizabeth wrote the three classifications on the whiteboard and generated a list of differences between the three groups. During the discussion, students were presented with a card representing the dead plants and animals of the ecosystem that sparked a debate amongst the class. Elizabeth then posed the question to the class, "Where do you think the dead plants and animals should go? Turn and talk." As students were discussing where they believed the card should go, Elizabeth walked to me and stated, "What do you think I need to do? I wasn't sure about where to go with them." I informed her of my observations based on students' thinking expressed during the gallery walk and she began moving the discussion to an introduction of predator prey relationships. This uncertainty illustrates the initiation of an emergent science teaching identity rooted in student understanding rather than scripted instruction, which privileged students' ideas by allowing them to wrestle with ways to represent complex relationships through modeling.

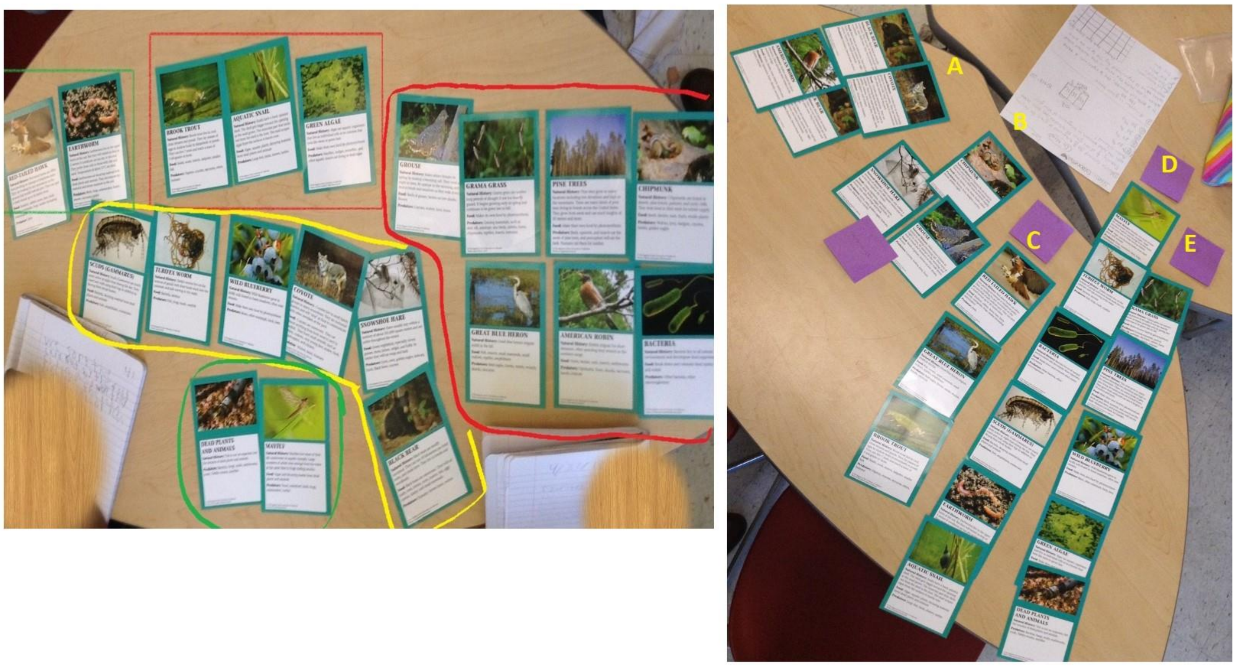


Figure 8: Living systems gallery walk. Left: food chain sorting. Right: Producer, consumer, decomposer sorting.

Emergent Science Teaching Identity

Overall, through supported instruction, Elizabeth developed a sense of agency within her science teaching identity. While initially hesitant about teaching science, this agency manifested as her capacity to develop a critical lens of the curriculum, make connections between its alignment to the standards, and how to deviate from the prescribed lessons to better meet her students' instructional needs. Despite her initial discomfort, she developed an emergent science teaching identity which allowed her to reflect on her teaching practices in ways that centered student knowledge rather than solely relying on the curriculum guide. Further, she began developing an interdisciplinary lens where she imagined incorporating the central ideas espoused within her science instruction across other subject areas. In the following excerpt, she detailed this identity shift.

> I think it's [my science teaching] changed quite a bit. Like I really enjoy (laughs) teaching science. You know, I thought because I did it every day, I thought there were several benefits. 1.The kids were highly engaged. They liked having the hands-on experience from the Earth Systems [FOSS module] especially. Everything was hands-on…and I think that they got much more from it. 2. Because of the way we did science notebooking, it was much more beneficial for me. I know what I want to change for next year, but they really did a lot of writing and so it was nice to actually incorporate science into writing. So just seeing how you could kind of make it a little more interdisciplinary and I think as a teacher, it was nice having you [Mr. B.] in the room because we could bounce ideas off—and it's great to teach it twice because after the first one, I got a lot more ideas and FOSS is such a great resource, but after teaching it once, you can think, "Oh, my kids need this thing, and this is what I need to add in." or "How do we give them the words and things that they need?" Because even with the last lesson, I already had them read about photosynthesis, but how many of them actually connected that to what we just saw? I don't think it happened, so this week, I would like to do something else with photosynthesis, like how do we connect what we just saw into that reading? (Interview 2, 6/17/2019).

This reflective exchange illustrates several important trends in Elizabeth's emergent science teaching identity. Because of her repeated instruction and support, Elizabeth developed an identity which allowed her to incorporate science within her writing instruction, critique curriculum materials by identifying misalignments between the instructional goal(s) and the central ideas espoused within the standard, and how to deviate from the instructional guide based on student knowledge. As a result of this emergent identity, Elizabeth gained a sense of agency within her science instruction and felt empowered to teach science daily rather than along the margins of her math instruction. In the sections to follow, I provide brief examples of Elizabeth's emergent identity enactments.

Critique of curriculum materials. Because of her expertise in her mathematics instruction, Elizabeth was especially mindful of how to utilize student thinking to inform her instructional practices. However, in one conversation, she expressed this perceived strength within her mathematics instruction as being a shortcoming in her science instruction as described in the following reflection:

> But, FOSS…I don't know if you've noticed this, but there's never really a time to assess what they've [students] learned until they answer the question in their notebook at the end [of the investigation]. …I often walk around with a clipboard in math, like with a list of possible misconceptions [students may have] or questions to assess [their thinking]. Like what they say and then what I'm gonna say back to them…I don't really have that for science. And like I said there [in the video], that was a misconception that I didn't even think about and so that's why I ended the conversation with them because I personally needed to think about it. I knew I needed to address it and I would come back later. And so FOSS doesn't really have what misconceptions kids are gonna have, and so I think that would be an important place that maybe they go (Interview 2, 6/17/2019).

Elizabeth's critique of FOSS' lack of accounting for students' possible alternative understandings begins to address a larger issue: a clear misalignment between the curriculum materials and the standards. Although the curriculum lists the standards the lessons address, the teacher recognized the curriculum's failure to fully address the central ideas of the standard. In addition, she acknowledged how critical centering student thinking was to the progression of their science understandings, which for Elizabeth, became more apparent after developing a more critical lens of the curriculum materials. I offer the following excerpt to illustrate this point.

> So like yesterday, that was easy for me to think of what question I would ask. For me, thinking like: "Ok, if the big idea is modeling, then they're all trying to agree, but they all have different pictures [of the black box model]." Asking a question to come together—like I can adjust that way on concepts such as that, but I guess scientifically, if a kid's not understanding the difference between evaporation and dissolving, and they didn't get it after all the experiments and reading that we've done, I guess I probably wouldn't know what to do next or adjust for that big scientific concept. Because to me, that would be like, "Ok, do I need to do another experiment, do we need to do another reading?", but if—would another reading even help, you know? (Interview 1, 3/22/2019).

Because the central idea of the standard Elizabeth was referring to requires a conceptual understanding of matter, it is clear that although she has done the work of understanding how to refine her instructional practices, she needs additional support in developing a stronger command of the content, which would allow her to further enact practices to better support students' conceptual understandings. The curriculum provides an overview of these ideas, but because of the misalignment with the standards, this overview will not adequately provide sufficient understanding to impact one's teaching.

Interdisciplinary teaching. Elizabeth's emergent science teaching identity encouraged her to incorporate science across multiple disciplines, namely writing. For example, shortly after one of the Living Systems lessons in which students explored how organisms within an ecosystem interacted with one another through feeding interactions, Elizabeth developed a writing lesson incorporating a pop culture-related science article. In anticipation of the last installment of the Marvel's *Avengers* movie franchise, Elizabeth planned a writing lesson centering an article entitled: *The "Endgame" with Thanos' snap: How would Earth fare in the aftermath?*

In the penultimate movie of the franchise, Thanos, the villain, gathers a series of six *infinity stones*, which once all have been collected, gives the holder unimaginable powers (e.g. space control, mind control, matter manipulation, time manipulation, capturing and controlling the souls of others, and invincibility). Once Thanos has gathered all six stones, he combines the stones on a gold, embellished gauntlet—the infinity gauntlet—and snaps his fingers. This finger snap effectively terminates half of all life in the universe.

Because many of the students were aware of the plot of the movie, Elizabeth used this article as an opportunity to connect with students' knowledge in a way that would allow them to apply their understandings of interactions within ecosystems to the central idea of the article. The article provided students with additional scientific background and possible explanations for the implications of Thanos' actions for all life. Elizabeth participated in a read aloud of the article with the class where they concluded with a class discussion and writing task of imagining how Thanos' snap would affect ecosystems given their understandings of how organisms interacted within terrestrial and aquatic ecosystems.

The planning of this writing lesson further illustrated Elizabeth's agency through her emergent science teaching identity. Her selection of the article required a general understanding of the content such that she could make connections between what students learned in class and the scientific explanations provided within the article. Although writing was scheduled as the first class of the day while science was scheduled last, Elizabeth recognized the significance of how students were directly applying their conceptual understandings to a different subject area, which bolstered her overall science instruction. Eventually, Elizabeth began sporadically teaching two science lessons per day to her class or adjusted the schedule to teach science at the beginning of the school day, further indicating her identity shift.

Attention to Students' Multiple Identities

Overall, Elizabeth's teaching practices and emergent science identity created a space where students' academic and disciplinary identities were acknowledged; however, like the curriculum, their racial identities were largely ignored. For Elizabeth, she recognized the significance of her racial identity (as a White female), but also attributed this racial identity to her lack of attention to students' racial identities. I provide an excerpt from one of our conversations to illustrate this claim.

> *Mr. B.*: And what about—one of the things that I've also thought about in being here is in thinking about the school motto___. In particular, how does the school recognize students' individual differences in ways that allow them to talk about those differences? Does the administration or district provide support for teachers to have these conversations with students?
>
> *Elizabeth*: There are…yeah, so we're doing a new—so for the past few years, we've really engaged in morning meetings around thoughts and feelings and we have had training on how to go about race…big ideas. Um there's girls that I went to grad school with, real big social justice people, and they do a ton of work around that in their morning meetings. I also think it's comfortability, like how comfortable you are bringing up those issues, especially when you yourself are the minority in the group. So when you are the White person bringing around the race issue, there is a lot of dynamics to consider because as we've talked about before, it's not even about you know, Black, White, and

Asian; it's about how people within the Black community are viewing people from Africa, for example. There's just a lot of dynamics, and so I think the District has done some work around that. I know as a school, we're doing this positivity project next year, so I don't know if there will be some [projects] around race. I know my colleague broaches the subject, um we've had some discussions, but not like really the in-depth [discussions]. But I think…I think the District does support it, obviously, but there could be more training around it. I think specifically on how to do it.

Mr. B.: So for you, what would it take for you to feel more comfortable or to increase the level of comfortability [with having conversations around race]?

