

Tracing different forms of politicized care in teaching physics to students traditionally underserved in science

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In this yearlong, naturalistic case study in a high school physics classroom, we examine the different dimensions of politicized care displayed by Sarah, an African American teacher teaching physics to working-class students of color traditionally underserved in science. Through extended field observations and a series of interviews with the teacher, we identified the various forms of care, *social*, *epistemic*, and *academic*, that Sarah expressed for her students throughout her teaching. We recognized that these forms of care are manifestations of Sarah's *politicized care*. As we traced Sarah's care along these different forms, we identified tensions and synergies among these expressions of care, differentially shaping opportunities for students' disciplinary learning. More broadly, our findings call for conceptualizing politicized care as an essential aspect of effective physics teaching, especially for minoritized students. This care involves careful acts of balancing disciplinary and teaching demands, mindful of wider societal and institutional inequities while honoring children as social, academic, and epistemic beings. Such care for her students can be understood as an intentional act of resistance to current oppressive educational and wider societal systems.

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I. INTRODUCTION

This work is inspired by an African American physics teacher, Sarah, and her teaching physics at an urban high school in the southeastern United States (U.S.), Grant High, serving largely African American students. Sarah had successfully grown enrollment in her physics courses in this school, where physics had not traditionally been well received, reflecting broader systemic inequities that historically marginalized specific student populations, particularly African American students, in science, technology, engineering, and mathematics (STEM) education. There is evidence to suggest that systemic inequities influence students' science learning in the United States [1] and beyond. For example, findings from Switzerland have shown that racial and gender inequities in physics impact preservice teachers' learning opportunities [2]. Gourlay and Mujtaba [3] describe gender disparity in physics education in England, with girls being underrepresented in students taking Advanced Level Physics, something they describe as an ongoing problem for the past 30 years. Taken together,

these findings suggest that nonmajority learners around the world (i.e., girls, students of color, and students from economically disadvantaged families) face barriers that complicate their STEM educational experiences. We look to the work of Sarah, in her efforts to teach physics to a group of nonmajority learners in the United States, to shed some light on effective ways to address these challenges.

Historically, physics at Grant High, and similar schools in the region, was not perceived as a core subject for many students, partly due to systemic inequalities and cultural perceptions that marginalized certain academic disciplines in predominantly African American schools. These trends reflect broader systemic issues identified in many STEM disciplines, where access to courses like physics is often limited for Black students due to historical and current underfunding, biased tracking systems, and cultural bias [4,5]. Research has shown that these inequities are not only systemic but are perpetuated by cultural narratives that devalue students from these communities from pursuing STEM areas. We launched our study with an observation from one of Sarah's classes, where students began a whole-class conversation about how other students at more affluent schools in the district did not respect the academic rigor of their school. They shared that students at other schools minimized their academic success, saying that "the work there [at Grant High] is easy" or "an A at your school is equivalent to a B at mine." After listening to this interchange, Sarah interjected, relating students'

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experiences to her own as an African American student at a Historically Black College and University and how she has often dealt with similar comments questioning the rigor of her education. During our reflection about this interchange with Sarah, she explained:

The students were explaining that they didn't want to attend a scheduled social with students from Valley High [a more affluent school serving a largely white student body]. Students from [Grant] get a lot of backlash because they are at a majority African American school and get looked down on, similar to other Black schools in the district ... Many people think that people from majority white schools like Valley get a better education. Also, people seem to think that because [my students] go to Grant High that their education is valueless, is not valued as much as [students who] go to Valley ... I was like, "yeah, the same perception exists for HBCUs [Historically Black Colleges and Universities], where I attended."

I mentioned the perception between Valley and Grant, which causes a lot of tension between the two schools because, as an HBCU grad, I witnessed it. My father witnessed it, and even my brothers witnessed it. It's the issue of us being looked down upon or thinking that students from PWIs [predominantly white institutions] are quote-unquote better or have a better education because they went to a PWI versus someone who goes to an HBCU. So, I understood what [my students] were saying in regard to why they didn't want to go with Valley students because they didn't want to deal with attitudes or misconceptions about them being at Grant, so I related to how they felt.

This honest, difficult discussion of class and racial tension in the local communities was far afield from the sorts of physics instruction we had expected to observe. While we immediately recognized the component of care in Sarah's physics teaching and work with her students, we came to understand Sarah's willingness to allow for and actively participate with her students in conversations about their racialized experiences as a form of *politicized care*, that is an enactment of care intentionally grounded in resistance to institutional and structural barriers that marginalize students of color and position them in deficit ways.

In the quote above, we see Sarah's racial identity serving as a means to empathize with her students, allowing her to connect with their lived experiences by channeling her own. In other words, Sarah's care for her students was rooted in her own experience with racism and class stereotypes as a Black woman in the southern United States. By exploring the complexities of Sarah's teaching

through the lens of politicized care, our work contributes to the growing scholarship on how teachers of color enact critical pedagogies within marginalized contexts [6]. We understood how Sarah's efforts to create a safe yet brave space allowed her students to collectively make sense of their racialized experiences within larger societal issues. This safe and brave space, where students can express their concerns and show vulnerability without fear of judgment or ridicule, supported Sarah's students to be more open and vulnerable about other challenges and emotions, personal and academic, that they were grappling with.

As we examined Sarah's physics teaching throughout the school year, we began to see the varied dimensions of this politicized care that supported students' success despite the social and institutional barriers that continue to stand in their way. In this work, we explore the different dimensions of politicized care and examine tensions and synergies between them to highlight the complexities in Sarah's physics teaching to students traditionally underserved in science.

II. THEORETICAL FRAMEWORK

As we began our investigation, we were inspired by Noddings' conceptualization of an ethic of care as central to teaching [7–9]. Noddings [7] suggests that the work of educators should be propelled by a commitment to an ethic of care that serves as a basis for ethical pedagogical decision making. Noddings described that educators must make a moral decision to enter into a relationship with students that "has both cognitive and affective dimensions" [7] (p. 775). We understand pedagogy that centers on an ethic of care to be grounded in a commitment to relationality. This commitment calls teachers to show deep, meaningful care for learners, care that shapes both students' personal identities and their academic success.

To build on Noddings' work, our study integrates aspects of cultural competence and social justice as defined by Parsons [10], which emphasized that care extends beyond just relationship building that often characterized early work in the field [11]. Consideration of care now includes a critically conscious approach to address systemic inequities that impact students' classroom experiences. In this study's context, cultural competence refers to Sarah's ability to recognize, respect, and integrate the cultural resources of her predominantly African American students into her physics instruction. Parsons' view of social justice involves creating a classroom environment that continuously pushes against systemic inequities and challenges deficit mindsets of marginalized students [10,12].

I do not mean to suggest that the establishment of caring relations will accomplish everything that must be done in education, but these relations provide the foundation for successful pedagogical activity. First, as we listen to our students, we gain

their trust and, in an on-going relation of care and trust, it is more likely that students will accept what we try to teach ... Second, as we engage our students in dialogue, we learn about their needs, working habits, interests, and talents. We gain important ideas from them about how to build our lessons and plan for their individual progress. Finally, as we acquire knowledge about our students' needs and realize how much more than the standard curriculum is needed, we are inspired to increase our own competence ([13], p. 4).

While this ethic of care has been recognized as an important aspect of education, conceptualizations of care too often pay scant attention to inequalities and power dynamics in school and the wider society. Extending Noddings' work, Parsons [10] urges our field to move beyond caring as relationship-building toward understanding care as embedded in cultural competence and a commitment to social justice. Parsons calls for *culturally relevant caring* that "acknowledges the goal of justice to safeguard the rights of all students—to be respected and to be treated fairly." Such a commitment mandates "some understanding on the teacher's part of systemic, political, economic, and social structures that disproportionately appropriate opportunity according to race and a commitment to challenge and alter them" [10] (p. 26). Parsons' conceptualization of care centers on racism and other forms of systemic inequities within a culturally sensitive, relevant, and sustaining pedagogy of care.

