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SCIENCE TEACHER EDUCATION

Grappling with racism as foundational practice of science teaching

Manali J. Sheth

Chicago, IL

Correspondence
Manali J. Sheth, PO Box 8464, Chicago, IL 60608
Email: mjsheth@wisc.edu

Abstract

While current science teacher education frameworks designed to support high-quality teaching have the potential to promote equitable science learning, they do not substantively engage with how racism organizes science teaching and learning. In this critical qualitative inquiry grounded in critical race theory and sociopolitical perspectives on teaching and learning, I analyzed the contradictions that emerged in science teaching practices that were both intended to support Student of Color science learning and engaged science-specific colorblind ideologies. The critical race theory analysis demonstrated how science teaching practices such as connecting to students' experiences, creating interests in science, representing scientists as role models, and scaffolding doing science maintain unequal racialized power relations between students and science when historical and contemporary legacies of racism are not directly confronted. I also propose a science teaching practice of "grappling with racism" as a possible transformative solution to disrupt racism in and through science teaching.

KEYWORDS

critical race theory, equity, practices, science teaching, secondary

1 | INTRODUCTION

While teaching about evolution, Mr. Solo asks the class: "Is there much variation in here—hair color, eye color, skin color—not really, but it exists. Darwin's observations—he noticed there were a lot of different kinds of birds—why? There are different animals in the rainforests in Africa and South America that are similar in climate—why? There are so many kinds of lizards on the Galápagos—why?" Romero raises his hand and quietly asks, "Why are we not all of the same race?" Mr. Solo quickly answers, "What do you mean? There is only one kind of human, though. Good question." Continuing with the lesson, Mr. Solo states, "He made all of these observations and started asking questions and asking why. That's what scientists do." Following a mini-lecture on fossil evidence for evolution, Mr. Solo introduced the day's sense-making activity, "Now you are going to be scientists and do a puzzle. You have [images of] bones in your envelope and you have to catalog the bones under chimpanzee or human." As class ended, Mr. Solo initiated debriefing the lesson while students, including Romero, were still in the

classroom. When I asked about Romero's question, Mr. Solo, not remembering it, asked Romero to repeat it. After Romero reasked his question, Mr. Solo validated that it was a good question and said he would have to look it up. The question was not revisited during class or interviews.

The above scenario, taken from a bilingual biology class serving Latinx students living in Great Lake City (all names are pseudonyms), sparks many questions: Why did Mr. Solo say there was not much variation in hair color, skin color, and eye color in the class when there was? What science teaching and life experiences prompted Romero to ask his question? How many students wonder something similar but never ask it out loud? Would White students ask this question? Why did Mr. Solo dismiss Romero's "why" question and legitimate Darwin's "why" questions? What about categorization of fossils would make students scientists? What messages did this science teaching send to students about themselves, their experiences, science, and science learning? How could and should have Mr. Solo responded—why? Does this classroom scenario provide insight into equity in science teaching and learning for science teacher education?

Students of Color, in spite of being interested in science, experience science teaching and learning that is qualitatively different from White students (Atwater, 2000; Brand, Glasson, & Green, 2006; Oakes, 1990; Tate, 2001). Institutional inequities prevent many Students of Color from realizing their full potential in several science measures such as achievement, course-taking, and career aspirations (Huang, Taddese, & Walter, 2000; Lewis, Menzies, Nájera, & Page, 2009; Oakes, 1990). In the classroom, standard curricula (Mutegi, 2011), nonresponsive teaching (Atwater, Freeman, Butler, & Draper-Morris, 2010), and inequitable classroom interactions (Kurth, Anderson, & Palinscar, 2002) further distance Students of Color from science. Those Students of Color who are high achievers must overcome the impacts of stereotypes or cultural dissonance from dominant conceptions of who is capable of science and who belongs in science (O. Lee, 1997; S. J. Lee, 1996; Rascoe & Atwater, 2005; Russell & Atwater, 2005).

Although policy documents make arguments for equity in science education based on the need to maintain economic competitiveness or to improve science through democratic representation, these arguments do not address the legacy of racism in society, science, and science education (Basile & Lopez, 2015; Parsons & Dorsey, 2015). Making science education more equitable is a necessary part of paying down the science/science education portion of the education debt (Ladson-Billings, 2006) and struggling for a more just society. Toward this goal, some science education scholars have called for explicitly addressing the racial dimensions of these persistent inequities (e.g., Parsons, 2014; Rodriguez, 2015). I engage this call in the context of research in science teaching to inform science teacher education.

Based on a critical race theory (CRT) analysis of the practice of three secondary science teachers, I illuminate how science teaching shaped by colorblind conceptions of science and students perpetuates racism by creating inequitable science learning opportunities for Students of Color. Following this analysis based in empirical classroom data, I propose the race-conscious strategy of "grappling with racism" as a possible transformative solution. The following research questions guide this analysis:

1. In what ways did secondary science teachers nurture the science learning of Students of Color?
2. In what ways did this science teaching perpetuate racism by maintaining unequal power relations between Students of Color and science?
3. What might a race-conscious solution in science teaching and science teacher education necessitate?

In this article, I define "Students of Color" as a political identity to further a justice-oriented science teaching agenda that seeks to end racism (for all racially subordinated groups) and other systems of oppression (see, e.g., Ross, 2011, for the origin of "Women of Color" as a political identity). I use "students" to mean all students, "Students of Color" to mean all racially subordinated students, "White students" to mean students from the dominant racial group, and African American/Black, Asian American, Latinx, and Native American students when identification of specific racial group membership and history of subordination (Mutegi, 2011; Parsons, 2014) adds to understanding the argument or teaching episode.

2 | CONCEPTUAL FRAMING

This research is grounded in critical conceptions of race and racism, science education, and sociocultural theory. The framework consists of the following four subsections: racism and critical race theory in U.S. contexts, racism and science, equitable science teaching and learning, and teaching and learning as socioculturally and sociopolitically mediated practice. Together, these ideas lay the foundation for critically examining how racism operates in science teaching.

2.1 | Racism and critical race theory in U.S. contexts

Race is a sociopolitical construction created by racism to categorize people by phenotypic markers, such as skin color, eye shape, and hair texture, and to attribute social meanings to these physical characteristics (Roberts, 2011). While racial categorizations, identifications, and meanings are fluid across contexts (Omi & Winant, 2014), racism remains permanent as a system of oppression that confers advantages to White people while exploiting, devaluing, and subordinating people of color (Bell, 1992). The permanence of racism means that racism does not consist of ahistorical, individual, or aberrational events but rather is endemic to and a normal part of American life (Matsuda, Lawrence, Delgado, & Crenshaw, 1993), including education (Ladson-Billings & Tate, 1995), science (Harding, 1993), and science education (Parsons, 2014). Although race is not a biologically or culturally determined set of fixed group characteristics, daily experiences are racialized or structured by sociopolitically and historically constructed racial meanings (Martin, 2009; Omi & Winant, 2014). Thus, while race may not "exist," people's experiences in society, science. and science education are racialized (Mutegi, 2013; Parsons, 2014).

Given the permanence of racism and the invisibility of racism to the dominant group, CRT emerged as a tool to understand and transform the relationship between race, power, and the law (Crenshaw, Gotanda, Peller, & Thomas, 1995). Over the past two decades, education scholars have adapted and expanded CRT to substantively engage with race and racism in education (Ladson-Billings & Tate, 1995). While varying strands of CRT in education scholarship foreground different tenets and constructs, one unifying theme of this scholarship is the critique of liberal and dominant ideologies (DeCuir & Dixson, 2004). CRT's critique of liberalism, which is based in ideologies of individualism and equal opportunity, demonstrates how colorblind social practices fail to produce equitable outcomes for people of color (Crenshaw et al., 1995; DeCuir & Dixson, 2004). For this analysis, I engage a critique of liberal ideologies salient to science teaching and learning—universalism and individualism, race neutrality, equal opportunity and meritocracy, and objectivity—to uncover how colorblind science teaching intended to support Students of Color further perpetuates racism.