Elizabeth: I just have to do it more, I think. I also think it's a conversation that happens later in the school year. Like it can't happen first off. Like you have to know your class. You have to know…I also think I would need someone with me at first, because when John brings up, "That's racist…" I had a student say that to me the other day, they were like "Ms. Elizabeth, do you trust me?" And it was a kid not even in my class. I was like "Well, I don't know if I trust you." and he replied "It's because I'm a boy, right? That's sexist." And I'm like, "What are you talking about?" So, having conversations when you have 30 kids in the classroom around that can be very daunting. And so, I would need I think, some more one-on-one support (Interview 2, 6/20/2019).

Elizabeth's discomfort with engaging in conversations with her students around race likely influenced their color-evasive perspectives, as students' differences were never acknowledged despite the school's emphasis on individuality. This also means that if race cannot be recognized, it removes students' option to use it as a tool to explain their experiences and to call out injustices. Although in previous conversations she mentioned her willingness to dialogue with colleagues who may espouse racist or otherwise problematic ideas, she did not share this same sentiment regarding her students, indicating a need for further development.

CHAPTER 5—Discussion and Conclusions

Discussion of Findings

Varelas, Martin, and Kane (2012) presented the CLIC framework to understand how the racial, disciplinary, and academic identity constructions (IC) of Black children interact with one another in the classroom as they learn science content (CL). Their proposed schematic (Figure 1) illustrated possible iterations of intersections of these various identities, while providing conditions under which these iterations may manifest. These scholars also provided prompts for classroom teachers to incorporate into their instructional practices intended to allow students a space where they can both reflect on and celebrate their emergent identities (identities-in-narratives). Although useful, these scholars further called for the need to understand how the performances of these identities take shape within the science classroom (identities-in-practice). The framework allows for researchers to “identify the complex ways in which these constructs interact with the three dimensions of IC and CL for African American students” (p.332). While instrumental in recognizing the need for the acknowledgement of these identities, unpacking the three-dimensionality of these identities for elementary students is quite complex, and seems to be greatly influenced by systematic representations of schooling and achievement.

Regarding the initial research question of how students of color construct their science identities in classroom spaces, their academic identity eclipses their disciplinary identity, operating separately from their racial identity. To better understand this claim and contribute to the scholars’ recommendations, I present a complimentary schematic (Figure 9) illustrating these occurrences.

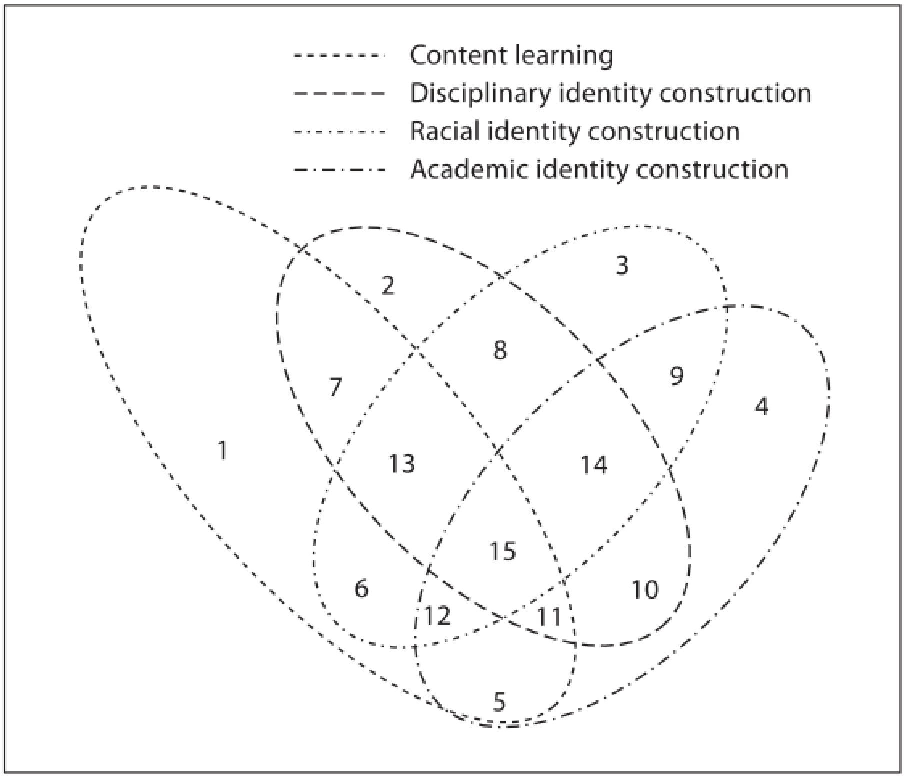


Figure 1: CLIC framework conceptual model. From Varelas, Martin, & Kane (2012)

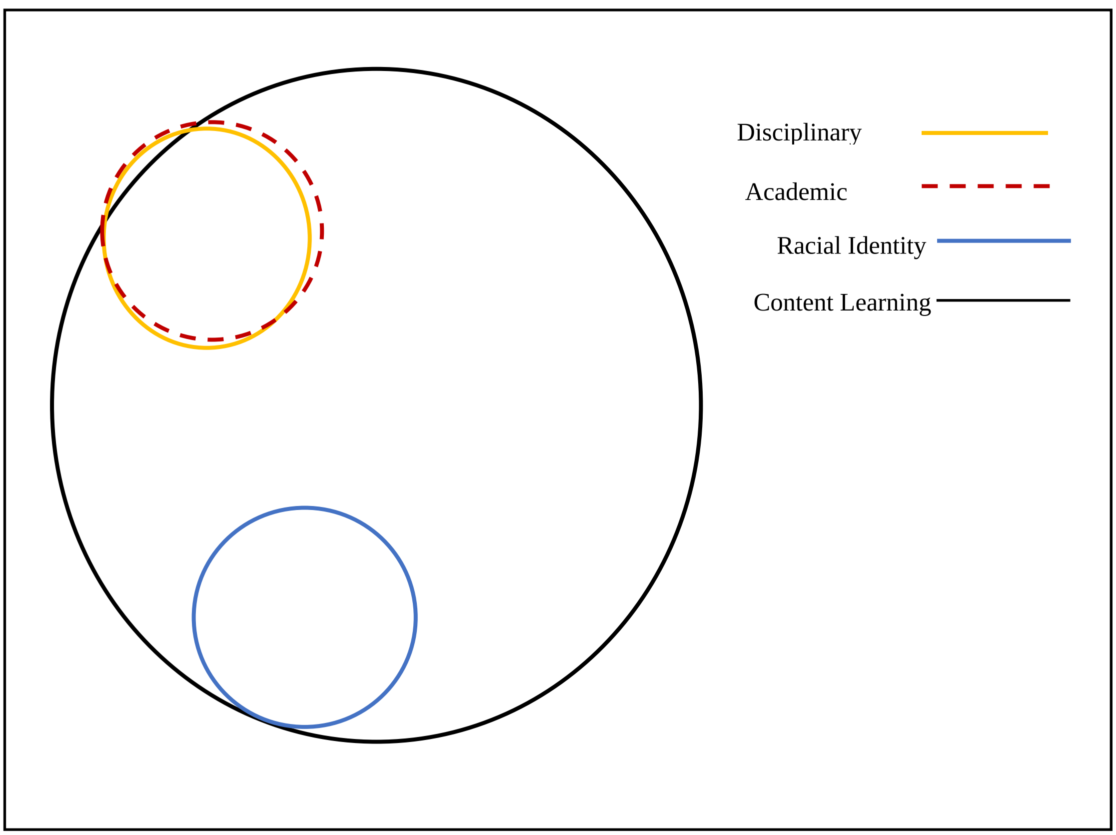


Figure 9: Proposed supplemental identities-in-practice schematic.

Influence of School Rules

The largest circle represents a student's science (content) learning, which as depicted in this figure, is the macro-level identity operating within the bounds of the daily classroom instruction and is influenced by the curriculum and teacher. Simultaneously, a students' contributing identity micro-level constructions are functioning within this larger identity. The data suggests that these elementary students of color's academic identities, as represented by the dashed circle in Figure 9, eclipsed their disciplinary identities (the yellow circle), where the two operate in tandem with one another. These identities are fluid, and in the elementary grades, appear largely influenced by authority figures.

However, given the significance of the development of one's identity during these critical years, one may deduce that students of color are socialized for compliancy rather than to engage in the student-centered learning experiences which would build on their funds of knowledge. In his seminal 2015 piece, *Between the World and Me*, scholar Ta-Nehisi Coates provided a clear example of the intersection of race (in this case Blackness) and schooling. In his argument of the role of schooling, he claimed:

> To be educated in my Baltimore mostly meant always packing an extra number 2 pencil and working quietly. Educated children walked in single file on the right side of the hallway, raised their hands to use the lavatory, and carried the lavatory pass when en route. Educated children never offered excuses—certainly not childhood itself. The world had no time for the childhoods of black boys and girls. How could the schools? Algebra, Biology, and English were not subjects so much as opportunities to better discipline the body, to practice writing between the lines, copying the directions legibly, memorizing theorems extracted from the world they were created to represent (pp. 25-26).

Rather than consider themselves scientists whenever they were practicing science, students used phrases such as, “because I raised my hands” or “I respected the teacher and did what she told me to do,” which are steeped in the academic identity of what constitutes a being a good student. Although tethered to their academic identity, several students utilized the agency afforded them vis-à-vis their disciplinary identities to reposition their designated academic identities. In other words, students who were designated as “difficult” students by their teacher or building staff used the science lessons to illustrate their science knowledge despite their perceived negative behaviors. For Seth, this meant taking on a leadership role during group assignments, sometimes without input from his groupmates. John, much like Seth, was a vocal participant in class discussions, but he oftentimes eschewed the discourse rules which, by design, provided him access to learning.

The Role of Race

The color-evasive rhetoric espoused by students, coupled with their acknowledgements of the intersection of race and societal expectations, indicates that these students’ racial identities functioned separately from their academic and disciplinary identities. Because students are socialized within the dominant (White) culture at early ages where they accept prevailing racial stereotypes, (Tatum, 1997/2017) this is not surprising. For example, Anna recognized the lack of representation of people of color throughout her science textbooks and defined her Blackness as “being a disadvantage,” illustrated in the following excerpt:

> *Anna*: [Regarding her Blackness] I don’t really—nothing really. Just skin color. It’s a tiny bit of a disadvantage, but that’s it.
>
> *Mr. B.*: And can you say more about that?

Anna: Like some people judge you because of that [skin color]. And say you can't do other stuff (Interview 2, 5/28/2019).

While this assertion was steeped in implicit stereotypical influences, Anna, like many of her peers, invariably designated themselves as scientists, but not scientists of color, meaning that their racial identities, while visible, were not yet salient identities in the classroom space. Within this science classroom, there were multiple opportunities for the teacher to honor her students' racial identities and their funds of knowledge. However, as evidenced by Elizabeth's own accounts, these instances were actively ignored, perpetuating the learning injustices the science standards sought to address. As a result, this notion that anyone can become a scientist despite the historical privileging of the White middle-class male's identity, indicates that elementary students of color are adopting ideals of a meritocratic society, one in which all individuals succeed based on their merits.

According to Godfrey et al. (2019), these ideals are best explained by Jost and Banaji's (1994) *system-justification theory*. This theory built upon previous psychological theories, namely group-justification and ego-justification theories, and is defined as "the psychological process whereby an individual perceives, understands, and explains an existing situation or arrangement with the result that the situation or arrangement is maintained" (p. 10). The maintenance of the existing situation(s) is "preserved in spite of the obvious psychological and material harm they entail for disadvantaged individuals and groups" (p. 10). To illustrate the enactment of system-justification theory, I provide the following excerpt of a conversation with Rebecca:

Mr. B.: Do you know any scientists that look like you?

Rebecca: Nope.

Mr. B.: Do you think it's a problem that you don't see any scientists that look like you [in pictures]?

Rebecca: No.

Mr. B.: Why not?