Gunckel and Tolbert [14] have called for engineering education to be reframed around ideas of empathy and care, but a care that acknowledges facets of the wider sociopolitical context and centralizes issues of justice. Similarly, Suárez and Krist [12] call for science teachers to adopt "a relational ideology of schooling" but mindful of societies' wider inequitable structures. They offer an intersectional, justice-oriented interpretation of Noddings' ethic of care, something they refer to as *justice-oriented critical caring* as supportive of students' development "as persons who care and are cared for within oppressive systems" (p. 553). Foundational to such justice-centered critical care in science classrooms is a commitment to caring as a "radical act in normative schooling that should *disrupt both meritocratic and technocratic aspects* of science teaching and learning" (p. 554, emphasis in original). Enacting such a justice-oriented critical care stance, Suárez and Krist [12] argue, must be relational, grounded in authentic relationships that are "rooted in solidarity and high intellectual expectations" (p. 553). Suárez and Krist convincingly argue that such relational work is essential to the epistemic work of learning science, particularly for those students who are often underserved and oppressed by larger inequitable social structures.

Centering racial oppression and a commitment to education as a means for liberation, especially as regards Black children's experiences in the United States, recent scholarship calls attention to the *political* in conceptualizing a

pedagogy of care [15–17]. This perspective asserts that while an ethic of care necessarily has a cultural dimension, as described in culturally responsive and relevant pedagogies, care must be centrally seen as a *political* act as teachers work to support students' learning and development toward social change that counters and resists wider racially biased norms and practices. Therefore, this scholarship posits *politicized care* as an intentional act of resistance to the racialized harm and neglect too often experienced by Black, Brown, and other children of color, both in and out of school settings. As part of this act of resistance, scholars are calling for the need to center young people of color as *children* as opposed to youths, teenagers, or K-12 students in response to the reticence of wider educational systems to see these Black youth as children in need of protection and care as they develop into adults. In their framework describing *politicized caring*, McKinney de Royston *et al.* [16] and colleagues present political clarity as teachers' critical understanding of the institutional nature of oppression that shapes Black children's experiences and communal bonds as referring to teachers' orientation to and relationships with children's communities as an extended family in their efforts to disrupt systems of inequality. They argue that politicized caring is potential affirming (i.e., affirms learners' potential) in that teachers endeavor to disrupt the "pervasive lack of institutional care" (p. 8) by maintaining high expectations and supporting students in realizing their full potential. It is also developmentally appropriate as it recognizes that Black children exist along a developmental continuum and that effective instruction can propel their development in ways that push back against prevalent racist social conditions and practices.

III. LITERATURE REVIEW

In what follows, we outline different dimensions of teachers' politicized care. We first discuss social care in research on culturally relevant and responsive pedagogies. Then, we make a turn to discuss how science education, including physics education, has primarily focused on epistemic care in research and practice, which we argue is related to but distinctly different from the calls for social care and politicized forms of care emerging in recent scholarship. We end with considerations of potential tensions and synergies between these different forms of care. We highlight the need for empirical investigations of politicized care within physics teaching, especially for students from historically marginalized backgrounds.

A. Social care in culturally relevant and responsive pedagogies

The role of care has been featured in discussions of underserved students' learning, as the scholarship on culturally relevant pedagogy has long emphasized the social and relational aspects of learning [18]. Culturally

responsive teachers enact an ethic of care that centers elements of students' culture to make learning more relevant and meaningful [19]. Similarly, Ladson-Billings [20] argues that attending to learners' culture as part of caring for students improves a teacher's ability to understand and have high expectations for them. Toward those ends, Meyers *et al.* [21] provide a more nuanced and complex description of care that centers teachers' understanding of students' social context to allow them to tune into their work and understand the motivations behind their behaviors.

Research on social care in teaching highlights its multiple benefits, including helping students feel heard and respected [22], improving student academic and behavioral outcomes [23], fostering student agency in taking on various classroom roles [23,24], improving student self-efficacy [25], and promoting student well-being through social tolerance and civic engagement [26]. In sum, compelling empirical evidence suggests that teachers who show social care toward their students create more supportive classroom environments where all students, regardless of demographic, experience a sense of belonging and value [27] and are better positioned to grow and thrive as learners and human beings [23].

B. Epistemic care in science learning spaces

While these aforementioned lines of work centered on care as a vehicle to foster more socially inclusive and equitable learning environments, another body of literature in science education and the learning sciences has focused more specifically on the epistemic dimension of care in teachers' efforts to support learners' epistemic pursuits. This dimension of care, which we call *epistemic care*, centers on the disciplinary substance of students' thinking and contributions [28–31]. This line of research emphasizes the role of a teacher's care for students as scientific thinkers in eliciting the students' conceptual and experiential resources and supporting students to use those resources in sensemaking in science [32,33]. Within this line of work, a specific form of epistemic care manifests in teachers' epistemic empathy, or their "capacity for tuning into and appreciating students' cognitive and emotional experience in making sense in science" [34] (p. 434). In this way, expressing care through epistemic empathy becomes essential to responsive science teaching [34,35].

C. Interactions of forms of care in science learning spaces

While epistemic care is central to fostering learners' epistemic agency, emerging research suggests that the dichotomy between epistemic and social dimensions of care may be short-sided. Parsons [10] describes a form of culturally relevant social care that allowed a white teacher to connect to and better support her black students as epistemic agents in their learning. This culturally relevant care developed reciprocity, challenged power dynamics that

emerged in the classroom, and leveraged students' contributions and experiences as assets. Parsons' analysis showcases how the teacher's care involved recognizing the need to attend to social factors emerging in the class while also caring for the substance of student thinking in ways that supported the children's epistemic work. The interconnections between social and epistemic care can also be seen in the work of Appleby *et al.* [1], who worked to understand students' physics learning at a private research-intensive, predominantly white university during a summer "bridge to engineering success," a program designed to help underrepresented students transition into an engineering program. Specifically, Appleby *et al.* describe how students' experiences of *social* care in the program were part and parcel of their feeling cared for as *epistemic* agents and, in turn, had consequences for their disciplinary engagement in physics. In this work, social caring was defined as caring for one another *as people*, which links back to Noddings' [8] definition of care and to Suárez and Krist's [12] (p. 553) call for students to develop as "people who care and are cared for," attending to them as social beings with cultures, feelings, goals, and drives that shape their lived experiences. While this form of social care has been traditionally explored as distinct from caring for students' disciplinary work, these scholars trouble this distinction, arguing for an entwined relationship between social and epistemic forms of care. In doing so, they show how the experience of social care is part and parcel of how students come to experience deep care for their own and one another's reasoning and one another as whole people.

In line with research on culturally responsive education [6,36], this work allows us to see the specific disciplinary significance of students' experiences of social care, an area of inquiry and practice that is underexplored in physics education research and teaching. In other words, this work begins to bridge disciplinary caring with culturally responsive forms of caring, calling for a more humanizing approach to physics instruction. We argue that a more explicit emphasis on cultural competence and sociopolitical consciousness in physics education scholarship and practice would indeed compel physics researchers and teachers to attend to students in ways other than just STEM sensemakers but rather as whole people embedded in wider cultures and histories of interactions that shape who they are and their access to learning opportunities. This wider sociopolitical sensibility and understanding of learners as complex and multifaceted epistemic and cultural beings require that physics teachers care for students *as people*, *acknowledging* that their concerns, interests, and goals can sometimes be distinct from those related to the canonical goals for any particular lesson. As discussed in Ref. [17], this calls for a more expansive recognition of care encompassing a complex amalgam of epistemic, sociopolitical, and culturally responsive forms of caring that are central to teaching and learning. The work presented here is in response to that call.