The interconnected web of liberal ideologies assumes an ahistorical understanding of race and racism creating the illusion that individuals and institutions can enact race-neutral policies and practices (Crenshaw et al., 1995). CRT analyses demonstrate that, in fact, these same entities have been inculcated in dominant racial meanings since inception, rendering race neutrality impossible (Lawrence, 1987). Notions of objectivity in knowledge production and other determinations of quality promote beliefs that criteria for validity, quality, and merit, and the practices that establish and assess these criteria, are not impacted by the social locations and perspectives of those who hold the decision-making power to reify and reproduce them (Crenshaw et al., 1995). CRT scholars engage methodological tools such as "looking to the bottom" (Matsuda, 1987)—or engaging the experiential knowledge of subordinated groups—to illuminate how seemingly objective perspectives, claims, and criteria are reflections of dominant White interests and cultures (Ladson-Billings & Tate, 1995; Solórzano & Yosso, 2002).

Similarly, notions of universalism deem that policies and practices transcend social and political racial groupings and can be applicable and legitimate irrespective of experiences shaped by domination and subordination (Parsons, 2014). Thus, claims of "science for all" or "building on students' ideas and experiences" create a false universality given the evidence that, in terms of symbolic and material experiences in science classrooms, science is for some (White people) and some students' ideas and experiences are centered over those of others (Students of Color). CRT affords countering claims to universality by grounding knowledge, policies, and practices in the particularity of group experiences, contexts, and interests. Toward addressing the myths of meritocracy—the idea that success is based purely on

individual effort—CRT scholars reveal how false claims to race neutrality, objectivity, and universality contribute to success for White people while presenting barriers for people of color (DeCuir & Dixson, 2004). Such analyses highlight the mechanisms by which historical, sociopolitical, and cultural factors perpetuate racism through supposedly merit-based institutions, such as schools and science (Ladson-Billings, 2012).

The ideologies discussed above mystify the ways that racism operates through erasing or distorting the institutionalized race-based experiences of people of color while centering and normalizing those of White people. By ignoring the existence of and connections between past and present injustices, these ideologies promote policies, practices, and beliefs that maintain asymmetrical power relations by race. Furthermore, the liberal focus on individual participation and opportunity constrains analyses and possible solutions to being grounded in colorblindness versus race-conscious ideologies. Thus, while supporting egalitarian and democratic ideals, liberal and dominant ideologies oppose direct changes to beliefs, policies, and practices that would make such ideals into reality. CRT scholars engage the contradictions that emerge to create possibilities for transformative race-conscious solutions (Crenshaw et al., 1995).

2.2 | Racism and science

Racism is inextricably linked to science as an institution and privileged area of knowledge construction (Harding, 1993). Although science is often misrepresented as an unbiased knowledge-seeking enterprise that objectively seeks universal truths about the natural world (Hodson, 1993; Walls, 2014), critical science studies scholars and scientists of color continue to demonstrate the ways in which science policies and practices have been informed by and inform racism. For example, White science institutions and scientists systematically have guarded the boundaries of science through gatekeeping mechanisms such as excluding the perspectives of communities of color and/or coopting the scientific work of people of color while erasing their contributions (Harding, 1993; Malcom, 1990). Additionally, White scientists and science institutions, operating from white supremacist assumptions rather than objective scientific methods, legitimated ideas about racial differences in relation to intelligence and personality/cultural traits to support the subjugation of communities of color (Gould, 1996; Hart, 2013; Jackson & Weidman, 2006). There is also mounting evidence that scientific knowledge production, represented as race-neutral, has been built on the unethical treatment and exploitation of the bodies and knowledge of communities of color for the benefit of White institutions and individuals (Jones, 1993; Montoya, 2011; Roberts, 2011).

2.3 | Equity in science teaching and learning

Research on student perspectives has implications for considering how teachers interact with and support Students of Color in science classrooms. Students of Color, both low and high achieving, are aware of the expectations that teachers have for them and the racial stereotypes that exist about their groups in science classrooms (Brand et al., 2006; S. Lee, 1996; Rascoe & Atwater, 2005). These perceptions and stereotypes influence student behavior such as feeling like they have to be "on guard" with teachers and/or feeling like they cannot ask for help when needed (Brand et al., 2006; Ryu, 2015). Deep-seated ideas about race and ability have limited how the intellectual resources and participation of Students of Color are perceived and leveraged for further learning (Kurth, Anderson, & Palinscar, 2002; Warren & Rosebery, 2011). The curriculum also becomes a site for negotiating, reifying, and challenging racial meanings (Donovan, 2015). Additionally, learning science, due to racialized life and school experiences, can be a painful process for Students of Color who must navigate between dominant ideologies and epistemologies of science and their lived realities (Aguilar-Valdez et al., 2013).

Given the inequitable state of science education, policy, and teaching research have supported efforts toward making science teaching and learning more equitable (see, Lee & Luykx, 2006). Drawing upon work from sociocultural and sociopolitical perspectives (e.g., Ladson-Billings, 2009) on teaching, different conceptions of equity in science learning have developed to include any or all of the following goals: (a) increasing opportunities for learning science content and practices, (b) supporting students to see themselves as scientists, and (c) empowering students to learn science as a vehicle for change. Although much of the scholarship around equity in science teaching and learning has been

developed through working with racially subordinated youth, substantive engagement with racism in understanding science teaching and learning is not readily available (Parsons, 2014).

Working toward equity goals has emphasized teaching that builds science learning on students' ideas and experiences, engaging students in science epistemological practices that both connect to and expand students' cultural repertoires (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001), supporting critical science agency for students to use science for their needs (Basu, Barton, Clairmont, & Locke, 2009), and making the science curriculum more inclusive through representations of scientists other than White men (Bianchini & Solomon, 2003; Malcom, 1990). Current conceptions of good science teaching, such as ambitious science teaching (Windschitl, Thompson, Braaten, & Stroupe, 2012), have much to offer in terms of promoting participatory equity goals. They, however, remain colorblind by not critically addressing racism embedded in science and science teaching.

Science teacher education research shows that science teachers also struggle to learn and enact equity-based pedagogical frameworks in the context of science (Bianchini & Solomon 2003; Braaten & Sheth, 2017). The reported challenges that science teachers experience is a culmination of sense making about innovative science pedagogies, social constructionist or sociocultural perspectives on science, and the tensions that arise from examining one's own positionalities in relation to broader societal structures (Mensah, 2009; Rodriguez, 2005). When specifically confronted with questions about how race and racism may inform science teaching and learning, science teachers had trouble reasoning with ideas about race as a part of science teaching and learning in large part due to colorblind or individualistic definitions of racism and universalistic ideas about science and science teaching (Larkin, Maloney, & Perry-Ryder, 2016). While local science teacher education efforts to critically address racism in science teaching and learning exist (e.g., Atwater, Russell, & Butler 2014; Warren & Rosebery, 2011), mainstream science teacher education policy has yet to substantively engage with race and racism.

2.4 | Teaching and learning as socioculturally and sociopolitically mediated practice

At the crux of conceptualizations of equity in science teaching and learning are the sociocultural and sociopolitical relationships between Students of Color, science/school science, and the teacher's role in mediating these relationships (Sheth, 2014). I define teaching as social practice, or group-defined, goal-oriented, everyday activity, rather than as the craft of individual teachers who behave and believe in unique ways (Ball, Sleep, Boerst, & Bass, 2009; Hatch & Grossman, 2009; Lampert, 2010; Windschitl et al., 2012). Practices consist of collectively routinized ways of knowing, desiring, and doing (for syntheses, see Reckwitz, 2002; Schatzki, Knorr-Cetina, & Von Savigny, 2001). A practice is constituted by the interconnection of particular ways of understanding the world and oneself, using particular tools and artifacts, and acting in the world. Practices are socially learned activities carried out by individuals who, as agents, engage in local performances, adaptations, and improvisations specific to their contexts. Thus, a social practice perspective on science teaching connects the work of individual teachers in particular contexts to broader socially learned, tool-mediated activities.

From a sociocultural perspective, learning is defined by interrelated shifts in goals, practices, and identities (Nasir, 2002). These shifts are mediated through activity supported by and the eventual appropriation of tools (externally oriented to support activity on the world) and artifacts (internally oriented to support activity on oneself) (Vygotsky, 1980). Tools and artifacts, arising from social interaction, support the development of the ways of desiring, knowing, and doing associated with a given teaching practice by enabling and constraining particular activity (Grossman, Smagorinsky, & Valencia, 1999). For this critical analysis, the conceptual or ideational tools and artifacts (Nasir, 2004) that are foregrounded are liberal ideologies embedded in mainstream conceptions of science as they inform science teaching. In exploring the potential for merging sociocultural learning perspectives with critical theories of race to understand classroom life, Nasir and Hand (2006) called for a focus on (a) classroom practice as instantiations of structural relations of racial power in terms of understanding "how hierarchies of power fueled by structures and perspectives in society become reproduced in the local activities of the classroom" (p. 465); (b) tools and artifacts, such as ideas of race embedded in liberal ideologies, as mediators of how sociocultural activity and access get organized; and

(c) learning as shifts in social relations organized by race such that the relationship between students, science, and science learning afford possibilities for transformative participation.