Rebecca: Because everyone can be a scientist. It doesn't matter what you look like. (Interview 1, 3/26/2019).

Although Rebecca acknowledged the lack of individuals of color within the standard stock images of scientists (the system), she maintained this implicit marginalization through her assertion that "it doesn't matter what you look like." When understanding the significance of these systemic issues, it is important to note that the implicit rules students like Rebecca adhered to were established by, and much to the benefit of, individuals in power (Lipsitz, 2019; Tatum, 2017). As a result, these rules likely predict negative behavioral responses for these students as they enter middle and high schools.

The findings of Godfrey et al.'s (2019) work suggested that sixth-grade students of color espoused system-justifying beliefs (e.g. meritocracy) which fostered their success throughout sixth grade; however, these same beliefs led to the manifestation of what they considered deviant behaviors (e.g. skipping class/school, fighting, etc.) across seventh and eighth grade. These authors further suggested that these behavioral changes where students actively rejected the system were likely due to the salient emergence of their racial identities, where these identities were reflected back due to environmental changes (Tatum, 1997/2017).

These environmental changes are not explicitly accounted for in the CLIC framework, as the framework assumes students' racial identities are acknowledged and affirmed within the classroom. However, as illustrated by Elizabeth's self-described discomfort dialoguing with her students about race, we see this is not the case. Consequently, systems of power are upheld, and according to Diangelo (2018), perpetuate a cultural domination in which the identity in power (White) sets the parameters for when and how other racial identities are acknowledged and how they are "allowed" to be enacted publicly, subsequently benefitting Whites (Lipsitz, 2019).

Fluid Identities

A critical shortcoming of the racial identity paradigm is revealed by the lack of a concrete framework designed to articulate how one comes to narrate and practice their racial identities. Students positioned their racial identities as irrelevant to their science identities and similarly separated other identities (e.g. gender), indicating that students have not yet come to view these identities from an intersectional perspective (Crenshaw, 1989), represented in Figure 9 by the designated identity circle attaching to, but not intersecting with, one's content learning. Thus, racial identity merely functions within the larger identity, and is not yet salient for preadolescent students. Although this identity has yet to become salient for students, the fluidity of these domains suggests a likelihood for one's racial identity to become more prominent throughout their educational trajectories, specifically when confronted with instances which activate these identities.

To illustrate the fluidity of one's racial identity, I return to Jackson's (2012) BID framework. As a reminder, his framework underscores the influential nature of Black culture on each state of Black identity development: *naïve*, *acceptance*, *resistance*, *redefinition*, and *internalization*. Although this framework was reviewed in Chapter 2, it is important to re-present the framework here to contextualize the fluidity of one's identity enactments.

<u>Descriptions of each stage</u>

- *Naïve:* children (ages 0-3) who have no notion of race. This stage marks a point where children may begin to recognize racial differences between individuals but largely rely on external factors to influence their positive or negative associations with said differences.
- *Acceptance:* person begins associating Blackness with societal (stereotypical) representations, which are usually negative. Young people (teenage to early 20s) have a difficult time navigating racism as they decipher their role in challenging these notions, which typically results in one's desire to gain acceptance by the dominant (White) identity. This is a time when acceptance of Black culture is beneficial in fostering a positive Black identity.
- *Resistance:* Individual begins to understand the systemic nature of racism and resents elements of Whiteness and other Black individuals in the acceptance stage. This stage is highly emotional, with Black individuals electing to either: fully embrace the resistance phase where they understand the risks of losing the benefits experienced during Acceptance, or passive resistance where they aim to "stay in favor of White society while rejecting racism" (p. 44).
- *Redefinition:* Individual develops and refines their Black identity for personal edification without concern for how it is interpreted through Whiteness. Actively seeks other Black individuals in redefinition.

- *Internalization:* This phase marks the period where an individual focuses on "nurturing their Blackness." Individuals in this phase are not inclined to "explain, defend, or protect their Black identity" (p. 45).

Although Jackson lists five stages, it is important to emphasize that the framework is not intended to suggest linearity of all Black-identifying individuals' racial identity constructions. It also does not suggest individuals will fully advance through each stage nor at the same rate. Rather, this highlights the role of external influences on one's racial identity constructions. While Jackson contends that all Black-identifying individuals begin in the naïve phase, life experiences coupled with the acknowledgement of racism influences one's trajectory. For example, consider Anna's association of her Blackness with being "a tiny bit of a disadvantage," or John's association of his Blackness with his perceived markers of socioeconomic affluence (e.g. videogame consoles, number of bedrooms in home, etc.). When applying the BID framework, their acknowledgement of their racial identities rejects the notion of naiveté, and their associations of Blackness aligned with stereotypical or societal influences disconnected from science, indicates John and Anna have likely entered the acceptance phase.

I acknowledge that this framework was developed to understand the racial identity development of individuals who identify as being connected to the African Diaspora or Black, and it is not my intention to co-opt the framework to generalize to all persons of color. I merely provide this framework as a concrete example of how one's racial identity might evolve throughout one's education, especially when these identities are subjected to environmental cues (Tatum, 1997/2017) or whenever students experience what I will refer to as a *reckoning moment*, defined as an incident rooted in a marginalizing practice which elicits and activates one's identity marker. This incident is reminiscent of further identity development, informed by one's lived experiences coupled with research further suggesting the likelihood of such occurrences (Godfrey et al., 2019; Holland et al., 1998; Jackson, 2012).

An example illustrating a reckoning moment occurred with Jaena as she reflected on the videoed classroom lessons detailing her participation. During her initial interview, Jaena described her gender identity as an insignificant contributor to her science identity, stating, “It doesn’t matter about the gender when being a scientist. You don’t have to just be a girl or a boy, you can be any gender to be a scientist.” However, in the videoed lesson from the Living Systems module in which she was grouped with Seth, John, and Terrance, she made several interjections throughout the lesson to recommend how the cards should be sorted. However, Seth, asserting his leadership role, was not willing to listen. He arranged the cards to show a food web that Terrance and John both agreed with. Jaena, becoming visibly frustrated, interjected one last time, stating: “Well, we have to make it neat.” Seth, John, and Terrance ignored her once more, at which point she visibly withdrew from the lesson. When reflecting on this exchange, Jaena stated:

> *Mr. B.*: And you were trying to tell your group—or give an idea to your group about where to put the cards and they didn’t seem to listen. How did you feel about that?
>
> *Jaena*: I dunno.
>
> *Mr. B.:* So what did you think about being the only girl in the group, because it was John, Terrance, and Seth?
>
> *Jaena:* Um I felt like they wasn’t [*sic*] listening to me. They thought that it [the cards] could go like how they think it goes.

Mr. B.: Hmm…and how did you feel about the fact that you didn't think they were listening?

Jaena: I was just like…invisible or something to them.

Mr. B.: Really…So one of the things we talked about the first time was that your gender wasn't important when it comes to you being a scientist. Do you think—because you said that you felt invisible because they weren't listening to you… do you think that your gender played in a role in why they didn't listen to you?

Jaena: I dunno…

Mr. B.: Ok. If you did this again [the POT] would you move gender to another place?

Jaena: Um…

Mr. B.: [Reminding her of her initial response] Because the first time, you said that it was over here [pointing to POT] and "not true for you".

Jaena: I think I would move it to here.

Mr. B.: So you would move it to "kinda true?"

Jaena: Yeah.

Mr. B.: Alright. One of the things I noticed—in another lesson, you were working with Blue and you two worked really well together. You were talking back and forth a lot. Do you think that when you are working with girls or your friends that it's easier to get your ideas out or feel like you're not invisible?

Jaena: Mmhmm (affirmative).

Mr. B.: Ok…and did you feel like a scientist when your groupmates weren't listening to you?

Jaena: Shakes head (negative)

Mr. B.: No? And why not?

Jaena: Because I had an idea and they wouldn't listen. So when scientists have ideas people listen to what you have to say (Interview 2, 5/30/2019).

In this exchange, Jaena positioned her gender identity as insignificant in relation to her science identity; however, when allowed to observe and reflect on her visible withdrawal (her reckoning moment) from the lesson, this appeared to activate her gender identity. In my observations of Jaena, she was an entirely different student when grouped with other female students and was a leader in classroom discussions, as she stated that she wanted individuals to "pick on her," allowing her a space to display her scientific knowledge. Yet when being ignored by her male peers, she stated that she felt invisible, and ultimately disassociated herself with being a scientist, indicating an emergent intersection between her gender and disciplinary identities. As illustrated through Jaena's experiences, I argue that when faced with other instances which activate various other identity domains, specifically one's racial identity, like Jaena, this identity would become more salient, eventually intersecting with their disciplinary identity.

Teacher Identity

Throughout the duration of the study, Elizabeth demonstrated shifts in her science teaching identity, largely through her developing sense of agency with the curriculum materials.

This identity was seemingly connected to her emergent content knowledge coupled with her reflections on student learning. It is important to note that while Elizabeth developed an agentic science teaching identity, like the students, this identity was not attentive to students' racial identities. While these changes were significant in addressing equitable science instruction, I argue that this identity is also fluid, and will only strengthen with continued support. However, if these supports are discontinued, she is likely to revert to her initial science teaching practices. Elizabeth became more attentive of her students' learning during instruction and felt more comfortable deviating from the materials after understanding the central ideas the modules intended to address. Because of the curriculum's failure to adequately support students' racial and disciplinary identity constructions, this agency also reflects the need for teachers to receive professional development around the NGSS, as this would provide opportunities to develop the cross-disciplinary instructional practices (e.g. modeling) that Elizabeth discussed during her reflections.

While she developed agency through her science teaching, these practices were not transferable to her practice of attending to students' racial identities. As one who positioned herself as a White female with superficial experiences in engaging in conversations related to race, she acknowledged her need to grow in this area. Rather than broaching the topic of race with her students, she ignored it altogether, and this failure to acknowledge students' racial identities further supported their color-evasive assertions. On the rare occasion in which a student would mention race, they would often hedge by using phrases such as, "not to be disrespectful" or "no offense," indicating that they have been socialized to view having these conversations in school as a violation of the rules, ultimately influencing their academic identities.

Elizabeth's acknowledgement of her discomfort engaging in race-related conversations with her students was solely tied to her own racial identity, which she implicitly acknowledged as a benefit when describing interactions with her colleagues, as illustrated in the excerpt below:

> *Mr. B.*: Given your teacher ed training, have there ever been any cases where you're positioned to interact with someone that you fundamentally disagree with regarding their philosophy around those statements [regarding race], and then putting you in a position where you feel like you have to address that or not?
>
> *Elizabeth*: Yeah, I mean I've come across people who are like, "No, it's just because of how their parents are." or "It's just because of where they're from." and you know, some—at times I'll have conversations about like those statements. But I was from a very small-town White community. I moved to a large, diverse city, and you know, my world was completely changed, so I feel like I've had a lot of different experiences that have made me the teacher I am so when I face people who have those types of views, I feel I can come at them with a different angle versus how some people are just…some people put up arms when they have those race/ethnicity conversations, where I kind of grew up in a place that was very you know one way and that's the way we were, and then [I] moved to a different place, so I feel like when I talk to them I can come at it in a way that they can understand a little bit (Interview 1, 3/22/2019).

Although expressing confidence in engaging with her colleagues in race-related conversations, when describing the school district's efforts to support her doing this work with her students, Elizabeth offered a different take, as illustrated in an excerpt from a conversation at the end of the school year:

Elizabeth: There are…yeah, so we're doing a new—so for the past few years, we've really engaged in morning meetings around thoughts and feelings and we have had training on how to go about race…big ideas—um there's girls that I went to grad school with…real big social justice people and they do a ton of work around that in their morning meetings. I also think it's comfortability, like how comfortable you are bringing up those issues, especially when you yourself are the minority in the group. So when you are the White person bringing around the race issue, there is a lot of dynamics to consider because as we've talked about before, it's not even about you know, Black, White, and Asian; it's about how people within the Black community are viewing people from Africa, for example. There's just a lot of dynamics, and so I think the District has done some work around that. I know as a school, we're doing this new program next year, so I don't know if there will be some [programming] around race. I know one of my colleagues broaches the subject, um we've had some discussions, but not like really the in-depth [discussions]. But I think…I think the District does support it, obviously, but there could be more training around it. I think specifically on how to do it.