IV. RESEARCH QUESTIONS

In this research, we examine the varied dimensions of politicized care in one physics teacher's work with her students of color in the context of the southern United States. Our guiding questions for this study were as follows:

What are the dimensions of politicized care that characterize the efforts of a high school physics teacher as she attempts to teach physics to a group of students traditionally underserved in science? In what ways are these dimensions of care supportive of one another? In what ways are they in contradiction?

V. METHODS

This study is a naturalistic qualitative case study [37,38] of a secondary physics teacher's efforts in her classroom of largely working-class students of color who were historically underserved in their STEM education. Through extended field observations in the teacher's classroom and school, in tandem with document analysis and a series of interviews, we sought to understand the teacher's interactions with her students to explore the various ways in which she expressed care for her students. This case study is bounded by its focus on one secondary teacher, Sarah, within the context of her classroom over one academic year. The boundaries of this study include Sarah's classroom, the instructional practices she used to enact Culturally Responsive Pedagogy (CRP), and the interactions with her students during the period.

A. Context and participants

The research reported here was conducted in a physics classroom at an urban high school where most students were students of color whose families lived below the poverty line in a school district in the southeast United States. This can be seen in the demographic makeup of the school where this study was conducted, as the vast majority include students of color (85%) and students from economically disadvantaged families (63%). The high school was the lowest-performing public high school in the district.

In this study, we distinguish between institutional and structural factors that shape Sarah's teaching context. Institutional factors refer to the norms, policies, and practices within the school district that influence how physics is taught, while the structural factors encompass the broader societal systems, such as socioeconomic inequality and systemic racism, that affect students' educational opportunities and experiences.

The physics teacher at the heart of the study is an African American woman, Sarah. During the year of this study, Sarah worked with the first author to enact culturally relevant pedagogy in her physics classroom as part of a larger project [39]. Sarah graduated from a Historically

Black College and University with a degree in Chemistry. Before beginning our study, she had five years of teaching experience. Although she started her career teaching Chemistry, she was assigned two physics classes because of her past success in supporting students of color in science classes. Once Sarah began teaching physics, she found it to be a "natural fit" with her approach to instruction. Enrollment in physics increased substantially after Sarah began teaching the class, a shift some school staff and students informally attributed to her strong reputation. During the year of our study, there were 18 students in the class. Most of these students were African American; one was biracial, and one was white. We intentionally chose to focus on Sarah and this classroom of students because of the long-term underrepresentation of African American students in high school physics, making the opportunity to explore effective pedagogical approaches in a physics classroom that serves primarily African American students particularly needed [40,41].

It is important to note that in this study, culture is not viewed as a monolithic entity. We consider multiple overlapping cultures, including students' home, community, and racial cultures, as well as the broader culture of the school and the discipline of physics.

B. Data collection

Data were collected from field observations and video recordings of one section of Sarah's physics class throughout the school year. The field observations were used to identify segments of the recordings for transcription and later analysis. A total of three observations were conducted each week, each lasting approximately an hour. The observations were done on the majority of days during an academic year, from December to May, for 59 days of observations in total. In addition, the first author met with Sarah each week of the study to reflect on her instructional decisions and pedagogical moves and plan for the next lessons. Weekly meetings with Sarah typically lasted an hour and were structured as either reflective discussions or planning sessions, depending on the focus for that week. These weekly meetings provided an opportunity to learn more about Sarah's thinking and motivations behind her instructional practices and develop a relationship of trust and support between the first author and Sarah. During these meetings, the first author presented episodes from the previous class sessions to spark Sarah's thinking and provide tangible examples for her reflection on her work. Other times, these meetings took the form of a planning session in which the pair designed and refined lessons for the following week. These weekly sessions were conducted on Zoom, recorded, and transcribed.

C. Data analysis

We drew on a constructivist grounded approach to explore the research questions related to dimensions of

politicized care expressed by Sarah [42], focusing on data from the weekly meetings and field notes from the classroom observations. Given the volume of data generated by an academic year of data collection, we first conducted an initial round of analysis where we tagged instances in Sarah's interactions with students from classroom observations and in her reflections on those interactions captured in interviews. In this phase, we tagged specific instances within the data; that is, we systematically marked and annotated these instances in our field notes and transcripts based on their relevance to our research questions. These tags served as preliminary codes, with comments or notes added to highlight the significance of the interaction, such as Sarah's expression of care, her pedagogical strategies, or her responses to students' needs. Examples included Sarah's willingness to advise students on career options they can pursue posthigh school, Sarah providing emotional support for students experiencing challenges at home, and Sarah spending extra class time with students who had questions about some physics ideas or problems from a previous class.

From these tagged instances, we engaged in an interpretive process to develop an understanding of Sarah's actions and reflections that we recognized as reflective of aspects of politicized care. Through this analytical process, we constructed different dimensions of Sarah's care, which we categorized as follows:

- *Social care* reflected Sarah's understanding and valuing of her students as *people* (instead of merely as physics learners), showing appreciation and concern for them as whole human beings and for their lives and communities. We understood Sarah's social care to center students' lived experiences as shaped by social, cultural, and political factors within and outside the classroom. Elements of this social care were *understanding students as social and cultural beings*, *cultivating a culture of support among students*, and *fostering a sense of pride in students' racial and cultural backgrounds*. Examples that reflected such care included Sarah's attending students' sporting events, Sarah's intentional efforts to highlight and normalize the success of African American scientists, and Sarah's announcing a student's college acceptance to the entire class offering congratulations.
- *Epistemic care* manifested in Sarah's acts to attend to, understand, and appreciate students' intellectual and emotional experiences as they worked on physics concepts and problems. This care emerged in Sarah's orientation to students as physics thinkers. It was evident in her efforts to attune to their thinking and emotions as they explored physics concepts and solved physics problems. Elements of Sarah's epistemic care included *attending and responding to students' epistemic vexation* and *expanding students' sense of themselves as capable physics learners*. An example of Sarah's epistemic care is when a small

group of students felt defeated because of the difficulty they experienced in solving for forces using a free-body diagram. Sarah helped reframe their feelings and negative self-perceptions, normalizing their struggle and asserting that they could understand the material if they gave themselves a chance.

- *Academic care* was salient in Sarah's recognition of her students' need and right to experience academic success, even one that is narrowly defined and constrained by the existing norms and structures of the educational system. While in our first round of analysis, we overlooked this dimension of Sarah's care, as we delved into the data, we came to see Sarah's commitment to and concern for her students' experience of academic success as an intentional act of resistance—indeed, an aspect of her politicized care. Elements of Sarah's academic care included *preparing students for academic success after high school* and *smoothing academic difficulties for students to experience a sense of success in school tasks*. An example of the latter is when students struggled to convert units in a physics problem. Sarah interjected to provide the conversion factors to allow them to experience success instead of feeling stifled and intimidated by those problems.

In this study, we conceptualize *social*, *epistemic*, and *academic care* as specific dimensions of politicized care, reflecting on how these forms of care interact to resist both institutional and structural inequities in the classroom. By examining these dimensions, we aim to understand how politicized care operates as a multifaceted approach to supporting students in historically marginalized physics classrooms.

Following these depictions of various dimensions of politicized care, we sought instances in the data where two or more dimensions of care were evident. Examples included supporting students in doing school tasks (academic) and in sensemaking about physics-related phenomena (epistemic); teaching students how to perform school-based tasks in the classroom (academic) while teaching them how those skills could be applied outside of the classroom (social); supporting students in their understanding of physics ideas (epistemic) while cultivating through explicit messaging their sense of physics identity (social). We then examined these moments to determine if the different dimensions of care were supportive of one another (e.g., instances when Sarah was supporting students in meaningfully understanding physics concepts and successfully completing assigned tasks in the physics classroom) or in contradiction (e.g., supporting students' ability to successfully complete physics tasks by lessening their rigor to prevent students' frustration; or using class time to have the entire class attend a student's performance, an action that centered students' interests and abilities outside of the classroom, but that reduced the amount of time devoted to the teaching of physics).