In the above section, I defined racism and the CRT tenet of critique of liberal ideologies, outlined a revisionist history of racism in science, highlighted understandings of equity in science teaching and learning, and conceptualized teaching and learning as sociocultural and sociopolitical practices. Taken together, these theoretical and conceptual underpinnings focused my research design and data analysis on ways that science teachers tried to promote equity in science learning for Students of Color, the ways that racism manifested in the social practice of science teaching, and how these manifestations constrained transformative science learning opportunities.

3 | METHODS AND RESEARCH CONTEXTS

In this critical qualitative inquiry (Cannella & Lincoln, 2009), I made principled decisions based in critical race methodology (Solórzano & Yosso, 2002) to maintain the centrality of race and racism, challenge dominant ideologies in research, engage the contradictions that arise from the institutional potential for oppression and transformation, and take a transdisciplinary perspective on understanding racism historically and in current times across science and educational spaces.

3.1 | Participants

Great Lakes City School District (GLCSD) is located in a midwestern urban center that, like many urban districts, serves a majority racially minoritized student population and has been experiencing divestment in public education. I enlisted GLCSD district-level science coordinators and local academic networks, consisting of people from diverse racial backgrounds, to purposefully identify secondary science teachers who taught in schools serving a majority of racially minoritized youth and had demonstrated a commitment to nurturing the science learning of Students of Color. Three teachers, Ms. Tomlin, Mr. Gentry, and Mr. Solo, were enrolled in the research following initial conversations and classroom observations verifying their goals to attend to the academic and social learning needs of Students of Color. Initial conversations also revealed the teachers to be active participants in professional science teaching communities and conversant in common science teaching ideas and activities.

Ms. Tomlin, who had been teaching for 23 years at the time of data collection, identified as White. Her selected focus course was an AP biology course that enrolled 19 African American/Black, 7 Asian American/Asian, 2 Hispanic/Latino, 2 Multiracial, and 3 White students.

Mr. Gentry had completed five years of teaching and identified as White. A biology course and an earth science course were selected to allow for the possibility of comparison across biology courses while offering insight into equity in physical science teaching. The biology course enrolled 2 American Indian, 1 Asian American, 19 Hispanic/Latino, and 15 White students. The earth science course enrolled 1 American Indian, 1 Asian American, 2 African American/Black, and 12 Hispanic/Latino students.

Mr. Solo, identifying as multiracial (Latino and White), had taught for nine years. The research focused on a Spanish bilingual biology course in which all 31 students were identified as Hispanic/Latino. Two of these students also identified as Black. I share this district-derived racial demographic data to contextualize the analysis in terms of how participant teachers engaged with race, racism, and racialization given who was and was not present in their classrooms. This demographic data do not engage the complexities and fluidity of lived social constructions of race and racialization.

3.2 | Data collection

Data collection consisted of participant observation, postobservation interviews, one semistructured interview at the beginning and end of the research year, classroom artifacts, and researcher memos. I observed each teacher's target course approximately one time per week. During observations, I noted turn-by-turn teacher and student talk,

body language, gestures, energy-level trends, visibly expressed emotional cues, and questions that were provoking for me. These notes were developed into ethnographic field notes that highlighted classroom instances related to students' experiences, ideas and sense-making, representations of science and scientists, teaching routines, participation/nonparticipation norms, and "what did not happen" (Patton, 2002, p. 295 in Merriam, 2009), given particular instructional openings.

Responsive interviewing methods (Rubin & Rubin, 2011) were used during two semistructured and postobservation interviews, all of which were audio recorded and transcribed. The semistructured interviews were conducted at the beginning and end of the study to gain insights into each participant's background and science teaching. The second interview is most pertinent to the current analysis as it centered on co-constructing a summary of each participant's teaching (e.g., goals, routines, tensions, and approaches), explicitly identifying tools, goals, and activity used to support Students of Color, and teachers' general ideas about equity and science. Postobservation interviews were designed to elicit teachers' goals, decision-making, interpretations of classroom events, and dilemmas. I also used these interviews to record teaching and learning activity on days that I did not observe.

Additionally, I collected teacher-generated classroom products (e.g., PowerPoints, activities, and exams) and student-generated learning artifacts (e.g., projects and discussion posts) to add to interpretations and critical analyses of participants' science teaching. In total, the data consisted of 121 hours of observation, ~50 hours of postobservation interviews, ~14 hours of semistructured interviews, and ~600 teacher- and student-generated artifacts.

3.3 | Data analysis

Data from each participant were first organized into discrete classroom teaching episodes consisting of related sections of field notes, interview transcripts, and classroom products. Data analysis was carried out in two stages. The first stage focused on constructing themes for the science teaching practices that participants engaged to support Students of Color in disciplinary science learning. The second stage consisted of an analysis of the science teaching practices using the CRT tenet of critique of liberal ideologies to uncover how these colorblind practices perpetuated racism.

To answer research question one regarding how science teachers nurtured science learning of Students of Color, I used first-cycle, in vivo and process coding (Saldaña, 2016) of teaching events for each participant teacher to construct categories of science teaching practices consisting of goals and activities. These science teaching practices were then coded for saliency of race and racism with respect to supporting Students of Color. Given the known silences around engaging with issues related to race in schools (Castagno, 2008; Parsons, 2014), saliency of race and racism was determined by the following criteria: (a) teachers or students explicitly named race or racism, (b) teachers or students used coded language that had connotations of race (e.g., supporting "these" students, "their" experiences, "they" need to see, etc.), and/or (c) I identified race or racism as salient based on theoretical and cultural sensitivity (Bernal, 1998; Strauss & Corbin, 1990). My theoretical and cultural sensitivity was developed from deep engagement with literature in critical science education, critical science studies, critical race studies, and my positionality. The science teaching practices in which race or racism had salience were analyzed using second-cycle focused coding (Saldaña, 2016) and constant comparison across participants using disciplinary science learning codes and equity in science teaching codes derived from the conceptual framework. The resulting categories were synthesized into themes (Saldaña, 2016) of supporting Student of Color science learning. Trustworthiness and authenticity for this portion of the analysis was established through member checking and refining representations of teaching, goals, and dilemmas with each participant as well as engaging in consciousness raising dialogue toward change in practice during the second formal interview (Lincoln, Lynham, & Guba, 2018).

The CRT analysis prompted by the second research question arose through analytical memo writing during data collection in response to the following contradiction: While the science teachers were trying to support Students of Color in learning science in ways considered successful by mainstream standards, they were struggling to name racism and to fully engage with the experiences, ideas, science activity, and collective histories that Students of Color were bringing into the science classroom—how were these disciplinary science teaching practices instantiations of broader power relations (Nasir & Hand, 2006)? To maintain fidelity to a CRT methodology and "look to the bottom" in this research

context, I engaged Student of Color participation in teaching episodes as an entry point into analysis. I grounded this analysis in the critical science studies portion of the conceptual framework that outlined the historical realities of communities of color and science (e.g., Harding, 1993; Roberts, 2011). Each science teaching theme and constitutive goal, activity, and ideological tool were analyzed as mediators of classroom racial power relations (Nasir & Hand, 2006) using the CRT tenet of critique of liberalism, selected for its affordance in illuminating how colorblind ideologies structure institutional practices (DeCuir & Dixson, 2004). Lastly, to illuminate how racism, perpetuated through these liberal ideologies and constrained rigorous and transformative science learning, the critical race analysis made visible how the science teaching practices failed to shift power relations between Students of Color and science.

I used the idea of social justice validity in alignment with CRT and critical qualitative methodologies and epistemologies (Parker & Lynn, 2002) to assess the rigor, usefulness, and authenticity of my analyses. I engaged the community in the form of critical friends well versed in equity issues in science education and CRT and centering the work of critical scholars of color to maintain the plausibility of the CRT analyses of science teaching practices. Additionally, I critically engaged with my positionality (presented in the next section) as it informed this research. Lastly, heeding Parker and Lynn's (2002) call to connect CRT research to educational practice and activism related to issues of race, I drew on my empirical analysis to advance "grappling with racism" as a foundational practice of science teaching.