Mr. B.: So for you, what would it take for you to feel more comfortable or to increase the level of comfortability [with having conversations around race]?

Elizabeth: I just have to do it more, I think. I also think it's a conversation that happens later in the school year. Like it can't happen first off. Like you have to know your class. You have to know…I also think I would need someone with me at first (Interview 2, 6/20/2019).

I offer these two differing illustrations of Elizabeth's position regarding race not as a personal critique of Elizabeth; rather, as an exemplar of what happens in schools writ large. In

Elizabeth’s articulation of her comfortability engaging with colleagues, she implicitly couched this comfort on the premise that her colleagues were White. She implied as much through her phrasing of “some people put up arms when they have those race/ethnicity conversations,” seemingly relying upon her Whiteness as the entry point to engage with her colleagues who may espouse racist positions. Elizabeth’s take on supporting her diverse students to develop language around their racial identities also invoked her Whiteness. In this case, she explicitly acknowledged her racial identity as “the minority in the group” as a barrier, illustrative of the power associated with choosing “when, how, and to what extent racism is addressed or challenged” (Diangelo, 2018, p. 109). Even though Elizabeth’s position as the classroom teacher afforded her a significant amount of power, she invoked “minority status” when addressing race with her students, suggesting that she was powerless. As such, this is a manifestation of what Tomlinson (2019) referred to as *powerblindness*, a discursive practice where colorblindness is used to evade both race and power, subsequently upholding existing racial hierarchies.

Because of the school’s tepid approach to approach to creating a space for students of color to bring their full selves to school while acknowledging and celebrating each other’s differences, students likely view the acknowledgement of their racial identities within schools as inappropriate, perpetuating oppression vis-à-vis the color-evasive paradigm. Further, whiteness is upheld, preventing the “exposure, analysis, and remediation of the skewing of social opportunities and life chances by race” (Lipsitz, 2019, p.24). This presents grave learning conditions for students, as Tatum (1997/2017) reminds us that “unchallenged personal, cultural, and institutional racism results in the loss of human potential, lowered productivity, and a rising tide of fear and violence in our society” (p. 337).

The Role of the Curriculum

Overall, the curriculum upholds the emphasis on traditional means of instruction through its emphasis on vocabulary and procedural tasks, privileging students' academic identities. This is problematic because the curriculum materials are marketed to school districts as being aligned with the NGSS, which have explicitly acknowledged the need for equitable science learning opportunities for marginalized students outlining specific recommendations for what this could look like within the classroom.

For example, in its 2013 publication, entitled *All Standards, All Students,* the NGSS suggested implementation strategies designed to provide teachers with ways to envision the standards enacted within their classrooms through the provision of equitable instruction. The document was informed by previous research and identified ten historically marginalized groups in STEM education. Scholars presented four major categories of strategies designed to specifically engage students of color: "(1) culturally relevant pedagogy, (2) community involvement and social activism, (3) multiple representation and multimodal experiences, and (4) school support systems including role models and mentors of similar racial or ethnic backgrounds" (NGSS, 2013).

Because the curriculum was marketed as being aligned with the standards, curriculum developers were likely aware of these explicit strategies proposed by the writers of the NGSS. Yet, upon close analysis of the curriculum, not only do the lessons fail to fit within any of the four categories, the modules are recycled from prior iterations of the modules when they were marketed as being aligned with previous science standards. Since elementary teachers have demonstrated a need for increased content learning opportunities (Chen & Mensah, 2018; Kane & Varelas, 2016; Mensah, 2016), their reliance on these materials result in the perpetuation of inequitable science instruction. However, I argue this is not intentional, as the school district and schools alike adopted these standards-aligned materials under the presumption of enacting equitable instructional practices.

Although the curriculum made deficit-oriented assumptions regarding the depth of conceptual understanding students possess (e.g. the particle models illustrated in Figures 6 & 7), students repeatedly demonstrated their deep conceptual understandings despite these assumptions, indicating a need for critical curriculum development. Students repeatedly demonstrated what they know and can do, a counternarrative (Yosso, 2006) which directly challenges the dominant deficit-oriented narratives assigned to students of color within urban communities. Much focus is devoted to standardized assessments which often fail to capture the rich knowledge students like Blue and Rebecca articulated within their writing. As a result, students are not credited as contributors to their own learning. Elizabeth also indicated that because of her lack of content knowledge, she was unsure of how to assess student learning, meaning that she was unable to assess students' notebook ideas in a way that made them accessible and visible to the entire class to promote learning.

Implications

The CLIC framework was designed to provide researchers with a means of understanding how Black children negotiate their academic, racial, and disciplinary identities as science learners within their classrooms. As such, Varelas, Martin, and Kane (2012) argued for the need to understand the intricacies of the interactions between one's narrated and practiced identities, as students engage in identity work allowing them to both make meaning of their science and mathematics learning amidst their positioning of themselves within these classroom spaces. Considering this framework, the findings of this work offer a theoretical contribution to existing research regarding science identities, particularly invoking Carlone and Johnson's (2007) *Performance, Competence, and Recognition* model, which was developed to understand the science identity constructions of successful women of color in science professions.

The framework suggests that "A science identity is accessible when, as a result of an individual's competence and performance, she is recognized by meaningful others, people whose acceptance of her matters to her, as a science person" (p. 1192). In this case, students could only perform as their competence were recognized as such only when enacting acceptable behavioral practices determined by the teacher, the individual in power. Although the framework assumes one's racial, ethnic, and gender identities are influential in shaping their science identity, the framework fails to account for the institutional structures of power and its function as a gatekeeper to science instruction. As such, the exploratory nature of this work effectively serves as the nexus between the two frameworks, a key contribution to the field.

Understanding students' identity work involves a close examination of how students are provided opportunities to do such by teachers and the curriculum alike, and these findings underscore the significance of opportunities to engage in science learning for elementary students of color. Preadolescent learners are constantly undergoing changes which influence these identities, yet these identities are largely shaped by environmental influences. Because students spend much of their time within schools, this environment requires great attention from a systematic perspective, which can begin being addressed through work with teachers and the curriculum.

Teacher Education

As the centering of student identities were central to this work, findings indicate that elementary schools are not positioned as spaces where students of color can bring their full selves into the learning space. Rather, it is viewed as an objective, color-evasive institution of learning where students come to solely engage in the learning of academic subjects. Students must follow arbitrary (White) rules that oftentimes provoke the behaviors they were created to address. When considering such rules, Lipsitz (2019) argues “Symmetrical treatment under decidedly unequal circumstances perpetuates injustice” (p. 44). The interpretation of these rules resides with those in power (the teacher), and are enforced differently from one student to another, upholding the historical deficit-oriented positioning of students of color within schools which are used to justify their creation.

Attending to students’ diverse and complex identities is uncomfortable, with those in positions of power viewing this work as existing beyond the purview of the school and classroom, resulting in the perpetuation of a color-evasive society governed by meritocratic beliefs. However, as illustrated throughout this work, elementary teachers are central to the identity work of students of color. They serve as the governing body of the classroom and determine how learning will happen, which rules will be followed, and how students will engage with one another. Specifically addressing science instruction, the implications for elementary teachers, both pre and in-service are several.

Varelas, Martin, and Kane (2012) advocated for teachers to create space for students to think about who they are just as they are provided spaces to think about the phenomena addressed within the content. However, when applying this recommendation to elementary students, the framework assumes adequate science learning is occurring. Elizabeth’s science teaching identity challenges this assumption, as she acknowledged her own discomfort with teaching science as the confluence of her pedagogical content knowledge and understanding of the NGSS. To make the case for students to begin thinking of who they are becoming as scientists, this sense of becoming hinges on their *access* to science.

The conscious decisions to ignore the racialized and inequitable learning instances within schools serving communities of color indicate a need for critical reflection on the purpose of education on a macro-level. As teachers and teacher educators, we must be reflexive in our teaching practices constantly asking questions such as: Who benefits from this instruction? How am I centering students' knowledge and experiences throughout my instruction? What supports do I need to better support student learning? Research suggests transformative intentional community-centered approaches to instruction as a tool to begin chipping away at these larger questions.

Haddix (2015) proposed what she termed *community-engagement* teaching as an approach to preparing preservice teachers for teaching in diverse schools. Regarding preservice teachers, Haddix (2015) argued that community engagement is more than a temporary standardized practice that positions teachers as the purveyors of knowledge; rather, it is an ongoing commitment to one's community which honors and incorporates students' funds of knowledge in ways that empower their learning. I argue that through my work in which I center the voices and multiple identities of elementary students of color, I have begun to engage in meaningful community-centered work.

Although Haddix's (2015) recommendations were specifically directed at teacher educators and preservice teachers, I argue the same for in-service teachers. Given Elizabeth's expressed discomfort broaching race-related conversations, her seemingly deficit-oriented positioning of some students in state-tested subject areas, and her pedagogical content knowledge, there is a clear indication of the need for teachers to better center students' experiences within their own instruction. Despite her pedagogical goal for students to "own their learning," this ownership must be situated within the bounds of community engagement if one is to truly understand the intricacies of the influencers on one's multiple identity domains. Stated differently, stakeholders of students' education (e.g. teachers, administrators, staff, etc.) cannot solely rely on subjective test scores to influence instruction without "uncover[ing] and address[ing] issues of racism and social and educational inequities" (Haddix, 2015 p. 64) which drive these practices. Similarly, the whiteness embedded within the curriculum and standards must be acknowledged to allow students of color to fully enter the learning space.

The Curriculum

A central purpose of the Framework (NRC, 2012) was to acknowledge and attend to issues involving inequitable science instruction, particularly for students of color. Regarding the fostering of positive student identities, the Framework charges teachers to "infuse in our lesson plans time for students to think about their identities in the same way we give them time to think about concepts and practices they are learning and how they are useful to them" (p. 336). Evidenced within the teacher guides, these elementary curriculum materials were not designed to bolster teacher's content knowledge, which also requires a deep understanding of the standards and student knowledge to enact more equitable science instruction. The curriculum materials alone will not check the box of equity, furthering the case for increased targeted professional development opportunities for teachers.

One such professional development opportunity as argued by various scholars, exists in the form of *lesson study*. Lewis et al. (2012) described lesson study as the synergy of constant interactions between the teacher, colleagues, instructional resources, and pedagogical practices that ultimately allow educators to "experience agency, competence, and human connection" (p. 373). Although mostly prevalent within mathematics instruction, Dotger (2015) asserted its relevance for improving science instruction as it works to build relationships between theory and practice, namely through the iterations of its seven features: “(1) teacher collaboration; (2) establishment of research themes and goals; (3) coupling standards with goals and curriculum materials; (4) live research lessons; (5) lesson introductions and post-lesson discussions; (6) iterations of development; and (7) learning products” (p. 352).

Perhaps most central to these features are the emphasis on teacher collaboration, attention to the alignment between curriculum materials and standards, and focus on the evolution of student learning. Dotger (2015) explained that the research lessons, which are enacted at the culmination of extensive planning (feature 4), are open to the public and as such, members of the community are invited to attend. These professional development practices are beneficial because they require critical analysis of the curriculum and standards. Because teachers exercise agency in determining the research themes and goals (feature 2), this selection can serve as an ideal opportunity for teachers to acknowledge and center student experiences as the driver of the lesson relying on the curriculum materials as supports rather than scripts.