Throughout the analysis, we also focused on instances of resistance, where Sarah's use of care countered institutional or structural challenges. Resistance is evident in her efforts to make physics more accessible, in incorporating culturally relevant content, and fostering discussions around race and inequity within the physics curriculum. In highlighting these moments, we aim to provide examples of how politicized care involves both everyday pedagogical strategies and broader efforts to challenge systemic inequities.

D. Analytical rigor and trustworthiness

Our study conceptualizes rigor as trustworthiness [43]. Trustworthiness is obtained by establishing credibility through triangulation and peer debriefing. Triangulation was sought through the analysis of different data sources around Sarah's teaching: observations of Sarah's classes, where two data sources were collected, video recordings and field notes; along with the third data source, video recordings of meetings with Sarah to confirm our analysis and allow her to explain and reflect on her actions and motivations. Observations followed a nonparticipant approach, where the first author took detailed field notes. Interviews were semi-structured, allowing Sarah to reflect on her practices and offer narratives about her pedagogical strategies. Our belief in the advantage of triangulation is analogous to Thurmond's [44] explanation, which is to "increase confidence in research data, creating innovative ways of understanding a phenomenon, revealing unique findings, challenging and integrating theories, and providing a clearer understanding of a problem" (p. 254). To further establish credibility, peer debriefing between the coauthors and member checking with Sarah were part of our analytical process throughout the stages of analysis. Sarah reviewed all data and analyses to determine whether our interpretations resonated with hers. All identified moments of care were brought to Sarah, and she affirmed and corrected our interpretations if they did not align with hers. As we discussed our interpretations with Sarah, we primarily sought to understand her perspective and how she responded to our interpretation; accordingly, we revised our interpretations and, in turn, our findings as needed. This prolonged engagement in the field and with Sarah through extended classroom data collection and lengthy, intensive interviews with Sarah over the course of the academic year was central to our understanding of our phenomenon of interest, that is, the various dimensions of politicized care in Sarah's physics teaching.

E. Authors' positionalities

Author 1's experience as an African-American male physics teacher gives him a unique perspective on equity issues within physics teaching. Author 1 has experienced aspects of teacher neglect that impact how he views and navigates physics spaces. He has taught physics to students of various cultural backgrounds and used different forms of

instruction. Author 1's experiences helped him analyze this physics teacher's varied approaches to classroom care. Through this study (both in data collection and analysis), author 1 continued to seek a better understanding of how Sarah's care was an important component of her approach to physics teaching, particularly to students historically underserved and marginalized in physics learning spaces. Given this background, the first author came into the project with a general awareness of the sociopolitical context surrounding Sarah's teaching. However, it was through sustained collaboration with Sarah that they together developed a deeper understanding of the political dimensions of teaching physics in an underresourced and racialized context. Thus, ongoing reflections and debriefs with Sarah, in addition to the first author's consistent visits and interactions within her teaching context, significantly influenced both the framing of the research questions and the interpretation of the data.

Author 2 is a cisgender white woman who was intimately involved in the larger project from which this research is drawn. As a former science teacher who worked with minoritized learners, while she could understand some of the dynamics occurring in this space, she did not bring a history informed by racial marginalization, particularly around the lived experiences of Blacks in the United States. Given this background, some aspects of the data were very common to the second author (i.e., need for personal connection), while others were unexpected (i.e., whole class discussions of racial inequities). But through continued analysis and discussion with the research team, author 2 began to recognize the importance of such recognition of systemic inequities. Author 2's research has focused on understanding intersecting issues of race, social justice, and science teaching and learning, and she brought insights from that literature to the group. She also had experience in research at this school in the past, which informed her guidance about data analysis, her observations revolving around Sarah's efforts with her students, as well as the interactions with the wider school community with this teacher's efforts.

Author 3 is a cisgender Arab immigrant woman who was involved in the project as an external advisor. Author 3 worked with the first author in her role as an educational researcher and teacher educator, discussing research design and pedagogical considerations as the project unfolded. As a former K-12 science teacher in various contexts in her home country, including working with children and families from backgrounds that have been underserved in schools and especially in STEM, author 3 brings a multicultural perspective to the study. That said, like author 2, author 3 does not have experience with racial marginalization as it relates to the lived experiences of Blacks in the United States. Given her research on empathy and responsive teaching, author 3 became particularly compelled by the project and the work of the partnering teacher,

which aligned with author 3's goals to promote more humanizing and dignity-affirming learning experiences in the science classroom and to explore tensions inherent in this work. Author 3 was primarily involved during the analysis phase, bringing an external perspective and contributing critical insights during the coding and interpretation stages.

While the researchers acknowledge that their varied positionalities do not provide an insider view of Sarah's efforts with her students, they collectively provided groundings by which the researchers, as community outsiders, could work to attend to different dynamics at play in Sarah's teaching and experiences.

F. Limitations

Despite the insights gained from this study, several limitations must be acknowledged. First, the study's focus on a single case, Sarah, a high school physics teacher in an urban school in the southeastern United States, limits the generalizability of the findings. While this case study provides in-depth insights into the enactment of politicized care within this specific context, the results may not extend to other teachers, schools, or regions with different cultural, institutional, and sociopolitical dynamics. Additionally, the participant selection, which centered on Sarah and 18 students from her culturally relevant physics class, restricts the diversity of perspectives, particularly those of students not enrolled in Sarah's class. Including perspectives from other physics sections could have offered a more comprehensive view of the broader school context.

Another limitation involves the researchers' active role in planning and reflecting on Sarah's teaching practices, introducing a participatory and interventionist element to the study. This involvement, while providing insights into the co-development of culturally relevant pedagogy, may have influenced Sarah's instructional decisions and classroom dynamics, potentially introducing researcher bias. Although measures such as member checks, reflective journals, and triangulation were employed to mitigate this bias, the presence of researchers may have affected the environment of the classroom.

Moreover, data collection was constrained by time and access. Observations were limited, potentially leaving out nuances of individual student experiences. The single school-year time frame may also have been insufficient to capture longer-term outcomes of politicized care on students' physics identity development and academic performance. Finally, the study was conducted in an underresourced school with unique challenges tied to systemic inequities. These specific contextual characteristics shaped the implementation and reception of politicized care, making the findings highly context-dependent and potentially different from those in schools with more resources or different institutional dynamics.

VI. FINDINGS

Our findings are organized into four parts: in the first three, we describe each dimension of politicized care that shaped Sarah's work, including social, epistemic, and academic care, and we describe how such care shaped her interactions with her students. To make these findings more tangible, we incorporate excerpts from our observation data, offering a clearer view of how each component of Sarah's politicized care developed in interaction with her students. In the last part, we discuss the tension that manifested across different expressions of Sarah's politicized care to illuminate how various dimensions of care can at times serve contradictory goals as Sarah strived to care for her students as social, epistemic, and academic beings. (See Table I for dimensions of politicized care.)

A. Social care

Our findings provide evidence of Sarah's displays of social care for her students, that is, her understanding of and concern for students as social beings. (See Table I for details about Sarah's social care.) We see this in her deliberate efforts to understand her students as *people* and to cultivate a culture of support within her classroom. Sarah endeavored to create a classroom learning environment where students were supportive of one another and interacted with each other easily; she encouraged her students to talk openly about topics or matters of importance to them (as reflected in the opening vignette of this paper). On a typical class day, Sarah would greet students by name and, once settled, start the class by asking her students how they were feeling and what was going on in their lives that they would like to share with the group. Other times, Sarah would ask more pointedly about weekend plans or events, querying her students about other out-of-class experiences (i.e., sporting or church events, students' jobs, or asking their opinions about specific instances drawn from popular media). The tone of these opening discussions was light, involving most of the class members, interspersed with much humor and gentle teasing by all parties. This classroom community provided students a context to share their views with their classmates, something that gained importance as Sarah positioned them to support one another on issues aside from those directly related to physics or even school.