3.4 | Researcher positionality

My angle of vision (Collins, 2000) for this research is rooted in my experiences as a science learner, science teacher, and science teacher educator of color who works in science and multicultural teacher education as an Asian American woman critical race scholar. My experiences of being Asian American in science, co-constructing scientific knowledge with Students of Color in a school system that was failing them, and struggling with White preservice teachers to engage ambitious science teaching with Students of Color informed every aspect of this research. Years of working closely with Students of Color who responded to science with wonder and skepticism and science teachers who question the usefulness of critical perspectives for better science teaching sharpened my focus during data collection and analysis. These experiences enabled me to question and "see" how racism operates in science classrooms and counter deficit-based perspectives of Students of Color embedded in science teaching. In this article, my multiple consciousness (Matsuda, 1989) enabled me to make meaning of participant teaching in the context of broader science education narratives *and* redefine Student of Color participation in science classrooms as pathways into unmasking manifestations of racism. As an Asian American working to disrupt African American and Latinx experiences of racism in science education, I engaged with collective critical consciousnesses of multiple communities of color and critical reflexivity in research decisions to limit the potential for exploitation and perpetuation of White supremacy (Matsuda, 1993).

4 | FINDINGS: MAKING COLORBLIND RACISM IN SCIENCE TEACHING VISIBLE

In this section, I present an answer to the first research question: What kinds of science teaching activity did participants intentionally engage to nurture science learning for Students of Color? The findings are grounded in my CRT analysis of participant teachers' equity-centered classroom efforts to support Students of Color. The following four themes emerged across participants' science teaching: (a) connecting with students' experiences to support conceptual understanding, (b) creating a vested interest in science and science learning through social relevance, (c) representing scientists (of color) to support Student of Color science aspirations, and (d) scaffolding doing science with a focus on science methods and tool use.

Based on the conceptual framing of science teaching as social practice, each theme is developed through evidence from field notes and interviews to bring key teaching goals, ideological tools, and activity into focus. Presentation of the themes also notes specific moves that did not unfold to highlight alternative activity. Multiple episodes are included in each subsection to acknowledge the variation in teaching within each theme. While episodes from each teacher's

classroom looked, sounded, and felt different, the continuity in science teaching goals, tools, and activity toward supporting Students of Color in ways that upheld colorblind science learning serves as an entry point into the critical race analysis presented in the subsequent Interpretation section.

4.1 | "Are you talking about you or Black people?": Connecting with students' experiences

A common science teaching activity engaged by participants to specifically support Students of Color was connecting students' experiences to promote conceptual understanding. Although teachers selected relevant examples to connect with Students of Color, universalistic and individualistic ideologies prevented race-conscious understandings of relevance and critical engagement with students' experiences in relation to the phenomena under study.

An illustrative instance of connecting science concepts to the experiences of Students of Color in colorblind ways arose more prominently when Ms. Tomlin adapted the textbook curly hair example for protein folding to focus on experiences of getting a perm to be more relevant to African American students in her class. As she stated during the debrief interview, "Hopefully they'll remember all this, but they're not gonna remember it if I don't give them anything that relates to an experience they've had." I include excerpts from my researcher notes to highlight the way science teaching created space for some Students of Color to connect to science while subsequently universalizing experience:

> *Ms. Tomlin lectured about protein structure and function and the energy level was low. Ms. Tomlin talked about hydrophobic side chains, hydrophilic side chains, and secondary protein folding. Half the class, particularly Black women, had their heads down. Then, Ms. Tomlin asked, 'If we say that the function of proteins depends on the shape, something needs to hold it in place. Who has gotten a perm?' Had I heard right—did she just ask the class about getting perms? I looked up to see how this would unfold between this White teacher and the class of mostly Black and Asian American students. Everybody's heads were up. Many Black women looked around at each other wondering if they should answer the question and how they should answer it. Aiyesha tentatively raised her hand, "Are you talking about you or Black people?" Ms. Tomlin smiled and responded, "Same end. I know when I get a perm my hair gets curly, when you go to get a perm, your hair gets straight. The result is the same. You are changing the shape of your hair." Ms. Tomlin and the class continued side conversations about perms and cultural hair experiences for a few minutes before she continued the protein structure lecture.*

Ms. Tomlin's intentional selection of the perm specifically created space for African American women to connect *some* of their hair experiences with science learning. The question sparked student interest while also revealing ideas linking hair texture, as a physical characteristic, to race and differential racialized experiences of hair. Ms. Tomlin, not ready to attend to and critically examine ideas of race and racism embedded in students' experiences of hair variation, focused on the sameness of the phenomenon to push standard science learning forward.

Similarly, in the article's opening vignette, Mr. Solo sought to connect abstract concepts of natural variation within populations to visible physical traits (skin color, hair color, eye color) that students noticed everyday. Rather than genuinely engaging with the variation in those traits within the class or with Romero's subsequent question regarding race, Mr. Solo erased the variation in traits that existed amongst students and circumvented Romero's question by negating the existence of race as a category that has meaning in students' lives.

Mr. Gentry, who routinely took a place-based approach to science teaching, created opportunities for students to develop deeper conceptual understandings while researching earth science phenomena connected to their interests. Toward this goal of engaging personal relevance, students were asked to select earthquakes, volcanoes, and rocks and minerals from around the world to investigate. My field notes highlighted many instances of Latinx students selecting topics that connected them to phenomena in Latin America as close to their families' countries of origin as possible and demonstrating higher levels of focus, participation, and assignment completion during these projects. In the second formal interview, Mr. Gentry reflected on this decision to "choose places that kids might be familiar with or that kids have some sort of cultural tie to" as a specific way to connect Students of Color with content; "I guess that sounds, on one level, really cheap, like surface-level—'oh because you've got Vietnamese kids they're going to be interested in Vietnamese caves,' but you could do the opposite and just talk about caves in southern Texas, which it may be just as

good, it may not." Mr. Gentry recognized the value of providing students with individual options to explore topics that held individual relevance; however, he did not recognize the potential of group relevance for Students of Color whose experiences of place are racialized and rarely centered in science learning.

4.2 | "Did he pay for it?": Creating a vested interest in science and science learning

Another way that participant teachers explicitly supported Students of Color in learning science was to motivate them to see societal benefits of science. They made moves to support Students of Color, who were at times skeptical, to develop a vested interest in science and science learning by invoking socially relevant contexts that demonstrated the power of science to positively impact communities and science learning to understand societal issues. Taking a race-neutral approach, however, constrained teachers from building upon the deeper science learning opportunities the students' skepticism and ethically oriented questions afforded.

During a unit designed to support student learning about micro- and macroprocesses of the hydrologic cycle in the context of Great Lake City, Mr. Gentry had students research a local superfund site (remediated toxic dump location) to focus them in on questions about water contamination and ground water. During this research time, Students of Color, who sporadically engaged in class, exclaimed: "I found it. It's this grassy land. They dumped garbage there"; "They bury garbage there"; "Is it by the Wal-mart"; "There is hazardous waste"; "It's where they bury it underground"; " Who buried it?"; "Well, I have a question. If they buried all that toxic stuff, then how does it have grass and stuff growing there?"; "Didn't something like this happen in the 70′s—contaminated water in this small town?"; "Can they take it out?"; "Is the guy still alive? Did he pay for it?" During this activity, Students of Color were making sense of social, political, and justice-oriented ideas in the context of where they lived as *a part of* science learning. While Mr. Gentry took up students' interests and questions related to movement of water and contaminants by assigning the development of investigations to explore various aspects of molecular (water and solute) movement, he did not take up the racial meanings, health repercussions, or economic costs of water-related issues on students and communities of color.

Mr. Gentry's goals and strategies to anchor students' learning of natural phenomena in the context of illuminating the social systems that interact with these phenomena were grounded in supporting students in making environmentally sound and health-conscious decisions. As he explained in a debrief interview around pedagogical decisions during the water unit,

> *[Be]cause water mixing right there does a lot to build motivation to learn about it because there's an obvious reason…Our day-to-day action—what we do and what we use, how we really are responsible, even if we say, "it's not my job"—we're impacting the lake.*

At the same time, he did not take advantage of an instructional opening to foreground the intersecting racial, economic, and class dimensions of these environmental issues.