As previously established, the curriculum materials failed to align to equity-driven science standards. In fact, the underlying assumptions of student experiences and their capacities to engage in phenomenologically driven learning, further marginalized these elementary students of color through its suppression of their multiple identities. However, these materials offer elementary science teachers and teacher educators alike a place to start. It is important to acknowledge that these are not the only curriculum materials which embody these critiques; many third-party materials advertised through internet repositories were derived from the same modules referenced throughout the analysis. Additionally, these assertions are not to suggest that urban school districts intend to harm its students through the provision of these materials. In fact, I argue the opposite. Because elementary science education is not well-supported throughout US schools (HRI, 2019; Smith, et al., 2016), the presence of curriculum materials indicates an acknowledgement of its significance. When we consider the growing diversity of our schools and communities, however, there must be a critical acknowledgement of learning as a sociocultural practice. Part of this acknowledgement manifests in the provision of a race-centered science curriculum that allows students to see true reflections of themselves within their curricula. Doing so would begin attending to the ever-flowing leaky STEM pipeline. This work should be ongoing, as it implicates both science teacher educators and the curriculum in a way that situates students' funds of knowledge as the center of teaching and learning. I view the promise of lesson study with specific attention to community-engaged instruction as a means to begin addressing these issues.

Limitations

Overall, while very insightful, there were various limitations encountered throughout the duration of the study. In the sections to follow, I highlight several limitations in addition to the steps taken to mitigate their effects on the overall study.

Inconsistent Scheduling

Throughout the study, there were multiple days where the school scheduling impeded science instruction resulting in inconsistencies in the data gathering. For example, on the day Elizabeth was scheduled to receive a peer observation of her science instruction, she expressed concerns of being behind. Since her colleague already had access to her proposed lesson plan, Elizabeth felt it was important to double her science instruction to ensure the observer would not raise concern with her pacing. To mitigate this concern, she decided to teach one 50-minute science lesson in the morning in lieu of their writing time and coordinated with the social studies teacher to have the same class in the afternoon for an additional science lesson. While it was great that Elizabeth felt empowered enough to adjust the schedule to accommodate more science instruction, this meant that her other class received less science instruction, as their regularly scheduled science time was prioritized to the other class. Additionally, students were pulled out of class in the mornings to receive supplemental services or take elective classes (e.g. speech therapy, band practice), resulting in several student participants missing the morning instruction and expressing confusion during the afternoon lesson. Other scheduled schoolwide assemblies, such as culminating music performances, art showcases, and fun-days further interrupted science instruction.

Regular student absences also contributed to inconsistencies in the data gathering. Central Elementary, like other schools, had multiple school social workers. However, the demand for home visits due to student truancy far outnumbered the number of personnel responsible for conducting such visits. The patterns of student absences were not predictable and over the duration of the study, there were fewer than ten days in which the entire class achieved perfect attendance. The school's schedule coupled with student absences impeded my ability to deeply track changes in student's conceptual understandings throughout the science modules, which while beyond the purview of the study, is important to acknowledge because it points to an opportunity further research. More specifically, rather than a limitation per se, this acknowledgement serves as an opportunity for further work to investigate how the designing of elementary science curricula builds on students' conceptual understanding.

Student Pairings

Because all students did not assent to participate in the study, there were multiple cases in which participants were grouped with others who were different from their typical assigned partners. For some students, they felt more comfortable participating in class with their friends, and one student, Anna expressed her unwillingness to participate in one video recording as a result. As the researcher, I worried student pairings would influence their engagement during the lesson, subsequently becoming invasive to their learning. To mitigate this, after the initial lesson, I consulted with the students and Elizabeth on the pairings to ensure all were comfortable. I also varied the groupings every other lesson to reduce student discomfort and increase the likelihood of more authentic lesson engagement. Further, in the second interview, I explicitly asked students to reflect on their experiences working with their classmates to understand if the pairings elicited any significant negative experiences. Although Anna reported not wanting to work with her designated groupmates for one of the lessons, when asked to reflect on her reasoning, she stated her participation was related to her desire to be with her friends rather than having anything to do with negative experiences with her groupmates.

Questions for Further Study

Parental Influence

A salient theme prevalent throughout each students' articulation of their color-evasive racial identities was the absence of parental influence in shaping these identities. Despite attending a school in which an overwhelming majority of all individuals in positions of power (e.g. teachers and administrators) identify as White, students did not acknowledge having conversations at home with their caregivers in which they unpacked the relevance of their racial identities in their school and community space. Although students claimed their guardians did not have conversations with them regarding their racial identities, these claims are not enough to conclude parental intentions. Said differently, I mention this as an observation, not a critique or generalization of the involvement of parents of color in their students' education. Clearly, students were aware of their racial identities and it is plausible parents may determine these conversations are more significant for them as they navigate middle and high school, especially given the various phases of Jackson's (2012) BID framework and the detrimental effects of adhering to meritocratic values (Godfrey, et al., 2019).

Considering the role of parental or guardian-figure influences in shaping identities of pre-adolescent youth, an additional area of exploration to contextualize students' positioning of themselves as both persons of color and scientists would be to understand how parents support and affirm their students' racial identities while encouraging their active participation in science. Evidenced in Pro's accounts of his parents purchasing various engineering-related games is a clear indication that parents and guardians actively engage in nurturing their students' science identities. However, exactly how they attend to shaping and influencing their racial, academic, and disciplinary identities remains unclear, indicating an area of further study.

Reflections of Self

When examining the most popular stock images of scientists (Appendix I) generated through a popular search engine, students immediately noticed the lack of perceived individuals of color. When discussing the cause of this, Nguyet articulated various systemic issues (e.g. racism, sexism, stereotype threat) which are influential in shaping one's science identity. In the following exchange, she noted the issues associated with the lack of representation of persons of color within STEM fields:

> *Mr. B.:* When we look at these pictures, do you see or notice any scientists that you think look like you?
>
> *Nguyet:* I think this one kind of [pointing to picture], because she has glasses and black

hair.

Mr. B.: Ok, and anywhere else?

Nguyet: Um…I'm not sure...no.

Mr. B.: And why do you think that's the case? What do most of the people look like?

Nguyet: Well most of them have like white skin color and most of them are men. A few are women.

Mr. B.: And why do you think that's the case?

Nguyet: Well, it's about equality. They used to have segregation on skin color…and women and men. And I think it's still here today even though the law said that all men and women are supposed to be treated equally…and…

Mr. B.: And what do you think needs to happen in order for that to be true?

Nguyet: Umm…I think that some people still believe that men are better than women, and men are like more good at things than women, and men do their own things and women do their own things. Like women [are expected to] do house chores, be a teacher, and men get to be a doctor, a scientist, an engineer, or something better (Interview 1, 3/19/2019).

As an eleven-year-old, Nguyet was already aware of the lack of diversity within STEM texts, and this coupled with the dismissal of her racial/ethnic identity within the curriculum, makes it difficult for Nguyet and others to view themselves as a member of that community. Scholars have argued for the increased need for persons of color represented throughout STEM text (Atwater et al., 2013; Brown et al., 2013; Kane, 2016), as well as for the recruitment of teachers of color (Easton-Brooks, et al., 2009; Mensah, 2019; Mensah & Jackson, 2018; Milner, 2016), as this serves as an affirmation of one's identity and helps to foster positive racial and disciplinary identities. Considering these recommendations beckons the future research questions: How would science curriculum materials representative of the racial and ethnic identities of elementary students of color influence their science identities? Additionally, how might teachers of color foster these identities?

Trajectory of Identities

As an individual matures, research suggests influences from one's environment (Tatum, 1997/2017; see also Carlone, et al., 2014) will shape how they come to view themselves within society. As such, it is likely that as elementary students of color progress through middle school and beyond, they will develop more succinct language to describe their identities. Given students' expressions of meritocracy regarding their science identities coupled with the specialized nature of science in secondary education, I am interested in exploring the trajectory of these identity domains as students progress beyond elementary school. In reflecting on my own experiences as an undergraduate, a classroom teacher, and a graduate student where I have been either the only or one of few males of color in an otherwise White space, I am increasingly aware of the salience of my racial identity. In essence, this identity foregrounds every other identity, influencing how I interact with and are received by the spaces around me—my own identity work.

Central Elementary is a feeder school for a local middle school which has been described by teachers as a "rough school." Much like Central, this middle school predominately serves students of color. However, because of its reputation, many students opt to enter lotteries for schools outside of their zone or leave the district altogether with the presumption of better educational experiences elsewhere. Oftentimes, these other schools position students' racial identities as more salient as they find themselves as being an outlier. Stated differently, these schools may consist of a largely White student body where students of color acknowledge the intersections of their racial identities with their academic and disciplinary identities more readily than when in elementary school. Because of these shifts in students' schooling, future research should focus on how students of colors' various identities shift with time.

Conclusions

Schools as Producers of Figured Worlds

Holland et al., (1998) conceptualized one's identity as being "formed and realized in 'as if' realms" (p. 49). These figured worlds further "take shape within and grant shape to the coproduction of activities, discourses, performances, and artifacts" (p. 51). Figured worlds are part of a sociohistoric construction where individuals, typically those in power, determine which actions, customs, etc. are valued within the community. These valued actions ultimately shape the identities of its participants as the values replicated within the community. Additionally, figured worlds are influenced through the use of artifacts, allowing the performer (the individual in power) to "open up" the figured world (p. 61).

When considering the structure of the science classroom and school community writ large, these function as students' figured worlds. In the classroom, the teacher, in performing the act of instruction, determined the artifacts, or the rules and expectations of students (e.g. discourse practices, writing and behavioral expectations), and students constructed their identities around these expectations, likely explaining why students viewed themselves as scientists through aligning with the features of their rule-laden figured world. While students' figured worlds were indicative of a compliant constituent of a rule-following society, the parameters of this world can be reshaped through changing the value assigned to these actions and customs, indicating a need to re-center the lived experiences of students of color such that they are allowed to engage in learning without being punished for the community-based artifacts which shape them.

Although the NGSS have illuminated issues associated with the historical inequitable nature of science instruction, various scholars have spent years arguing these very points (Atwater, 1993; 1995; 2000; Atwater & Riley, 1993; Calabrese Barton, 2001; Mensah, 2009; 2011; Mutegi, 2013; Parsons, 2003; 2008). To this point I argue, it is not enough to *just teach science* for elementary students. As standards-aligned curriculum materials have demonstrated, student experiences can become lost within the presuppositions of what they are incapable of, which I argue only perpetuates these injustices while undercutting the premise of the standards. Sure, *some* science instruction is indeed better than none, but the instruction that *is* happening should be led by teachers who: (1) feel supported in growing their pedagogical content knowledge, and (2) engage in the reflexive practice of learning about themselves through learning about their students. Student experiences are tantamount to the science learning we desire for them to engage in, and this learning is restricted without the consideration of these two recommendations.

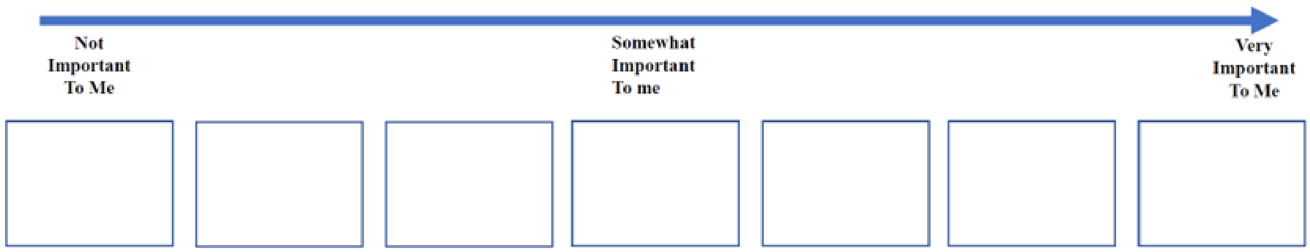
Throughout my time at Central Elementary, students were eager to show me who they were as learners within their school community. Given my position as a Black male in a space typically dominated by White females, students felt more inclined to share parts of themselves which were typically silenced through the classroom norms. Although they had not yet tapped into the intersectional nature of their multiple identities, this work indicates that these identities are in fact growing. Given the school's emphasis on managing student behaviors, the bulk of their work is done around learning to follow arbitrary (White) rules, which only serve to appease those in power. Despite this, students repeatedly demonstrated their deep engagement in science learning, vis-à-vis their classroom participation, writing, and conversations, illustrating the intricacies of their emergent identities. To this end, Varelas, Martin, and Kane (2012) remind us that we must:

> …consider Black students as members of two groups: (a) classroom communities where issues of hierarchy, power, marginalization, inclusion, success, failure, agency, and structure get negotiated and develop over time; and (b) a social group that has historical relationships with institutions such as schools where meanings associated with, and beliefs about, what it means to be Black have direct relevance to the dynamics and outcomes of teaching and learning (p. 334).