1. Understanding students as social and cultural beings

Sarah demonstrated social care in her deliberate efforts to learn about and connect with her students' cultural backgrounds and social lives. In doing so, she reflected on and channeled her own upbringing. This was evident, for instance, in a statement Sarah made about understanding her students' home lives:

TABLE I. Comparisons across three dimensions of Sarah's politicized care.

	Dimensions of politicized care		
	Social care	Epistemic care	Academic care
Definition/emphasis	- Attending to students as cultural, emotional, and social beings	- Supporting students' thinking, reasoning, and identity as knowers	- Supporting student success within traditional schooling structures
Illustrative practices	- Greeting students by name	- Attending to student confusion without deficit framing	- Reminding students of unit conversions
	- Supporting out-of-school activities (i.e., dance performance)	- Emphasizing understanding over grades	- Revising tasks to ensure completion
	- Centering racial identity and pride through Black STEM figures	- Validating multiple ways of knowing (i.e., cultural connections to concepts)	- Emphasizing life-after-school readiness
Overlaps/synergies	- Supports epistemic care by affirming students' cultural knowledge	- May reinforce social care when students' lived experiences are carefully integrated within and leveraged as resources for teaching and learning	- May reinforce epistemic care by helping students "feel successful"
	- Builds relational trust needed for rigorous thinking	- Challenges narrow academic metrics	- Could potentially empower students within and beyond academic tasks
Tensions/contradictions	- Time invested in racial identity work or community building may reduce time for direct physics instruction	- May conflict with academic care when rigor is reduced to maintain confidence	- Can constrain epistemic agency when tasks are simplified
		- Institutional constraints may limit epistemic flexibility	- Risk of overemphasizing compliance or performance

You know, most of them [referring to her students] didn't come from a two-parent household. I was fortunate enough to have a mother and a father. My biological mother and father were married for like 40 years ... So, I don't come from the typical household [my students experience]. So, even though I don't feel like that life has afforded me with opportunities to be able to witness things for different people ... [it has allowed me] to kind of see some of the things that [my students have] been through. Even my own father grew up in a household similar to theirs: single-parent household, mother's struggling ... I can relate to a lot of things that they have been through.

In this reflection, Sarah showed an understanding of the nontraditional family structure of many students in her class and a recognition of the struggles they may have experienced. Even though Sarah did not experience a similar family experience as many of her students, she was able to draw on her experience and the experiences of people she knew to appreciate her students' family lives and the ways their lives may impact their well-being (e.g., having to work after school, care for siblings, and having unstable housing). For instance, Sarah drew on her father's

upbringing to identify and empathize with many of her students from a single-parent household.

2. Cultivating a culture of support among students

Another way Sarah showed social care was by creating a culture of support amongst her students so that students saw themselves as a source of support to, and not competition with, one another. For instance, during the school year, Sarah canceled class so her students could support a classmate performing in a Black History program that celebrated African Americans' contributions to education, arts, music, dance, sports, and technology. One of Sarah's students was part of a dance performance, and Sarah wanted all of her students to attend it to foster a sense of community among the members of her classroom. She, therefore, canceled class on that day to allow students to attend the program as an act of showing care for and supporting one another's efforts, even outside of the confines of the physics classroom.

3. Fostering a sense of pride in students' racial and cultural backgrounds

In addition to knowing and valuing her students as social beings, Sarah sought to foster in them a sense of pride in who they are and in their cultural backgrounds. As such,

Sarah made intentional efforts to highlight and normalize the success of African American scientists. For example, she created opportunities for her students to learn about African Americans who have contributed to STEM fields. One such instance included having her students attend the Black History program at the school. When we asked Sarah about her choice to use class time to attend this program, she highlighted the key importance of the program's focus on students' sense of pride and belonging in STEM:

So for me, teaching physics or for me teaching chemistry, a lot of girls will say "Ms. [Sarah's last name] I look up to you because you're in STEM and you don't see that often." Number one, you don't see women for the most part, and number two, a lot of times you don't see Black women in the STEM area. So, it gives them someone to look up to know that: "Hey, I can do this." So with that being said, it's very important for them to know that there are Black scientists and they were important, and they did contribute to our culture, and our history so they know that they can do it.

Sarah understood that her students do not often see images of themselves in STEM areas, and allowing students to attend the Black History program was a form of social care designed to show care for one another's efforts in support of their peer's participation in the program but also importantly to foster their understanding of the contributions of Black scientists and feel inspired that they too can contribute to STEM fields. For many of Sarah's students who attended the Black History program, this was their first time learning about different Black Americans in science. Sarah recognized the value of expanding students' conceptions of who is and can become a scientist and cultivating and affirming their sense of pride in their own racial and cultural backgrounds.

B. Epistemic care

Throughout her teaching, Sarah expressed her epistemic care for her students in how she attended to and elevated their different ways of reasoning in physics. (See Table 1 for details about Sarah's epistemic care for her students.) Sarah noticed and responded to her students' vexations as they engaged in physics explorations. She also made different moves to expand how students think of themselves as physics learners to foster their confidence and sense of agency in doing physics. Below, we discuss how Sarah reflected on these instances of epistemic care in her interviews and her efforts to tailor her instruction to support students' physics sensemaking.

1. Attending and responding to students' epistemic vexation

In one interview reflecting on her lesson on waves, we noticed Sarah paying particular attention to *why* her

students had difficulty understanding the difference between transverse and longitudinal waves, a staple of many basic physics classes. Instead of positioning her students in deficit ways, Sarah described the reasons that render this topic difficult for students:

There were struggles with identifying wavelengths for longitudinal waves. They [students] also struggled with identifying all types of ways you can measure for transverse waves as well. I think they understand compression and rarefaction [referring to wave properties]. It's just that's not the wavelength. First off, most of them probably have never ... launched a new [longitudinal] wave. They don't know what it is; their typical wave is a transverse wave. That's the way they identify waves, as the up and down transverse wave [similar to a sine wave]. That's what they identify with the most, that's what they'd been taught.

So, whenever I give them longitudinal waves and they've never seen it cause [other teachers] ... don't teach that in chemistry. So this is the first time and they're like, "what are longitudinal waves?" So it's hard for them to wrap their head around the concept of longitudinal waves, how they travel, what's their properties, when you introduce a new wave, and then you tell them, 'Okay, now give me the wavelength of this wave [that] you'd never heard about before.'

In this reflection, Sarah showed epistemic care for her students by rationalizing what caused their confusion as they learned to distinguish transverse and longitudinal waves. By recognizing that most visual waves students are exposed to in textbooks are transverse, Sarah anticipated that the concept of longitudinal waves would be difficult for students to understand firsthand. Sarah also understood the influence of students' former instruction and how that instruction might cause additional confusion regarding this topic. We view these instances as moments when Sarah expressed epistemic care in endeavoring to understand students' epistemic vexations and difficulties from students' perspectives.

2. Expanding students' sense of themselves as capable physics learners

On multiple occasions, Sarah worked with her students to challenge their view that grades reflect their capacity to learn and understand physics. In the excerpt below, Sarah explained how she enacts this belief in her efforts to allow students opportunities to experience themselves as competent physics thinkers beyond the traditional bounds of exams or quizzes:

Success to me is not based on a grade ... Success is based on: "Do they understand content or the

concept I'm trying to teach them?" ... Because I may have a C student who makes a C on the quiz, but based on ... if I ask them certain questions or if I, ... give a lab or have a discussion and they understand the content, then, they're successful. Just because they didn't make an A on the test doesn't mean they weren't successful ... because success comes in different areas ... so you can't use assessments, just to measure success [in learning physics].