While Mr. Gentry sparked student interest through the power that science learning afforded for understanding human impact on environmental health, Ms. Tomlin worked toward cultivating student interest in science through demonstrating the value of scientific knowledge and technology. For example, recognizing that some Students of Color in the class had voiced skepticism about science and biotechnology, Ms. Tomlin oftentimes provided examples of how science and technology are being used to benefit society. During a debrief interview, Ms. Tomlin shared her goal to support students in considering how biotechnology specifically benefited them after they had expressed concern over the possible negative impacts of gene and human cloning,

> *I mean these kids are touched by diabetes. Yesterday, I asked for a show of hands and more than two-thirds of the class knows somebody personally that has diabetes. It's really easy to get them caught up in the ethics of biotechnology… This was an attempt to say, there's two sides to this. Sure it's a slippery slope. Can things be taken too far? Of course, but you all know somebody with diabetes. Well, here's a way we've been able to use biotechnology to treat something that actually affects your life.*

In Ms. Tomlin's reflection about her emphasis on the positive side of science in general and biotechnology in particular, she recognizes the prevalence of diabetes within the lives of Students of Color and uses this fact as a way to counter

the seemingly abstract or distant possibility of science and technology going "too far" or having a negative impact on communities of color. Although she intentionally chose an example that could motivate Students of Color, she did not engage with the scientific and social ramifications for why diabetes is so prevalent in communities of color and how biotechnology has different costs and benefits along racial categories.

4.3 | "Wait!? She's the scientist?": Representing scientists (of color)

A third theme that arose across participants' science teaching to nurture Students of Color science learning was representing scientists of color in the curriculum toward providing role models for Students of Color. Ms. Tomlin and Mr. Gentry identified teaching moves to increase the visibility of scientists of color in their courses to address the underrepresentation of people of color in science and scientists of color in the science curriculum. Although Mr. Solo did not make efforts to represent scientists of color in his biology classes, he expressed in interviews that he saw himself as a Latino scientist role model for Latinx students and emphasized the importance of representation. The equal opportunity and meritocracy narratives undergirding the teachers' representational efforts masked the racialization of who count as and get to be scientists.

When asked during the second formal interview about specific pedagogical decisions to support Students of Color, Mr. Gentry talked about providing opportunities for students to research contributions of non-European or non-White men scientists as well as incorporating resources that highlighted the work of scientists of color into unit plans: "You know if they can see other people that either look like them or come from similar backgrounds as them being like, 'Oh, I could do that.'" He hoped that seeing examples of people from similar group memberships would support Students of Color in seeing science career aspirations as possible.

The main strategy Mr. Gentry used to counter students' images of scientists as White males was to de-emphasize White scientists by substituting the work of scientists of color as focal curricular resources (e.g., Neil deGrasse Tyson's *Death by Black Hole: And Other Cosmic Quandaries*) rather than relying on textbooks. During the second formal interview, he described instances in which he provoked students to question their ideas about who scientists could be as well as their ideas of what it meant to be African American or Mexican in relation to science:

> *What I'll try to do is deemphasize the White male role… Or, this is problematic in some way, but if you're changing your class role model from Bill Nye to Neil deGrasse Tyson, kids are like, 'Whoa, the funny African-American guy is—he's a really brilliant cosmologist and that's not what I pictured him to be after I heard him talk or after I read his article' … They [VICE] have this one about the trash in the North Pacific and the lead researcher is this Mexican woman. She's heading up the science for this trip out into the ocean. Then, it's just not what I think kids think of—they're like, 'Oh, so she's the scientist?' and it's like, 'Yeah, she's the scientist. She's the water expert here.' I think of those things that I do as my effort to try to make things—to try to kind of break down that stereotype of science.*

While acknowledging that these media provoked students to question the ideas they held about who does science in relation to racial stereotypes, Mr. Gentry did not publicly address these ideas.

Ms. Tomlin, in the second formal interview, framed the issue of racially diverse representations of scientists in terms of addressing the disconnect between Students of Color knowing they were capable of being scientists or science-related professionals and an internal doubt about those very capabilities: "I think if you asked them, 'could you be a doctor,' they would say 'of course I can.' But I think there's something underlying having never seen somebody that looks like them… that maybe cultivates a little bit of doubt." In an effort to publicly acknowledge a lack of scientists of color during a DNA research timeline activity, Ms. Tomlin shared her introduction to the assignment during a debrief interview,

> *I looked ahead to their DNA timeline and I scoured the (DNA timeline) history for an African American to put in there and I found one guy. So, I told the guys, I said, 'I couldn't find a Latino, I couldn't find an Asian, but I got some women in there and I got one African American. That's the best I can do. I'm going to tell you up front—this is a lot of old White guys'.*

With this teaching move, Ms. Tomlin sought to acknowledge and warn students of the pending hypervisibility of White scientists. She did not, however, critically engage students in possible explanations for the overrepresentation of White people in science. She continued on during the formal interview, "Everywhere they look—in their textbook, in video clips—everywhere they see these major advancements in science and it's always a White face, and that's not the whole story." While Ms. Tomlin acknowledged that the common narrative told by media and resources that only White men do science was incomplete, she did not address the source of this narrative as part of the science curriculum.

A contrasting example of how Ms. Tomlin incorporated the work and life of Charles Darwin to introduce the evolution unit demonstrates the treatment of prominent White scientists as exceptional rather than peripheral individuals who made it in science. Field notes from these introductory lessons show that students read a detailed account of Darwin's development of the theory of evolution, watched a video clip about Darwin from the History Channel, and continued to talk about the importance of his work throughout the year. During the debrief interview following the initial introduction to Darwin, Ms. Tomlin emphasized her goal of wanting students to get a sense of Darwin's person, life, and work so that they could appreciate both his human qualities and the exceptionalism of his scientific ideas:

> *I chose that article and then followed it up with the video because I just want them to see Darwin not as this mythical person, but he was human … How elegant that he came up with this idea that he couldn't completely substantiate at the time because we didn't have the science. And yet, all of the science we've learned since then has done nothing but confirm his idea.*

Ms. Tomlin's goals and classroom activities around Darwin focused on representing him as a complex person who engaged in revolutionary science whereas her goals for including scientists of color focused on representational diversity and tokenism.

4.4 | "Can you be other colors?": Scaffolding doing science

Aligning with the goal of wanting Students of Color to see themselves as capable of being scientists was the fourth teaching theme of providing scaffolded opportunities to engage in science practices. These opportunities consisted of developing testable questions, sensemaking around data, designing and conducting investigations to develop conceptual understanding, and learning how to use scientific tools of inquiry. As exemplified in the opening vignette when Romero's "why" question was dismissed while Darwin's why questions and the fossil activity were legitimated as doing science, the teachers maintained narrow definitions of science practices, grounded in objective, value-free conceptions of science, that often excluded the socially situated, intellectual participation of Students of Color.

The subtle ways in which the scientific engagement of Students of Color went unrecognized is demonstrated in the following lesson excerpt taken from field notes in Mr. Solo's class. Mr. Solo and the student teacher placed with him cotaught a lesson focused on the use of pedigrees to determine inheritance patterns through a case study of the Fugates of Kentucky. The episode highlights the ways in which the White student teacher and Mr. Solo disregarded Latinx student science participation:

Student Teacher: [Projects picture of Fugate family after Romero reads the introductory paragraph to the activity]
Multiple students: Oh! Oh, they are Smurfs! Oh, they are really blue!
Student Teacher: [Reads the next paragraph describing the physiology of the condition]
Multiple students [interjecting with questions]: Can you be other colors? Are you born with it or do you get it as you get older? If you get a tan, does it go away? Can you bleach your skin?
Student Teacher: [Snapping back] You could change your skin but the point is they still have a disease. All you need to know is that they have a disease.
Mr. Solo [Visibly upset at student teacher]: "So this is real science…" [Continues with a personal story outlining the use of pedigrees to determine cancer risks in family histories].