High-quality student-centered science learning opportunities in elementary school are critical in allowing historically marginalized individuals, namely persons of color, a figured space to view themselves as members of the scientific community. However, this high-quality instruction involves an acknowledgement of the deeply rooted sociohistorical context in which learning takes place. It is only through this acknowledgement and the centering of students' multiple identities (namely race) that we will afford them an opportunity to become develop an agentic science-literate identity; only then will we begin moving the needle toward more equitable science instruction.

APPENDIX A

Pre-Observation Task



1. I am good at science because….

2. It's important for me to show my teacher/classmates that I am good at science because….

3. What do you do in science that scientists don't do?

1. Overall, my race/ethnicity has very little to do with how I view myself as a scientist.
2. Overall, my friends support me being a scientist.
3. Overall, my family supports me being a scientist.
4. Overall, in science class, it is important to respect others.
5. Overall, in science class, it is important to talk like a scientist.
6. My gender [identity] is an important part of me being a scientist.
7. Overall, my race/ethnicity is an important reflection of who I am as a scientist.

APPENDIX B

Interview 1 Protocol for Students

Introductory Script:

Hi, my name is Terrance Burgess. I am a graduate student at Syracuse University and I study how students learn science. Thank you for agreeing to participate in this study. I will ask you several questions and then give you time to ask me questions.

Questions:

Can you tell me a little about yourself?
Have you thought about what you'd like to do when you grow up? Why (that particular choice)?
If you had to guess, how would your teachers describe you? Your friends? Your family?
And how would you define science in your own words?
What are you currently learning during your science class?
Do you remember what you did in science last year (as a 4^{th} grader?) And what was that?
What things do you enjoy about your science lessons?
What things do you dislike about your science lessons?
What types of science activities do you participate in outside of school?
Do you think of yourself as a scientist when you're participating in these activities or doing science here at school?

Administration of the POT

Ok, so next, I'm going to give you some cards. On each of these cards is a statement. I would like for you to read each statement and figure out if the statement is really true for you, kinda true for you, or not true at all [for you]. Once you decide, place the card under the arrow where you think it best describes you. Then, I'd like for you to respond to the three questions at the bottom of this page, and we'll come back together and talk about it.

POT Interview Questions

Can you tell me a little about why you placed the cards where you did?

Can you talk to me about what you wrote?

Ok, so I've asked you a lot of questions. What questions do you have for me?

APPENDIX C

Post-Lesson Student Interview Questions

Interview 2 with Alexis

Video: Black Box Investigation 3/26/2019 Class B (Video a)
Monday 4/22 Living Systems Investigation (Woodland ecosystem card sort) Class B (Video B)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

The interaction between the 3 students. Alexis (left) presents an idea to Anna, who agrees and presents the idea to Nick. How does Alexis position herself as a scientist based on the POT?

How did you feel when Anna took the box from you without asking when you were trying to look at it? What do you think Anna thought about her actions? Given how she's typically positioned, and self-identifies as "quiet," is this identity read as one of submission by her peers?

I noticed that you didn't talk much in this lesson. Can you tell me what you were thinking? (11:12 A)

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip?

What did you think of Charlotte's decision of how to arrange the cards? Would you have done anything differently? (17:29 B)

In the POT, you mentioned that your gender is an important part of you being a scientist. How did you feel about working with other girls in science class? What if you were the only girl?

How did you show Ms. Elizabeth. that you were a scientist? What do you think she thought about your work?

In the POT, you mentioned that your race/ethnicity was an important part of you being a scientist. What does being (racial identity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Anna

Video: Black Box Investigation 3/26/2019 Class B

What were you learning in this investigation?

What did you think about this investigation?

Did you feel like a scientist during this investigation?

In this clip, why did you choose to agree with Nick even though you voiced your own ideas?

Why do you think Nick didn't agree with you after you explained your thoughts to him?

How did you show your groupmates/teacher that you were good in science?

How did you support your groupmates' science learning? (Namely moment at 6:15).

(Moment at 12:00) You seemed to disengage from the investigation and begin drawing in your notebook. Do you remember how you were feeling during this time?

In your POT, you stated that it was not true that your gender played a role in you being a scientist. Do you think Nick's gender played a role in how you responded to him during this investigation?

How did you talk like a scientist in this clip?

Return to gender and race per the POT.

What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Anthony
Video: Tuesday 4/23 Living Systems Investigation (Woodland Ecosystem)

What were you learning in this investigation?

What did you think about this investigation?

How do you feel when you are participating in science class? (2:37). How did this investigation make you feel like a scientist? (9:34)

What did you learn woodland ecosystems from this investigation? How does it add to your science identity? (10:04)

In this clip, you seemed very interested in the lesson. What was it about the investigation that was interesting to you? How did this allow you to show your science skills? (12:51).

How did you talk like a scientist in this clip?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned that you were bored even though you were really interested in the lesson at first. What changed? Did you feel like a scientist when you became bored? (19:49).

How were Jaena's ideas similar to yours? (22:41).

You left some good ideas for your peers. Were you bored here? What were you thinking when you were doing the gallery walk? (27:32).

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (racial identity) mean to you?

How does your notebook show you being a scientist?

Interview 2 With Blue

Video: Physical Changes Lesson 3/26 Class A

What were you learning in this investigation?

What did you think about this investigation?

Did you feel like a scientist during this investigation? Why?

Why did you become upset with Terrance in this clip? 13:00

In the POT, you said that it was “very true” that your gender affected your science identity. Do you think your gender had any role in your interaction with Terrance? Do you think his gender was a factor?

The last time we met, you stated that you were good in science because you show your teachers/classmates that you’re smart. How did you show your classmates that you were a scientist? (15:10 timestamp) How did you show Ms. Elizabeth? Was it different for each group (classmates/teacher?)

How does your notebook show you being a scientist?

How did you support your groupmates in this lesson?

What does being (racial identity) mean to you?

Interview 2 with Charlotte

Monday 4/22 Living Systems Investigation (Woodland ecosystem card sort) Class
Black Box Investigation 3/26/2019 Class B (Video B)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

OC: Charlotte is a lot more active in this pairing than she was with her previous partner. Given what she's said around her gender identity (not being able to participate in sports w/ boys, does she feel like she's better able to participate in this investigation?) (16:53 A)

OC: Charlotte engages in the task while her male classmate looks on. This is reminiscent of the gender roles where girls are expected to be the 'doers' and the males are expected to supervise. Question: How did you feel about working with this student? (14:56 B)

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip?

How did you feel about working with your two different groupmates?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (racial identity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Jaena

Videos:Physical Changes Lesson 3/26 Video A
Tuesday 4/23 Living Systems Investigation (Video B)
Tuesday 4/23 Kelp Forest Ecosystem (Video C)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

In this clip, you didn't seem like yourself—you seemed quiet. What did you think about your groupmates in this clip? Did you feel like a scientist at the time? How/why? (Video A 15:34)

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them? How did they respond? (15:56 A; 24:44 C)

(Moment at 25:59 B) What were you thinking here? Did you feel like a scientist? Why or why not?

In this clip, you seemed more interested in the lesson. Do you remember how you were feeling here? You mentioned in the POT that gender was not an important part for you but you didn't talk much when you were in groups with all boys. In the groups with the boys, you stated your opinion, but they didn't seem to listen. (C 09:21) Do you remember how you felt? (29:28 B)

How did you talk like a scientist in this clip? (29:28 B)

How did you feel about working with your group? You placed your hand on your head here. What were you thinking about? (26:52 C)

Why do you think your groupmates were not as concerned with neatness as you? (34:40 C)

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work? (29:55 B)

What does being (racial identity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with John

Video: Tuesday 4/23 Kelp Forest

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist? (9:34)

What did you learn about food chains? (12:17)

In this clip, what were you writing about? You seemed very interested in the lesson. How did this allow you to show your science skills? (17:17)

How did you talk like a scientist in this clip?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them? (21:36)

You mentioned that the task was difficult (23:02). What was difficult about it?

(Moment at 25:32) How did this show you being a scientist?

How did you show Ms. Elizabeth. that you were a scientist? What do you think she thought about your work?

What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Nguyet

Videos: 4/22 Living Systems Investigation (Woodland Ecosystem Card Sort A)
Tuesday 4/23 Living Systems Investigation (Woodland ecosystem card sort) Class A (Video B)
Note: Whole-class videos and individual student audio used to inform this interview

What were you learning in this investigation (25:28 B) ?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip? (6:36 A)

What do you think of working with your peers in science class? How do they support you as a scientist in this clip?

In the POT, you mentioned that your gender is an important part of you being a scientist. How did you feel about working with other girls in science class? What if you were the only girl[in your group]?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

In the POT, you mentioned that your race/ethnicity was not an important part of you being a scientist. What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Nick

Videos: Black Box Investigation 3/26/2019 Class B (Video a)
Monday 4/22 Living Systems Investigation (Woodland ecosystem card sort) Class B (Video B)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist? (Each One)

(5:05 a) Gender Interaction: What does it mean for Nick to be the only male in the group? What does it mean for Anna to explain her ideas to him?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip?

How did you feel about working with your two different groupmates?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (racial identity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Pro

Videos: Physical Changes Lesson 3/26 Video A
Tuesday 4/23 Living Systems Investigation Woodland Ecosystem (Video B)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

From this lesson, do you know what the difference between dissolving and melting is? (3:09 A)

You mentioned in our last conversation that it was very important to respect others in science class. How do you feel about the interaction with your group here? (9:36 A)

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them? Why did you get frustrated with Seth here? How does it affect your science identity? (17:36 A)

How do your science ideas change throughout the lessons? At the beginning, you stated that you thought the chocolate would melt first. What does it take for your ideas to change? (19:33A) Do you feel like a scientist when these ideas change?

How do you feel when you get the “right” answer in science class? What about when you’re wrong? (20:27 B)

In this clip, you talked about food pyramids. Where did you learn about them? (21:30 B)

How did you talk like a scientist in this clip?

How did you feel about working with your group?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Rebecca

Videos: Tuesday 4/23 Living Systems Investigation (Woodland ecosystem card sort) Class A (Video A)
Physical Changes Lesson 3/26 Class A
Note: Whole-class video and audio used to inform interview questions.

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them? (12:00 A)

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip? (26:51 A)

What do you think of working with your peers in science class? How do they support you as a scientist in this clip?

In the POT, you mentioned that it is important to respect others in science class. How did you respect your peers?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work? How did you show that you are a leader?

In the POT, you mentioned that your race/ethnicity was not an important part of you being a scientist. What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Seth

Video: Tuesday 4/23 Kelp Forest Lesson

What were you learning in this investigation?

What did you think about this investigation? I noticed that you took on more of a leadership role. Why did you feel the need to be the group leader? (8:14)

Did you feel like a scientist during this investigation?

What did you learn about food chains? How did this help you become a better scientist? (12:17)

In this clip, what were you writing about? How did this allow you to show your science skills? (13:50)

How did you talk like a scientist in this clip?

How did you show your groupmates/teacher that you were good in science?