By challenging these settled expectations of "doing school," such as reliance on tests as a measure of learning, Sarah enacted epistemic care for her students as she asserts that what matters for her is their epistemic contributions and conceptual understandings rather than their performance on a test. Sarah used varied, sometimes nontraditional forms of assessments in her teaching, including in her course activities where she asked students to build things (e.g., rockets and roller coasters) based on their understanding of certain physics ideas, as well as to draw as a way of expressing themselves and their physics thinking. In diversifying her approaches to instruction and assessments, Sarah's goal was to foster students' conceptual understanding while at the same time broadening their conceptions of physics learning, an act of politicized care aimed at desettling school expectations [45].

C. Academic care

At the same time, Sarah understood that her students' schooling experience was situated in broader politicized institutional norms and expectations that continue to privilege narrow definitions of "academic success." Sarah also understood that these norms and definitions are of central concern for her students and their families. (See Table I for details about Sarah's academic care for her students.) We saw Sarah's care for and appreciation of the pressures exerted on her students by these expectations as an aspect of her academic care. This reflects Sarah's understanding of the politicized nature of academic achievement, especially for minoritized students. We came to recognize the prevalence of academic care as we noticed Sarah's concerns for students in being successful in performing certain academic tasks, such as completing homework assignments, turning that work in, and coming to class, as part of her broader concern that they are prepared for such work after high school.

1. Preparing students for academic success after high school

During an interview, Sarah shared how she openly discussed with her students that life after high school presents challenges they need to be aware of and ready to face:

I always tell my students ... I've let them understand that the real world isn't like [their high school]. There are no quiz corrections in college, there's not a lot of time, ... there's no "do overs." You can't, ... go through life thinking "I'm gonna just give the bare minimum that I have that I'll have a second opportunity to present my best shot." That's not how life works. Sometimes you just get "one and done." So, you must always bring your best foot forward.

In this excerpt, we see Sarah feeling compelled to openly discuss "the real world" with her students, where they cannot simply rely on "do-overs" or "a second opportunity." Sarah recognized that, for students from minoritized communities, there is an added pressure of having to "bring your best foot forward," especially in higher education academic institutions that may not be as "gentle, forgiving, and loving" as the classroom learning environment she had developed for her students. Sarah felt that part of her responsibilities as the teacher is to make her students aware that life after school, including in college and higher education, will be different so that they could proactively face this reality with agency. In these ways, we see Sarah's expression of care for her students' academic success after school and, more broadly, as they get ready to "go through life" as an aspect of her politicized care.

2. Smoothing academic difficulties for students to experience a sense of success in school tasks

At another level, we saw evidence of Sarah's academic care in her desire to keep students engaged in classroom efforts by grounding projects in real-world applications while structuring them in ways that allow students to experience academic success in school tasks more easily. This aspect of Sarah's academic care was motivated by her recognition that her students often disengage when things become "too difficult," as her students would metaphorically throw up their hands and say, "*I'm done with it! ... [and] they begin to shut down on you.*" We saw evidence of Sarah frequently anticipating where her students might struggle with a task and making teaching moves to help them avoid such struggles. For instance, during a class where students engaged in a project requiring them to calculate the power of moving different objects at a specific height, Sarah described a moment where she anticipated some students would forget to convert units in their calculations. As a result, Sarah frequently reminded them to make the proper conversions of units in their power calculation. During a subsequent interview with Sarah, we discussed this teaching move:

First off, I have to remind them to use the metric side because even with me reminding them of the metric side [of the meter stick], a lot of them still

use inches. They have to be reminded that we use metric when it comes to physics. That's number one, so I reminded them of the metric side, and then I reminded them that their whole meter stick was actually one meter, and it's broken down into inches and centimeters. But they can't use centimeters to do the calculations; they're going to have to use meters. So I told them that, ... If [something] was ... 64 centimeters long, that means 0.64 m. So, I have to remind them, because if not, they're going to default into inches, because inches is what they normally use in everyday life.

Sarah's constant reminders about conversions of units stemmed from her tacit desire that students reach the correct answer as a way for them to feel like they performed the task successfully. Here and in other instances, Sarah's care for her students to experience academic success, narrowly defined, shaped her actions and expressions, with implications for student epistemic agency that we discuss in the following example.

In one instance, Sarah described a project where students had to identify the most energy-efficient route to Disney World. In this project, students researched different properties of cars, such as gas mileage, weight, and fuel cost. Students also researched distances and speeds at different points along the path. The purpose was for students to apply their understanding of energy to solve a real-world problem. However, as students worked on the project, many needed clarification about which distances and speeds to use. To help alleviate students' confusion, Sarah revised the task to make it more specific by providing her students with a certain distance and speed to use in their calculations. When asked about these actions, Sarah stated:

I revised [the assignment] because they [asked] "Well, what? Should we look up the gas mileage [and] the number of miles to Disney world for number one?" And I said, "Yeah, you really, you should." So that's why I took that and I put it to number one instead because that's where they needed the most, the miles to Disney world ... So they understood the mileage part has to [be converted]. And they understood they had to look up the gas. But when they looked at the gas, the price of the gas, then they wanted to know "What was the third column for? And that's when I thought about it, I was like, they really did ... That's why I decided I would try to eliminate that one because it was kind of throwing them off.

Sarah's actions in these instances can be interpreted in multiple ways. From one perspective, it is evident that Sarah wanted to help her students experience success in academic tasks as a way to sustain their engagement in their schoolwork and ultimately succeed in the course.

From another perspective, this move to lessen the rigor of assignments may inadvertently limit students' epistemic agency and conceptual development concerning these physics concepts and practices. The tension between academic and epistemic care emerged several times in our analysis and will be discussed in an upcoming section. These expressions of academic care may have allowed students to succeed in the outcome of the given work; however, as discussed in the following section, Sarah's academic care for her students may have precluded them from developing the skills necessary to deal with complex data, thus serving to hamper them epistemically.

D. Tensions within politicized care

Throughout our examination of Sarah's teaching and her sensemaking about it, we found instances where tensions manifested around and between the different forms of care, social, epistemic, and academic, in her instructional choices and student interactions. This section discusses these tensions and their influence on students' learning opportunities. (See Fig. 1 for a diagram highlighting the intersection of dimensions of Sarah's politicized care, along with examples.)

1. Tensions between epistemic and academic care

As hinted in the previous section, while Sarah grappled with how to ensure her students experienced success in school tasks, she was also concerned with supporting their epistemic efforts and cultivating their sense of agency. These two forms of care, academic and epistemic, were sometimes in tension. Sarah's decision to revise some assignments by providing more scaffolding is an expression of academic care in that she sought to reduce students' confusion and ensure they would complete the task.

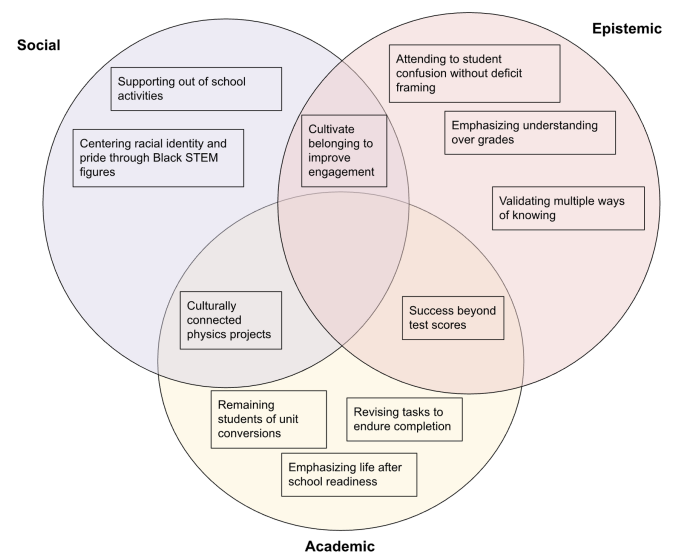


FIG. 1. Graphic representation of interactions of three dimensions of politicized care.