As the student teacher rushed to get to what she conceived as the science portion of the activity, several students attempted *to do* science. Their epistemic work included figuring out: (a) whether this condition was genetic or

brought about by environmental variables, (b) whether the blue was the result of skin pigment or something else, and (c) whether the blue could be changed by influences that changed existing skin tones. These were all legitimate science questions that directly related to constructing complex knowledge about the transmission and inheritability of a trait. Although the student teacher interpreted student participation as disruptive, students developed hypotheses to explain the phenomenon based on their experiences with skin color, skin-related phenomenon, and race. For example, the question about bleaching was asked by a Latina who, as a young woman of color, is probably aware of skin lightening creams advertised to make Women of Color "fair and lovely". Additionally, while Mr. Solo was upset by the student teacher's treatment of the class, he also did not interpret or leverage students' questions as doing "real science," a label reserved for doctors and scientists who engaged in practices such as using pedigrees or categorizing fossils (from the opening vignette).

An episode from Ms. Tomlin's class around a case study of the Tuskegee Syphilis Trials from the *National Center for Case Study Teaching* further illuminates the theme of scaffolding doing science specifically for Students of Color in ways that separate positionality from scientific knowledge production. Ms. Tomlin selected the case study as a resource that would both serve as an example of African American physicians and nurses working in and for Black communities and build student skills in critiquing scientific methods in terms of AP Biology requirements. During the second formal interview, Ms. Tomlin continued to process the divergence between her goals and students' goals during the learning experience:

> *Okay, so it's really easy to say what a horrible thing that was done to these people. Okay, but let's look at what we understand about how you design and implement an investigation, did they do those things? And in that context then, how do you evaluate what happened? Did they have a control group? Did they have all of those things—all of those things that we've been harping on all year that you need to have this, you need to have a large sample size or you need multiple trials. There were flaws in the design of that investigation that I wanted them to focus on but they got very stuck in the racial inequity and I think if they had read that article and not known the race of the study participants we might have had the conversation I wanted to have but that was just a little too raw for them.*

While Ms. Tomlin's science teaching and learning goals focused on developing better research skills through objective critiques of experimental design, Students of Color, particularly young Black men, engaged epistemic resources arising from collective experiences with racism to level a sociopolitical critique of the research. Students tried to provide a critical analysis of the science through questioning the epistemic validity of race-based decisions, taking and supporting stances, and debating the ethics of methodological decisions. Although these socially situated moves would be considered legitimate scientific practices for a justice-oriented science and could have been leveraged for deeper understandings of doing science, Ms. Tomlin adhered to mainstream guidelines for teaching experimental design.

5 | CRT CRITIQUE OF LIBERALISM IN SCIENCE TEACHING

The science teaching themes arising from participant teachers' classroom efforts were colorblind even though they were meant to specifically support Students of Color. CRT, as a theoretical framework, presupposes the permanence and presence of racism while providing analytical tools to uncover racism in particular, seemingly "race-free" contexts (DeCuir & Dixson, 2004). In this section, I use CRT to illuminate how the colorblind science teaching activity—defined as social practice consisting of goals, activity, and associated tools and artifacts—described in the Findings engaged liberal racial ideologies to maintain unequal power relations between Students of Color, science, and science learning. The historically contingent and science-specific particularities of the ways in which racially liberal ideological tools were used to maintain colorblind science teaching and learning stemmed from mainstream narratives of disciplinary science in science teaching and served to perpetuate, rather than disrupt, racism. Analysis of each science teaching theme is organized in three subsections: (a) a summary of the science teaching activity highlighting the liberal ideological tool(s)

engaged, (b) a critical race examination of how the ideologically informed teaching activity stemmed from dominant perspectives of science, and (c) an analysis of how the science teaching perpetuated racism through constraining shifts in power.

5.1 | Using universalism and individualism to ignore racialized experiences

5.1.1 | Summarizing the teaching

A central science teaching activity was to support relevant conceptual understandings of science through connecting to students' experiences and interests. In biology classes, this activity provided opportunities for students to consider biological concepts such as variation and protein folding in the context of familiar natural phenomena related to hair texture and skin color, the experiences of which are racialized. In supporting earth science learning, this activity focused on connecting to students' experiences of geographical and geological place to support conceptual understanding of phenomena related to plate tectonics, hydrologic cycles, and rock formation and mining. In both classes, the science teaching goal focused on relating to student experiences while ignoring the racialized dimensions of those experiences. Ideological tools such as "we are all humans" and "sameness" universalized all experiences while "everyone has different interests" individualized all experiences with the same result of hiding racial subordination as a daily experience for Students of Color.

5.1.2 | Analysis: Stemming from science

Ideas of science knowledge as universal suggest that all individuals and groups understand and experience the "natural" world in the same way irrespective of social and political experiences (Parsons, 2014). Universalist claims about science content continue to inform science education in spite of critical science studies arguments demonstrating that the natural, social, and political (i.e., decision-making) worlds are mutually reinforcing and constitutive (Harding, 1993). In trying to connect with the experiences of Students of Color without engaging with their sociopolitical experiences in relation to science's history in constructing race and racism, universalist ideologies reinforced the naturalization of race and legitimated the role of the scientific enterprise in naturalizing race via physical traits and geographical similarities. In doing so, existing power relations between people of color and science were maintained rather than disrupted and transformed.

5.1.3 | Analysis: Perpetuating racism

As science teaching created opportunities to relate science concepts to students' experiences, it also provoked racial sensemaking through focus on physical traits and geological features in the Global South. While some Students of Color engaged in this sensemaking publicly, it is safe to say that even more were doing this privately (Lewis, 2003; Pollock, 2004). The universalizing move to flatten differences by focusing on the sameness of biological processes or amplify differences by focusing on individual interests masked the embodied racialization that comes with those differences and normalized White experiences and interests. For example, skin color, hair texture, and geological phenomena are created through universal natural processes; however, students' connections to these are lived differently, have different political meanings, and have different symbolic and material consequences (Caldwell, 1991; Huber, Lopez, Malagon, Velez, & Solórzano, 2008; Roberts, 2011). These differences are part of racial group experiences shaped by racism for the purposes of domination and subordination and must be addressed as such for transformative science learning. Engaging ideologies of universalism and individualism constrained the possibilities for connecting to students' experiences with natural phenomena as a means to publicly work on and disrupt ideas about race as natural.

5.2 | Using race neutrality to dismiss student of color skepticism

5.2.1 | Summarizing the teaching

The teaching activity of "creating a vested interest in science" consisted of using science-as-solution scenarios (e.g., prevalence of diabetes or local water dynamics and quality) that directly related to communities of color to convince Students of Color that science was beneficial for them. While these scenarios, selected to be of interest to Students of Color, had the potential to stimulate productive and critical science learning, the race-neutral perspectives on science benefits, interests, and risks prevented interrogation of how racism structures community interactions with science. Thus, skepticism expressed by Students of Color was dismissed rather than considered an entry point into authentic learning about the value of science and science learning for Students of Color.

5.2.2 | Analysis: Stemming from science

Race neutrality, as an ideological tool, wrongfully presupposes that the benefits and risks of science are and have been equally distributed amongst all groups, regardless of racial categorization (Harding, 1993; Montoya, 2011). The science teaching moves derived from this idea prioritized race-neutral perspectives on how science-related issues may be relevant and motivating. In the case of engaging with environmental issues, concerns about environmental and community health did not center the specific concerns of communities of color that arise from the convergence of racism and classism and that could inspire learning and critiques of science and technologies. Additionally, race-neutral views on the value of science ignored how racism in science has and continues to shape policies and practices, lauded as well-intentioned, that maintain unequal power relations (e.g., forced sterilizations, social Darwinism and eugenics, forensic science and criminal justice).

5.2.3 | Analysis: Perpetuating racism

When presented with the implicit question of the worth of doing and learning science, several Students of Color in each teacher's classroom publicly shared ideas or questions that brought up ethical and conceptual questions toward learning the science at hand. While the teachers took up some of these questions, they were not prepared to engage with students' questions and ideas in race-conscious ways that validated the legitimate skepticism that Students of Color brought to science learning and that examined the racialized dimensions of science and community relationships. In missing these opportunities to leverage students' skepticism to name and confront racism while deepening conceptual understanding in science, science-teaching moves promoting race neutrality constrained the possibility of science learning that had the power to work toward a more just science.

5.3 | Using equal opportunity and individualism to imply meritocracy

5.3.1 | Summarizing the teaching

The "representing scientists" theme demonstrated science teaching equity concerns related to the question of who can be a scientist. The participant teachers made efforts to diversify representations of scientists to counter stereotypes of scientists as White. They hoped to create spaces for Students of Color to aspire to science learning and careers through incorporating media that featured or were authored by scientists of color. These episodes were the only time when all three teachers explicitly talked about a science issue in relation to race. However, liberal ideologies of equal opportunity and individualism emphasized a role model approach that unintentionally supported meritocratic myths about succeeding in science and made institutional racism in the science pipeline invisible.