How did you feel when you were disturbed from making your food web? How did you feel supported by your classmates? (20:36) (reference POT)

(Moment at 34:31) You seemed to become upset when you were trying to present your ideas. Do you remember how you were feeling during this time?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Terrance

Videos: Physical Changes 3/26 (Video A)
Kelp Forest Ecosystem Lesson 4/23 (Video B)

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist? 10:51 video B)

What did you learn about food chains? (12:17)

In this clip, what did you think about this interaction? Seth was telling you to stop and you didn't have any cards to read/sort.17:17 (Video B) Did you feel respected (POT)?

How did you talk like a scientist in this clip?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them? How did they respond? (15:56)

(Moment at 25:59 B) What were you thinking here? Did you feel like a scientist? Why or why not?

In this clip, you seemed more interested in the lesson. Do you remember what you were learning here? How do you think your groupmates felt about this interaction? (Reference previous clip + Gender) (13:03 A)

How did you feel about working with your group? (26:01 B)

How do you think you would investigate this question? What materials would you need? What would the investigation look like? How does this make you feel like a scientist?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

What does being (racial/ethnicity) mean to you?

How does your notebook show you being a scientist?

Interview 2 with Westpaul

Videos: Tuesday 4/23 Living Systems Investigation (Woodland ecosystem card sort) Class A (Video A)
Physical Changes Lesson 3/26 Class A
Note: Whole-class video and audio used for interview.

What were you learning in this investigation?

What did you think about this investigation?

How did this investigation make you feel like a scientist?

How did you show your groupmates/teacher that you were good in science? How did you communicate your ideas to them?

You mentioned on your POT that it is important to talk like a scientist in science class. How did you talk like a scientist in this clip? (26:51 A)

What do you think of working with your peers in science class? How do they support you as a scientist in this clip?

In the POT, you mentioned that it is important to respect others in science class. How did you respect your peers?

How did you show Ms. Elizabeth that you were a scientist? What do you think she thought about your work?

In the POT, you mentioned that your race/ethnicity was not an important part of you being a scientist. What does being (race/ethnicity) mean to you?

How does your notebook show you being a scientist?

APPENDIX D

Teacher Interview 1 Protocol

How long have you been teaching?

How long have you been teaching science? How has your science instruction changed from the beginning of your teaching to now?

On a scale of 1-10, with 10 being the most comfortable and 1 being the least, what is your comfort level in the science content you are being asked to teach? Why?

How does that level of comfort (with your science teaching) compare with your level of comfort in other content areas?

What science training (classes/professional development) have you had to prepare you to teach science?

What do you think of the curriculum materials you are being provided with to teach science?

What would you improve about the curriculum materials?
How are you supported to teach science?

How would you describe your students' engagement during science time?

How would you describe students' understanding of the content you are teaching?

In what ways (if any) do you incorporate local experiences into your science instruction?

Post-Lesson Reflection Questions

How do you think today's lesson went?

What were your instructional goals?

How well do you think you met those goals?

How would you modify this lesson to re-teach it to your other class?

Were there any issues meeting the instructional goals?

How can I assist in helping you better meet your instructional goals for future lessons?

APPENDIX E

Teacher Interview 2 Protocol

When reflecting on your science teaching for the past 3 months, how has it changed?

In the first interview, you described your comfort teaching science as a "5 or 6." What would you give it now? Why [that number]?

Black Box Investigation Class B 3/26/2019 00:08:13

I noticed that you are very reflective of your teaching practice. In this clip, how do you use these reflective moments to adjust your teaching? How do you know that these are the best implementations?

16:10 I've noticed it as a very large part of your math instruction but also comes through in your science instruction. How does questioning inform your teaching practice?

12:42: How do classroom discourse practices end up being reduced to rule following? (Can also see Living Systems Investigation Woodland Ecosystem Card sort part 3-3:32)

When interviewing many of the students, the cited following instructions as the way that they show you that they're a scientist. Is this a part of your instructional goal? What are your thoughts on this?

Physical Changes Lesson 3/26 Class A 16:31

Students have really great ideas about the investigations, namely because of these instructional moments. How could we make the ideas from their notebooks visible? Would this be beneficial? How do you ensure that they've answered the focus question/met the standard?

Monday 4/22 Living Systems Investigation (Woodland ecosystem card sort) Class B. You bookmarked 17:31. Do you remember why this point in the lesson was significant? Why?

4/22 Living Systems Investigation (Woodland Ecosystem Card Sort part 3) You bookmarked at 5:55. Do you remember why this point in the lesson was significant?

Tuesday 4/23 Living Systems Investigation (Woodland Ecosystem Card sort class A) 22:30DG decided to do a 'gallery walk' with this class rather than taking pictures of the foodwebs so that each group could see how their peers organized their cards. The students were instructed to leave questions/constructive feedback on their peers' foodwebs. Q: How do you think this instructional change went? How did you know to do this? Would you do this in the future?

Tuesday 4/23 Living Systems Part 2 5:10 What led to this line of questioning?

7:10 How do you think your instruction would change if you were to implement more of this into your instruction? What would it take for you to feel more comfortable?

This was an AM lesson. Do you see opportunities for integration of Math in science? Or science in math?

In the groups with the boys, you stated your opinion, but they didn't seem to listen. (C 09:21) Do you remember how you felt? (29:28 B) Tuesday 4/23 Living Systems Investigation (Video B) Tuesday 4/23 Kelp Forest Ecosystem (Video C)

How does the administration/district provide support for teachers to have conversations about race with students? Is it even a part of the conversation? Are there workshops/professional development opportunities?

You mentioned a few weeks ago that as a person who identifies as White that you didn't feel like you knew how to address the conversation between John [and another student]. What would it take for you to feel comfortable engaging in a conversation with them around race?

What final reflections/remarks do you have?

APPENDIX F

Student Video Recording Grouping Chart

Lesson	Participants	Type of Data Gathered
1	Elizabeth (Main Camera)	Video and Audio
2	Elizabeth (Main Camera) Alexis, Anna, Nick (Camera 2) Charlotte (Camera 1)	Video and Audio Video and Audio Video and Audio
3	Elizabeth (Main Camera) Pro, Seth (Camera 1) Terrance, Blue, Jaena (Camera 2) Nguyet, Rebecca, Westpaul	Video and Audio Video and Audio Video and Audio Audio Only
4	Elizabeth (Main Camera) Anna, Nick (Camera 1) Charlotte, Alexis (Camera 2)	Video and Audio Video and Audio
5	Elizabeth (Main Camera) Blue, Jaena (Camera 1) Nguyet, Rebecca	Video and Audio Video and Audio Audio Only
6	Elizabeth (Main Camera) Anthony, Jaena (Camera 1) Pro, Seth, Blue (Camera 2) Nguyet	Video and Audio Video and Audio Video and Audio Audio Only
7	Elizabeth (Main Camera)	Video and Audio
8	Elizabeth (Main Camera) John, Jaena (Camera 1) Pro, Anthony (Camera 2) Terrance, Seth (Camera 3) Nguyet, Westpaul	Video and Audio Video and Audio Video and Audio Video and Audio Audio Only
9	Elizabeth (Main Camera) Alexis, Anna, Charlotte (Camera 1) Nick (Camera 2)	Video and Audio Video and Audio Video and Audio
10	Elizabeth (Main Camera) Blue, Pro, Anthony (Camera 1) Seth, Jaena, John, Terrance Nguyet, Westpaul, Rebecca	Video and Audio Video and Audio Video and Audio Audio Only
11	Elizabeth (Main Camera)	Video and Audio
12	Elizabeth (Main Camera)	Video and Audio

APPENDIX G

Identity Prompts

Varelas, Martin, & Kane (2012) pp. 334-335

Table 1. Prompts for tasks aimed at identities-in-narratives

Reflecting on disciplinary engagement
I usually give my best effort in my mathematics/science classroom if …
It's important for me to show my teacher/classmates that I am good in mathematics/science because …
Mathematics/science are important parts of my school (out-of-school) life because …
What I like best (or least) about doing mathematics/science is …
Imagining and representing self in disciplines
I am good in doing mathematics/science because …
I want to be better at mathematics/science because …
… shows that I am good in doing mathematics/science
Doing mathematics/science can be helpful to me in these ways …
What my teacher (or classmates) thinks of me doing mathematics/science is …
Aligning self with disciplinary practices
What do I do in mathematics/science that mathematicians/scientists do (or don't do)?
What is most (or least) important in doing mathematics/science?

Table 2. Questions for exploring identities-in-practice

About disciplinary identity
How are students more or less central members of the mathematics/science classroom?
How are students seen as competent in mathematics or science?
Which mathematics/science practices, language, and norms are students engaged in and how?
How are students supported (or not) in engaging with mathematics/science language, practices, and norms?
Do certain practices encourage more or fewer students (and who among them) to see themselves as doers of mathematics/science?
About racial identity
How do students assert and negotiate their African American identities in their mathematics/science classroom?
How are students encouraged, challenged, and supported in engaging in classroom practices to build strong African American identities?
What practices encourage students to embrace strong African American identities, and which students respond to which practices?
About academic identity
How are students positioned, and how do they position themselves, as strong, knowledgeable, curious?
How do students succeed (or not) in the mathematics/science classroom?
How do students engage (or not) with schoolwork?
How does the teacher engage a range of academically successful students in mathematics/science practices?
How do students support (or not) each other in academic tasks?

APPENDIX H

GLOSSARY OF TERMS

color-evasiveness: historically referred to as "colorblindness," this term serves as an expansive racial ideology that "resists positioning people with disabilities as problematic as it does not parake in dis/ability as a metaphor for undesired" (Annamma et al., 2016 p. 153)

conceptual models: “are explicit representations that are in some ways analogous to the phenomena they represent allow[ing] scientists and engineers to better visualize and understand a phenomenon under investigation or develop a possible solution to a design problem” (NRC, 2012 p. 56)

cultural mismatch: the misalignment between the lived (cultural) experiences of African American students and the established traditional (White) culture of their science classroom. (Parsons, 2003)

curricular role identity: "those dimensions of an individual's professional teaching identity that are concerned with the use of curriculum materials" (Forbes and Davis, 2008 p. 910).

figured worlds: the socially and culturaly constructed realms of interpretation in which characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others. (Holland et al., 1998 p. 32)

funds of knowlege: “the strategic and cultural resources…that households contain” (Vélez-Ibáñez, C. & Greenberg, J., 1992 p. 313)

identities in practice: identities embodied by individuals which are influenced by institutions of power adn contextualized by three factors, one's figured world, positionality, and the process of authoring oneself. (Holland et al., 1998)

identity work: "the actions that individuals take and the relationships they form...at any given moment and as constrained by the historically, culturally, and socially legitimized norms, rules, and expectations that operate within the spaces in which such work takes place" (Calabrese Barton et al., 2013 p. 38).

mental models: “internal, personal, idiosyncratic, incomplete, unstable, and essentially functional [with the] purpose of being a tool for thinking with, making predictions, and making meaning of experience” (NRC, 2012, p. 56).

powerblindness: a discursive practice where colorblindness is used to evade both race and power, subsequently upholding existing racial hierarchies (Tomlinson, 2019).

reckoning moment: an incident rooted in a marginalizing practice which elicits and activates one’s identity marker.