Thus, she wanted them to experience academic success. That form of care was at times in tension with Sarah's care for her students as epistemic agents who have the right and the capacity to grapple with intellectual challenges and figure things out. Sarah reflected on this tension as she grappled with how to keep students engaged in thinking through "complex" physics concepts while also worrying about them "shutting down":

A lot of times, even when I'm explaining concepts, when they get confused. A lot of times, they'll shut down on you, and when they shut down they're done! So you want to avoid them shutting down on you. You want to avoid them saying "I don't understand this," "I don't get this," "I don't get that." One of the things I had with [the concept of physical collision] is it's so complex, the formula so complex that a lot, sometimes they don't get it. It takes multiple times to practice. And then when a problem gets long, they're like "I'm done with that problem" ... It's hard to kind of kickstart them again when they do that.

Here, we see that Sarah felt conflicted between finding ways for her students to conceptually grapple with ideas without "shutting down" when they feel overly frustrated with certain aspects of this epistemic work. One might interpret Sarah's concerns and her resulting changes in the tasks she presented to students as emerging from a deficit view of students. Instead, we understand these concerns to be grounded in her knowledge of and attunement to her students' needs, including thresholds related to both their interests and their tolerance of uncertainty. At the same time, we see Sarah's fear of students "shutting down" as potentially steering her away from intellectually challenging her students in ways that may inadvertently close off opportunities for rich scientific sensemaking.

2. Caring for disciplinary learning while caring for students as socially racialized human beings

As evident in the findings, Sarah made various intentional efforts throughout her teaching to help students understand the racial discrimination they experienced as part of her social care, specifically "justice-oriented critical care" for her students [12]. Sarah was willing to invest class time to discuss students' experiences with racism as well as to share her own experiences with racial discrimination as a Black woman in the southern United States. Clearly, her students were thoroughly engaged in these discussions based on their willingness to share their experiences and comment on their peers' experiences. It must be recognized, however, that while these conversations were important for Sarah's students, both to commiserate with one another and to have safe and brave spaces where they could begin to make sense of and interrogate racial

dynamics, these discussions took precious instructional time in which physics was not centered. Likewise, Sarah's choice to cancel class so that her students could attend a STEM Black History Program (described earlier), evidence of her social care for students, was also at the expense of spending that time discussing physics and engaging in disciplinary learning. Overall, we see these instances as reflective of tensions arising from, at times, contradictory goals in Sarah's caring for students as social beings while also caring for their engagement in academic tasks and their efforts to understand physics.

3. Tensions pertaining to the current socio-political climate in the conservative southern United States

Another factor that influenced Sarah's ways of caring for her students was the sociopolitical climate within which Sarah's instructional efforts unfolded. Throughout her physics teaching, Sarah aimed to use socioscientific issues to connect physics more meaningfully to students' lives and seed opportunities to examine larger social and political issues impacting her students and community. These efforts were grounded in Sarah's social and epistemic care for her students and her interest in connecting their learning within the classroom to what was happening beyond their school walls.

One such example was designing a physics project that encouraged students to make a physics-based argument regarding the use of different firearms. Sarah's goal was to use the law of conservation of momentum to explain the destructive potential of various guns. Students were given a list of guns, along with the mass of the bullet and recoil speed, and had to determine which guns were most powerful and justify why. This lesson was Sarah's attempt to leverage students' recognition of gun violence within their community as a tool to connect physics to that part of their lives and as a motivator for them to explore the concept of momentum. Similar dynamics emerged in another instance where Sarah designed a project for her students to provide a rationale for building a border wall, a sociopolitical issue emerging from the national political media about which students were intrigued. This activity required students to find the static friction of different materials for the wall and calculate the wall's costs to determine the true costs of such a wall, as well as the limitations of such structures. In making their case, students were to research the materials per square footage and determine the risks associated with these materials in terms of weather damage. They also had to calculate the physical quantities of the materials, such as weight per square mile, friction, and thermal stress, to assess the feasibility of building the wall. That said, when Sarah checked with her department chair regarding the border wall project, she was advised not to proceed. Sarah described that the school administration did not condone any instruction that might be construed as revealing a teacher's support (or lack thereof) of a particular political figure. Although this

conversation occurred informally during a setup for classroom observation and was not recorded, we felt it was important to include this moment to illustrate how institutional and sociopolitical forces constrained Sarah's enactment of politicized care.

These tensions constrained Sarah's ability to design her instruction in ways that built on and leveraged her knowledge of her students' interests, concerns, and curiosities. While these tensions and concerns shaped Sarah's instructional and curricular choices, Sarah often found ways to maneuver around them, propelled by her desire to enact care for her students as social, epistemic, and *political* beings. Table I includes a description of the intersections and tensions between the three dimensions of Sarah's politicized care for her students.

VII. DISCUSSION

In this study, we sought to understand the nature of care evident in a high school teacher's efforts to teach physics to students traditionally underserved in STEM spaces. Informed by research on the role of care in teaching [1,7–10,12,15,16], we understood Sarah's efforts to attend to and care for her students, socially, academically, and epistemically, as reflective of her politicized care for her students. In this way, our work connects with Appleby *et al.* [1], who described how student engagement in physics courses as part of a learning community designed for students from underrepresented groups was significantly shaped by how students cared for one another socially and felt cared for by the instructor. This sense of social care allowed students to engage more deeply with physics concepts on an epistemic level. The authors argue that both epistemic and social care play central roles in supporting students' physics learning, especially for those students who have been and continue to be marginalized in science. In these ways, Appleby *et al.*'s [1] research provided great insight into our understanding of Sarah's work with students, as it allowed us to understand the implications of her care for students as social beings and as physics learners.

However, recognizing that students' engagement in the discipline is shaped by interactions between local practices and systems of oppression and privilege [46], as we worked to theorize from our findings, the need to acknowledge the unique nature of the context in which this study was conducted became clear. That is, this study is about an African American teacher's efforts to teach physics to students who have been historically underserved in science classrooms in a sociopolitically contentious and divisive context of a conservative state in the southern United States. In recognition of the specifics of our research context, we are compelled to draw on particular aspects of the literature to frame this work.

While we were initially focused on the different forms of care that shaped the work of this physics teacher, the wider

literature allowed us to recognize the thread that ties together the three dimensions of care we documented by situating this care into a broader awareness of and resistance to systems of oppression. Parsons' [10] call for culturally relevant caring, which requires that teachers understand the systemic, economic, and social structures that shape the opportunities students of color are afforded, necessarily centers an awareness of racism and other systemic inequities as a fundamental aspect of science teaching. For example, in our analysis of classroom observations, Sarah often used culturally familiar contexts, such as references to community events or well-known African American figures, to explain physics ideas. Her approach aligned with cultural competence, as described by Parsons, making physics more relatable and accessible to her students. Likewise, Suárez and Krist's [12] description of justice-oriented critical caring involves a relational ideology of schooling that is mindful of society's wider inequities. More pointedly, McKinney de Royston *et al.*'s [16] and Watson [17] description of *politicized care* as essential when teaching Black children resonated with our understanding of culturally relevant and justice-oriented conceptualizations of critical care. By framing Sarah's caring efforts as politicized care, we came to recognize the political nature of her efforts as she worked to nurture her students' development as caring people, support their physics learning, and position them for success in institutions that were, at best, not set up for them. We, therefore, came to understand the different forms of care that Sarah expressed in her teaching as an intentional act of resistance to current oppressive educational and wider societal systems.

Studies suggest that CRP is central to creating inclusive STEM learning environments. Scholars have examined how physics teachers' dispositions toward CRP influence their instructional practices, with findings indicating that teachers who adopt CRP are better able to engage marginalized students in learning [47]. This aligns with Sarah's case as she understood her students' backgrounds and incorporated them into her instruction to support engagement and identity development in STEM.