5.3.2 | Analysis: Stemming from science

The ways in which representing scientists unfolded in these classrooms drew from images of science as an equal opportunity field—a field in which anybody capable of asking good questions, being willing to hold their ideas up for objective scrutiny, and thinking innovatively is able to become a scientist in spite societal barriers. These narratives of scientists

rendered institutional racism nonexistent or invisible. Representing White scientist exceptionalism further promoted the myth of meritocracy because White scientists were represented as individuals who were smart, worked hard, and asked the right questions, whereas scientists of color, when included in curriculum, were held up as tokens for the sake of representational diversity.

5.3.3 | Analysis: Perpetuating racism

Teachers attempts to subvert the mainstream curriculum's focus on White scientists through de-emphasizing White scientists and sporadically inserting scientists of color tokenized scientists of color as individuals who made it whereas White scientists were included as exceptional parts of the scientific community whose work was central to our understanding of the natural world. The absence of nuanced conversations about racism in the successes, struggles, and contributions of scientists of color and White scientists resulted in distorted, meritocratic notions of scientific knowledge production and, by association, science learning.

The focus on supporting Students of Color to think that they *could* be scientists overshadowed the possibility and need for critical conversations about who *gets* opportunities to be scientists and why. The "you *could* be a scientist" conversation centered assumptions about and changes to Students of Color, whereas the "who *gets to be* a scientist and why" conversation would necessitate confronting racism in all aspects of the science pipeline toward envisioning possibilities for more justice-oriented solutions. One such solution is the necessity of engaging White students and scientists in envisioning scientists of color as competent, significant, and full participants in the scientific enterprise.

5.4 | Using objectivity to minimize race-based epistemologies of communities of color

5.4.1 | Summarizing the teaching

The last theme presented in the Findings section highlighted varying attempts to support Students of Color in seeing themselves as scientists by scaffolding opportunities to do science. Science activity included asking questions about natural phenomena, designing experiments, using tools to analyze data, and making sense of data to draw conclusions. Because conceptions of science activity were grounded in an acontextual and objective ideology of scientific knowledge construction, this science teaching activity prioritized technical and intellectual work that delegitimized Student of Color participation in scientific sensemaking as people of color.

5.4.2 | Analysis: Stemming from science

Research in critical science studies and multicultural science education continues to demystify and demythologize science as an objective, value-free form of knowledge production uninformed by systems of oppression. However, mainstream science education centers teaching science practices devoid of historical, social, and political contexts. Adherence to principles of objectivity and focus on the technical aspects of understanding the natural world supported science teaching activity that centered questions of controlled experiments, multiple trials, and tool use (e.g., pedigrees, Punnett Squares, etc.) over questions of ethics, justice, and considering ways of knowing grounded in the epistemologies of communities of color. For example, objective ideas of doing science enabled dismissing the critiques and ideas of Students of Color, Latinas and Black men in particular, founded in collective knowledge and experiences of racism.

5.4.3 | Analysis: Perpetuating racism

Students of Color were engaged in sociopolitically oriented science; however, perspectives of science as objective placed these epistemic resources and possibilities as counter to the goals of doing science. Students were not encouraged to consider the ways in which positionalities and subjectivities inform the worth of asking particular questions, the interests served in particular lines of inquiry, and the frameworks used to define and guide science practices. Thus, when Students of Color engaged their epistemic resources based on their positionalities and experiences to critically

engage with doing science, teachers were not prepared to recognize, legitimate, or leverage these students' science participation. These science teaching moves served to reinforce boundaries and unequal power relations between Students of Color and science practices by constraining opportunities for Students of Color to see their endarkened epistemologies as important to doing science. Furthermore, by disregarding the possibility that Students of Color could engage in sociopolitical science practices, science teaching perpetuated racism by minimizing group of color collective experiences of racism and narrowing doing science to White conceptions of science.

6 | DISCUSSION

The purpose of this article was to examine ways in which racism manifests in colorblind secondary science teaching intended to nurture the science learning of Students of Color. Although participant teachers, selected for their commitment to the science achievement of Students of Color, engaged in teaching that is informed by broader science equity narratives, their goals and activity did not explicitly mention or address racism as a structuring factor in science teaching and learning. In other words, the science teaching fell short of transforming the relationship between students, science, science learning, and race. In this section, I summarize the answers to the first two research questions highlighting the contradictions made visible through a CRT critique of liberal ideologies.

6.1 | Science teaching supporting students of color—Science teaching perpetuating racism

6.1.1 | Connecting to relevant experiences—Flattening experiences of racism

Aligning with existing equitable science teaching research, participants made efforts to connect standard science content teaching to experiences that were significant to Students of Color (Windschitl et al., 2012). However, reluctance to grapple with race and racism served to flatten the ideas and experiences of Students of Color, as members of communities of color with particular historically contingent racialized experiences with science (Harding, 1993; Mutegi, 2011). Although the science teaching analyzed in this research sought to provide Students of Color a relevant entry point into developing conceptual understandings, the colorblind goal and activity left the science teachers unprepared to engage with experiences of phenomena as racialized and the possibilities of engaging with differences in political and generative ways. Students' experiences related to race and racism were minimized, in general, and considered irrelevant to science teaching and learning goals. Thus, racism was perpetuated by not engaging with the racialized dimensions of relevance (Ladson-Billings, 2009) as a part of science learning (Donovan, 2015)—an activity that could enable transformative opportunities for conceptual understanding, taking up tools to critically examine student ideas and experiences of racial categories, hair, or geography, and learning science's role in racial formations.

6.1.2 | Creating vested science interests—Cloaking the losses

The participants wanted students, particularly Students of Color, to develop interests in science as a discipline; however, the science teaching that was enacted did not leverage the sociopolitical and ethical questions around the uses of science that garnered their interests. The science teaching move centered on selecting local community concerns to cultivate a sense that science knowledge could afford a vehicle for agency (e.g., better decision-making to protect the water supply) and change (e.g., providing insulin to a community in which diabetes was prevalent). As students, primarily Students of Color, demonstrated a skeptical engagement with science and science learning through questions about ethics and accountability, the science teachers increased their focus on the benefits of science in race neutral ways. Leveraging students' interests in the fruitful and problematic aspects of science and technology in society could have afforded more transformative conversations about community-based concerns (Morales-Doyle, 2017; Parsons & Dorsey, 2015) and critical science agency (Basu et al., 2009) toward disrupting racism as an important dimension of science teaching and learning. Instead, student of color skepticism, an important quality of scientists and tool for people of color to protect themselves against racism, was dismissed.

6.1.3 | Representing scientists—Reifying the meritocracy

The participants explicitly identified the importance of including scientists of color role models in the curriculum as a science teaching activity that supported Students of Color in seeing themselves as scientists. Although there was much variation in the way that each participant addressed the issue of representation of scientists of color, their hopes were to counter ideas that individuals of color have not contributed to science or that only White scientists have made significant contributions. While scholars of color have called for more substantial inclusion of the counterstories of scientists of color (Butler, 2014; Cantú, 2008; Malcom, 1990), diversifying representation without addressing structural racism posits the problem in Students of Color and further reifies myths of meritocracy and equal opportunity (Baber, 2015). The visible responses from Students of Color when presented with resources or a blunt acknowledgement of the lack of scientists of color in the curriculum ranged from incredulity to acquiescence. Both of these responses highlight the need to understand students' explanations of racialized representation trends in science to disrupt racism. The goal and instantiations of science teaching designed to include scientists of color as role models rather than fully engage with how racism mediates access to, struggles for, and success in science careers and education curtailed the possibilities of students learning tools and skills of resisting racism. Supporting youth of color in developing critical consciousness about dominant ideologies like meritocracy and equal opportunity has been cited as a necessity for empowerment and hope (Lardier, Herr, Barrios, Garcia-Reid, & Reid, 2017).

6.1.4 | Scaffolding doing science—Illegitimizing students of color doing science

With the rising focus on science practices, all the participants were committed to having students see themselves as scientists by scaffolding opportunities for students to do science. This science teaching activity consisted of supporting student sensemaking around data, asking research questions, supporting claims with evidence, and learning how to use tools of inquiry. While the science teachers recognized student science activity when it resembled acontextual, technical perspectives on science, they did not engage with student epistemological activity that expanded ideas of knowledge construction in science. When Students of Color engaged their racialized experiences as sources of knowledge for doing science, teachers refocused on objective and technical notions of science practice. By not further exploring the epistemic work of Students of Color when they made the socially situatedness of the knowledge construction process visible, science teaching maintained the inequitable relations between scientific knowledge construction, power, and race (Harding, 1993).