APPENDIX I

Stock Scientist Images (From POT)


Scientist dictionary definition ...
yourdictionary.com
Male scientists are far more likely to ...
sciencemag.org
Kristin Jacobsen
profile of scientists at Bio-Techne ...
rndsystems.com
scientist. What will my salary ...
theglobeandmail.com
NRI scientists: Scheme for NRI ...
m.economictimes.com
Advice for Young Scientists: Be a ...
blogs.scientificamerican.com
5 days ago
Rising Heroes of the Coronavirus ...
nytimes.com
redeploying to fight coronavirus
nature.com
Medical Laboratory Scientist - Explore ...
college.mayo.edu
What Jobs Could I Do In Life Sciences ...
career-advice.jobs.ac.uk
UK science salaries top £40k for the ...
jobs.newscientist.com
Image Gallery of Mad Scientist Pictures
thoughtco.com
Lab coats help students see themsel...
theconversation.com
The problems scientists face – by a ...
brunel.ac.uk
Stress, anxiety, harassment: huge ...
nature.com
academic scientists quit after just ...
cnbc.com
Moratorium on Editing Inherited Genes ...
scientificamerican.com
Super Bowl athletes are scientists at work
phys.org
Mixed Verdict on Who Benefits From ...
news.gallup.com
Meet Dr. Olga Shimoni, a scientist ...
thefemalescientist.com
New Scientist survey shows science job...
newscientist.com
Amid coronavirus shutdowns, some grad...
sciencemag.org
Related searches
clipart scientist
lab scientist
male scientist
Annual Research Symposium to Fea...
mcc.jhu.edu
Four Attitudes & Behaviors of a Good ...
work.chron.com
What Jobs Could I Do In Life Sciences ...
career-advice.jobs.ac.uk
Why Would Someone Want to Be a Sc...
polymersolutions.com
Scientists Rises, Pew Poll Shows ...
the-scientist.com
The Translational Scientist
thetranslationalscientist.com
Scientists synthesize anticancer drug ...
medicalnewstoday.com
call for help amid Covid-19 crisis
siliconrepublic.com
Biodegradable Plastic ...
forward.com
How to Be a Good Scientist: 11 Steps ...
wikihow.com
Adapted New Avian Virus Vaccine Aga...
nocamels.com
Do Scientists Need Philosophers ...
philosophytalk.org
Scientists Say Coronavirus Mutations ...
wsj.com
Related searches
scientist images
scientist drawing
research scientist
Medical Scientists at My Next Move
mynextmove.org
Coronavirus: Five burning questions ...
latimes.com
1 day ago
Coronavirus spread in New York in ...
thestar.com.my
Scientists Sell Research to China ...
m.theepochtimes.com
What does a Medical Scientis...
yourfreecareertest.com

**Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*

5-PS1-2 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-2. **Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.] [*Assessment Boundary: Assessment does not include distinguishing mass and weight.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

Science and Engineering Practices

Using Mathematics and Computational Thinking

Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.

- Measure and graph quantities such as weight to address scientific and engineering questions and problems.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

PS1.B: Chemical Reactions

- No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)

Crosscutting Concepts

Scale, Proportion, and Quantity

- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

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Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems.

Observable features of the student performance by the end of the grade:		
1	Representation	
	a	Students measure and graph the given quantities using standard units, including:
		i. The weight of substances before they are heated, cooled, or mixed.
		ii. The weight of substances, including any new substances produced by a reaction, after they are heated, cooled, or mixed.
2	Mathematical/computational analysis	
	a	Students measure and/or calculate the difference between the total weight of the substances (using standard units) before and after they are heated, cooled, and/or mixed.
	b	Students describe* the changes in properties they observe during and/or after heating, cooling, or mixing substances.
	c	Students use their measurements and calculations to describe* that the total weights of the substances did not change, regardless of the reaction or changes in properties that were observed.
	d	Students use measurements and descriptions* of weight, as well as the assumption of consistent patterns in natural systems, to describe* evidence to address scientific questions about the conservation of the amount of matter, including the idea that the total weight of matter is conserved after heating, cooling, or mixing substances.

*Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.

5-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-1. **Develop a model to describe that matter is made of particles too small to be seen.** [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [*Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use models to describe phenomena.	**PS1.A: Structure and Properties of Matter** • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

Observable features of the student performance by the end of the grade:			
1	Components of the model		
	a	Students develop a model to describe* a phenomenon that includes the idea that matter is made of particles too small to be seen. In the model, students identify the relevant components for the phenomenon, including:	
		i.	Bulk matter (macroscopic observable matter; e.g., as sugar, air, water).
		ii.	Particles of matter that are too small to be seen.
2	Relationships		
	a	In the model, students identify and describe* relevant relationships between components, including the relationships between:	
		i.	Bulk matter and tiny particles that cannot be seen (e.g., tiny particles of matter that cannot be seen make up bulk matter).
		ii.	The behavior of a collection of many tiny particles of matter and observable phenomena involving bulk matter (e.g., an expanding balloon, evaporating liquids, substances that dissolve in a solvent, effects of wind).
3	Connections		
	a	Students use the model to describe* how matter composed of tiny particles too small to be seen can account for observable phenomena (e.g., air inflating a basketball, ice melting into water).	

**Unless otherwise specified, "descriptions" referenced in the evidence statements could include but are not limited to written, oral, pictorial, and kinesthetic descriptions.*

5-LS2-1 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

5-LS2-1. **Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.**[Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 3–5 builds on K–2 models and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop a model to describe phenomena.

Connections to the Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- Science explanations describe the mechanisms for natural events.

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment.

Crosscutting Concepts

Systems and System Models

- A system can be described in terms of its components and their interactions.

Observable features of the student performance by the end of the grade:			
1	Components of the model		
	a	Students develop a model to describe* a phenomenon that includes the movement of matter within an ecosystem. In the model, students identify the relevant components, including:	
		i.	Matter.
		ii.	Plants.
		iii.	Animals.
		iv.	Decomposers, such as fungi and bacteria.
		v.	Environment.
2	Relationships		
	a	Students describe* the relationships among components that are relevant for describing* the phenomenon, including:	
		i.	The relationships in the system between organisms that consume other organisms, including:
			1. Animals that consume other animals.
			2. Animals that consume plants.

		3. Organisms that consume dead plants and animals.
		4. The movement of matter between organisms during consumption.
		ii. The relationship between organisms and the exchange of matter from and back into the environment (e.g., organisms obtain matter from their environments for life processes and release waste back into the environment, decomposers break down plant and animal remains to recycle some materials back into the soil).
3	Connections	
	a	Students use the model to describe*:
		i. The cycling of matter in the system between plants, animals, decomposers, and the environment.
		ii. How interactions in the system of plants, animals, decomposers, and the environment allow multiple species to meet their needs.
		iii. That newly introduced species can affect the balance of interactions in a system (e.g., a new animal that has no predators consumes much of another organism's food within the ecosystem).
		iv. That changing an aspect (e.g., organisms or environment) of the ecosystem will affect other aspects of the ecosystem.

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CURRICULUM VITAE

TERRANCE BURGESS

Syracuse University
Department of Teaching and Leadership
STE 150 Huntington Hall
350 Huntington Hall
Syracuse, NY 13244
tburgess@syr.edu

EDUCATION

Ph.D. Candidate, Teaching and Curriculum—*Science Education*, Syracuse University, Spring 2020

Dissertation Title: Understanding the Science Identity Work of Elementary Students of Color
Advisor—Sharon Dotger

M.A., Education, University of North Carolina at Chapel Hill, May 2015

B.A., Geological Sciences, University of North Carolina at Chapel Hill, December 2011

RESEARCH INTERESTS:

Science Education, Equity and Access, Science Instruction for Social Justice, Science Identity Development, Science Curriculum Evaluation

PROFESSIONAL EXPERIENCE

Lecturer, Department of Education, Ithaca College 2017-Present

Courses Taught:

- **Curriculum and Instruction in Elementary School Science**
    - Required course for NY licensure designed to orient pre-service elementary MEd candidates to the content and design of Next Generation Science Standards-based curriculum in elementary science curriculum. The course involves current research, theory, practices for teaching science, and the integration of content-area literacy.
- **Professional Semester in Education—Student Teaching Field Supervisor**
    - A full semester of observation and supervised student teaching at both the middle and high school levels for MAT candidates seeking NY Secondary Licensure.

Teaching Assistant, Department of Teaching & Leadership, Syracuse University 2016-Present

Courses Taught:

- **Elementary Science Methods and Curriculum**
  - Co-taught required course for undergraduate students seeking NY licensure through the Inclusive Elementary and Special Education program. The course provides students with opportunities to explore relevant research regarding science teaching methods and content needed to plan and teach science units to all elementary students. Students further engage in and study approaches to science instruction (integration of literacy, writing, etc.) that engage all children in meaningful, powerful, and relevant science experiences.

- **Curriculum Problems in Science**
  - Discussion-based graduate course designed to provide students with opportunities to read and react to various educational issues pertaining to science curricula and pedagogy. The course considers both practical and theoretical considerations concerning science curricula, their development, and their implementation outcomes.

Secondary Science Teacher, Durham Public Schools, Durham, NC 2011-2015

Courses Taught:

- **Biology, Earth/Environmental Science, AP Environmental Science**
  - Participated in summer program with Duke University's Clinical Research Institute designed to conduct collaborative research involving clinical doctors, college students, high school students, and one high school teacher. Collaboration resulted in a peer-reviewed research publication.

Gulack, B. C., Laughon, M. M., Clark, R. H., **Burgess, T.**, Robinson, S., Muhammad, A., ... &Arnold, C. J. (2016). Enteral feeding with human milk decreases time to discharge in infants following gastroschisis repair. *The Journal of Pediatrics*, *170*, 85-89.

AWARDS AND FELLOWSHIPS

- National Science Foundation Graduate Research Fellow, 2017-Present
  - Proposal Title: Navigating the White space: Understanding how a group of undergraduate students of color persist in STEM. *Grant no. DGE-174698*.
- Jhumki Basu Scholar Award, National Association for Research in Science Teaching, 2019
- American Educational Research Association Workshop on Equity, Inclusion, and Diversity—*invited participant*, April 16-17, 2020.
- Brown and Holman Scholar, Syracuse University, 2016-2017 ($3,500)
- Graduate Scholar, Syracuse University, 2016-2017 ($500)
- Ronald E. McNair Scholar, University of North Carolina at Chapel Hill, 2010-2011

MANUSCRIPTS UNDER REVIEW

Burgess, T. Exploring the science identity development of elementary students of color through multiple domains. (Revise & Resubmit pending)

Burgess, T. "Science is Adventure." Using personal narratives to redefine science and understand the science identities of elementary students of color. (Revise & Resubmit pending)

CONFERENCES AND PRESENTATIONS

Burgess, T. (2017). Supporting equitable science instruction in the secondary classroom. Presented at the 2nd annual *It's GO Time* Lesson Study Conference. Syracuse, NY: November 7.

Burgess, T. (2018). Supporting equitable science instruction in today's classroom. Invited lecturer for NY Academy of Sciences' *Scientist in Residence* Program. Syracuse, NY: January 30.

Burgess, T. (2019). Exploring the science identity development of elementary students of color through multiple domains. Annual international conference of the National Association for Research in Science Teaching. Baltimore, MD: April 1.

Burgess, T. (2019). "Science is Adventure." Using personal narratives to redefine science and understand the science identities of elementary students of color. Annual meeting of the American Educational Research Association. Toronto, ON: April 7.

Bell, C. & **Burgess, T** (2020). Liberty and Justice for Us: using dialogue to center the lives of youth of color. Annual Globalization, Diversity & Education Conference. Airway Heights, WA: February 27-28.

Burgess, T. (2020) Exploring science identities through the lenses of possible selves. Annual international conference of the National Association for Research in Science Teaching. Portland, OR: March 15-18.

SERVICE

- Reviewer, National Association for Research in Science Teaching (NARST) Research Symposium, 2020
- Secretary, Equity and Ethics Committee, NARST, 2018
- School of Education Academic Integrity Panel, Student Panelist, 2017-Present
- Science Technology Entry Program (S.T.E.P.) Saturday Science Teacher, 2016-Present
- School of Education Assembly, Student Representative, 2016-2017; 2019-2020
- Black Graduate Student Association, President, 2016-2017
- Graduate Student Organization Department Representative, 2016-2017

PROFESSIONAL LICENSES

- North Carolina Comprehensive Science Teaching License (9-12)

PROFESSIONAL MEMBERSHIPS

- American Educational Research Association
- National Science Teacher Association
- National Association for Research in Science Teaching