6.2 | Proposing "grappling with racism" as a foundational science teaching practice

I now address the third research question of this article by proposing "grappling with racism" as a race-conscious foundational science teaching practice that disrupts racism in and through science teaching by supporting transformative science learning. Building on the idea of core science teaching practices (Windschitl et al., 2012), I refer to a foundational science teaching practice as one that other core practices are rooted in, informed by, and critically assessed with. As a foundational practice, I envision "grappling with racism" as mediating additional science teaching practices that are currently constrained by not explicitly naming, addressing, and disrupting racism. Thus, "grappling with racism" would facilitate transformative planning, implementation, and reflection on the nexus of core science teaching practices that constitute teaching science equitably. Additionally, aligned with the definition of core science teaching practices as being modeled, taught, and accountable, "grappling with racism" as a foundational practice of science teaching necessitates that it becomes an institutionalized part of the professional responsibility of science teaching and science teacher education, regardless of teaching contexts.

In proposing core science teaching practices designed to support novice teachers in intellectually rich science pedagogy, Windschitl et al. (2012, p. 898) suggested that "the most advanced forms of rigorous and equitable instruction are unattainable if the teacher does not have a caring relationship with students." Justice-oriented scholars have contended that caring for Students of Color academically and socially means developing a critical consciousness about how racism shapes the learning of all students in school (Ladson-Billings, 2009) and science (Mutegi, 2011; Parsons &

Dorsey, 2015; Rodriguez, 2015). In this research, empirical data analyzed using CRT as a theoretical framework uncovered the kinds of contradictions that arose from science teaching that attempted to support Students of Color while ignoring how racism differentially manifests across all racialized communities. Although the participants of the study were selected by district administrators and science teacher educators as science teachers committed to nurturing Student of Color science learning, their science teaching goals and activity were not grounded in substantively engaging with racism in relation to (a) students' experiences and ideas, (b) science-specific individual or community interests, (c) representations of scientists, and (d) doing science as socially and politically situated. They were not prepared to question and disrupt dominant racial ideologies embedded in learned notions of science and science teaching to make intellectually rich, transformative science learning attainable for Students of Color or their White peers.

Given the contradictions identified in the kinds of colorblind science teaching analyzed, I define "grappling with racism" as a foundational practice that provokes teachers to critically engage with these contradictions that emerge from racism manifested in science and science teaching to make principled decisions that disrupt persistent unequal relations of power between students, race, and science. An initial delineation of "grappling with racism" in science teaching consists of a complex of the following goals, mental activities, and physical activities:

- *Desiring*: Science teachers want to work toward deep science learning equity goals that support real (as opposed to abstract) symbolic and material shifts in power between students, race, and science. This means starting from the assumption that naming, confronting, and disrupting racism is a part of science teaching and learning goals (Mutegi, 2011) rather than extraneous, additive, or counter to science education goals. As goals and identity are connected (Nasir, 2002), developing these goals requires critical reflexivity on science teachers' own social positions and roles in taking up and relinquishing power (Joseph, Haynes, & Cobb, 2015; Mensah, 2012).
- *Knowing*: Science teachers understand the ways in which racial ideologies shape oppression and resistance with respect to science experiences, interests, representation, and participation. Learning to "look to the bottom", science teachers develop historically contextualized understandings of how community experiences with and engagement in science have been and continue to be racialized. This also means that science teachers develop sociopolitical conceptions of scientific knowledge construction grounded in epistemologies of communities of color in which asking the following types of questions is part of doing science: Relevant for whom, who benefits, whose interests are served, what are the costs and for whom, who gets to be scientists and according to what criteria, and from whose perspectives is this understanding of the natural world constructed.
- *Doing*: Science teachers engage in teaching enactments, curricular development, and critical reflection that explicitly confront racism and its contradictions in science teaching and learning while creating spaces for relevance and doing science rooted in the experiences and concerns of students and communities of color. This means taking and creating opportunities to disrupt racism as a part of science teaching and learning rather than avoiding and silencing these opportunities.

As a foundational practice that informs other core science teaching and learning practices, "grappling with racism" needs to be taught during science teacher certification programs with on-going learning of the practice particularized to contemporary social situations, student and community populations, and institutional contexts in which teachers work.

I return to the classroom episode that began this article to discuss implications for science teaching. While Mr. Solo acknowledged Romero's question of "*why* are we not all of the same race," he was ill equipped to engage with the contradictions that Romero's question illuminated: Race is based on biological traits but is not biological and race does not exist but it has real material outcomes. He validated Romero's participation as a student, but did not validate Romero as a scientist by centering Romero's question—one that has been pursued by communities of color working from resistant epistemologies for hundreds of years. Furthermore, by continuing on with standard science learning by saying "he made all of these observations and started asking questions and *asking why*. *That's what scientists do*," Mr. Solo silenced any further meaning-making around race and racism and excluded Romero's observations, racialized experiences, and why question from doing science while legitimating the scientific exceptionalism of Darwin. Lastly, when considering

the particularities of this episode in historical context—a Latino student asked about why racial categories exist in a science learning context about categorization and variation and he asked it at a time when Latinx youth in GLC were being racially targeted due to anti-immigration rhetoric around the DREAM Act—Mr. Solo did not grapple with racism, dismissed Romero's question, and, so, ended up perpetuating it. "Grappling with racism" in this particular context could have made the following possible:

- *Desiring*: The goal for science teaching and learning in this classroom could have been to support deeper biological understandings related to the diversity and unity of life based in evolutionary theory while wanting to support Latinx youth in using these understandings to debunk the idea that race is a biological category and facilitate empowerment to resist racism as they were experiencing it.
- *Knowing*: The science teaching could have engaged understandings or seeking out resources to learn the historical and current connections between racism and science knowledge related to diversity and evolution toward developing resistant or anti-oppressive racial ideologies and epistemologies. The science teaching also could have engaged sociopolitical perspectives of science teaching and practices to recognize Romero was doing science in that he was trying to make sense of ideas about variation and evolution to explain a phenomenon that was relevant to him.
- *Doing*: Potential enactments could have included (a) eliciting ideas and experiences from the class to leverage the connections they were making across ideas of natural variation, evolution, and race, (b) planning and implementing classroom discourse to teach students to critically analyze racism with respect to biological arguments of race, and (c) engaging students with the data and work of scientists, both of color and White, who have been establishing the nonbiology of race using various methodologies and epistemologies.

7 | IMPLICATIONS FOR SCIENCE TEACHER EDUCATION AND RESEARCH

To support science teachers and teacher candidates in learning "grappling with racism" as a foundational science teaching practice, science teacher education policies, practices, and resources must confront and disrupt the historical and contemporary legacy of racism in science and science education. This will require the continued design of critical ideological and material tools, resources, and practices that support science teacher learning in methods courses, field experiences, and teaching contexts. Additionally, these critical tools and resources should support engaging with race-based contradictions and making improvisations based on the particularities of various science areas, groups of students, teacher positionalities, and institutional contexts. As a field, we may also consider altering who gets to be science teachers and science teacher educators by incorporating openness to grappling with racism in all science teaching contexts as a criteria in admissions and hiring decisions.

With this article I also take up and extend the call of science education CRT scholars for increased research using CRT as a tool to illuminate how systems of oppression shape science education and to reconstruct science education as a justice-oriented field. The various tenets, constructs, and forms of CRT have the potential to inform equity conversations in science education. For example, engaging a TribalCrit lens could enable critiques and conceptions of grappling that identified settler colonialism and racism in the place-based practices of Mr. Gentry; AsianCrit could provoke critical explanations for the invisibility of the Asian American students in Ms. Tomlin's class, many of whom were underachieving, in teacher talk of support in this article; and Critical Race Feminism could engender intersectional analyses of science teaching and learning to understand how multiple systems of oppression interlock to shape particular student experiences and outcomes. Such analyses are necessary for a more generative and multi-dimensional understanding of "grappling with racism" as a foundational practice of science teaching.

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ORCID

Manali J. Sheth http://orcid.org/0000-0002-2206-3366

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