As we examine the dimensions of politicized care individually, some aspects of Sarah's social care for her students are straightforward to understand. For instance, her caring for students as social beings compelled her to cultivate a warm, open classroom environment in which students and their interests and abilities were recognized, allowing students to feel "cared for," as described by Appleby *et al.* [1]. As described by a host of researchers [18,27,48], such social care, which cultivates a learning environment centered on warmth, trust, and respect, is necessary for students to develop a sense of belonging in the classroom that supports them to engage deeply in the work of learning [27,48].

Other aspects of Sarah's social care are more complex, and their ties to the political are more overt, as they speak to how "classroom-based disciplinary learning is shaped by

interactions among local practice *and* systems of privilege and oppression” [46] (p. 477) and also described by Suárez and Krist [12]. Sarah’s willingness to create a space for open dialogue where students could share and reflect on their experiences with racial discrimination and micro-aggressions allowed her to recognize and legitimize their experiences and make note of their importance for her students. Through sharing her own racialized experiences as a STEM major in an HBCU, Sarah worked to help her students recognize broader patterns of unjust systems of oppression. Her efforts here are notable and allow us to see how this facet of social care, justice-oriented critical caring [12], helped her students stay engaged in schooling despite the inequitable and oppressive structures pervasive within the schooling system.

Overtly grappling with race has been a very challenging aspect for many teachers [49]. This is a challenge that has only intensified because of recent political efforts across the United States, particularly in conservative states where this study took place, to equate classroom considerations of race as indoctrination or “pernicious ideologies” [50]. Many teachers consider discussions of race as a “taboo” topic and express concerns that they are ill-equipped to foster such discussions, as they do not want to appear racially insensitive, racist, prejudiced, or politically incorrect [51]. Thus, many teachers avoid discussions of race and other sociopolitical concerns of their students. This negative dynamic is particularly pernicious because race is central to many learners and how they see themselves [52]. By ignoring the powerful racialized experiences students bring into the classroom, we fail to support them as social agents, and thus, we underserve them as learners. Perhaps because Sarah had similar racialized experiences as her students, she recognized the importance of these experiences for her students, fueling her willingness to engage in discussions about race with them. These discussions allowed her students to critically analyze social issues as related to their positionality as learners and social agents and to develop sociopolitical awareness that informs them about the issues and possible ways to interrupt them [6,53]. In Milner’s [53] insightful considerations about incorporating race into CRP, he described how race is central to many African Americans’ identities and how they see themselves. In that sense, Sarah’s efforts illuminate how physics teachers can capitalize on these cultural concerns and enhance students’ critical awareness, which is central to both how they come to understand themselves as citizens and how they engage in the work of the discipline [15,16,53].

Epistemically, Sarah showed care by centering students’ resources within class discussions around physics ideas. Sarah also attended to students’ sensemaking by anticipating vexations around physics ideas. For example, when Sarah described a time her students were trying to make sense of the difference between longitudinal and transverse waves, she showed an awareness of students’ challenges based on their prior understanding of waves. She understood that most of her students were not exposed to

visualizing waves in a transverse or longitudinal form. Sarah assisted her students by relying on her knowledge of student backgrounds, which aligns with an asset-based, funds-of-knowledge approach [54].

Additionally, Sarah attended to students epistemically by expanding their perspective toward success. Sarah centered students’ success on how and what they learned instead of their final grade. This perspective aligns with various multicultural frameworks that emphasize that academic success is not only measured by students’ grades [6,36].

The related literature in science—specifically physics education—did not prepare us to recognize or understand the importance of Sarah’s use of academic care. We understood academic care to be a teacher’s attending to and centering students’ ability to perform academic tasks. In her work with students, many of whom had weak mathematical preparation for physics in a school setting in which physics was not a traditional strength of the student population, Sarah showed extreme care in honing experiences to increase students’ willingness to complete academic tasks. Sarah’s use of academic care was propelled by her desire to prevent her students from experiencing frustration as they encountered challenging work. She responded to her academic care by providing “hints” or reminders to students regarding their work, increasing their likelihood of success. This tendency for teachers to lessen the demand of tasks in response to or in anticipation of student struggle has been described in the literature [55], but often in ways that suggest such moves are to be avoided. Sarah’s case allows us to see that, particularly when working with students with limited experiences with success in a discipline and those who have been historically marginalized and underserved in science learning spaces, the choice to reduce the demand of tasks so that students can experience success may be ultimately productive for keeping students engaged in the thinking of the discipline. Thus, her academic care was an important dimension of Sarah’s politicized caring for her academically underserved students. We understand that this dimension of care as inherently political in that Sarah’s academic care was directed toward troubling persistent educational inequities that prevent many groups of students—including Black and other historically marginalized and minoritized students—from accessing the “academic” codes of power [56] and from experiencing themselves as successful STEM learners.

It is therefore not coincidental that Sarah’s work as a physics teacher serving students traditionally and historically underserved in physics instruction involved academic care. Because students in underresourced schools often have access to less experienced teachers and fewer resources [57], Sarah was compelled to build a classroom where students could experience success in their learning. However, it is important to recognize that while Sarah’s use of academic care was an asset in that it prevented student discouragement, this same care could be detrimental in preventing the development of student autonomy and gaining experience with productive struggle required in

physics sensemaking. Thus, Sarah's case allows us to see how the varied dimensions of a teacher's politicized care for her students can sometimes be complementary and, at other times, contradictory. We understood that part of her work inherently involves tensions between the goals aimed for in these different dimensions of care.

With our focus on the different dimensions of politicized care in the work of one physics teacher, we are not arguing that the responsibility for moving toward more effective, equitable physics instruction lies solely with the teacher. We recognize and applaud the work that focuses on structural forces that shape the work of teachers [58–60]. Indeed, we recognize that minoritized students are all too often placed in schools and disciplines that are deeply historized, serving to push students of color to the peripheries of those spaces. However, we can see Sarah's attempts to enact physics lessons that allowed students to understand and shed light on some aspects of their lives (as seen in the bullet propulsion lesson described). However, the administration's rejection of her efforts to explore the physics involved in "building a border wall" speaks to the real boundaries that this teacher had to work within.

It is also important to highlight that Sarah was committed to supporting the success of her students in a wider context that did not expect excellence from them and a context that limited, monitored, and constrained the work of its teachers. With that in mind, we argue that our work helps illuminate how teachers must first recognize these structures if they are to work within and negotiate such spaces by leveraging care as a resource to optimize the present realities of their students. It is that recognition of the inequitable social realities that students of color must negotiate and the willingness to counteract and resist such structures that led us to politicized care, which we saw in Sarah's efforts.

While this study focuses on Sarah's use of politicized care in a U.S. high school, similar discussions about equity in STEM education have emerged in international contexts. There is much research that has highlighted the importance of culturally relevant teaching in STEM education internationally. For example, recent studies have analyzed how science teachers in Jamaica and Nigeria have addressed marginalization in STEM education through leveraging students' cultural resources into their instruction [61,62]. These studies emphasize the significance of social, epistemic, and academic care in fostering student engagement and agency, particularly among underrepresented learners.

VIII. IMPLICATIONS

Our findings suggest that it would be useful for teachers to recognize the role of these varied dimensions of politicized care in teaching physics to students traditionally underserved in science spaces. While the physics education research community has traditionally emphasized epistemic dimensions of care and has recently begun to recognize the role of social care in shaping the science learning

experiences of underserved students [1], our work also calls attention to the importance of understanding how different dimensions of care can together serve to address politicized caring for learners that continue to be underserved in various learning spaces. Our work also calls attention to what we are referring to as the academic dimension of care in shaping teachers' practice and highlights its ties to politicized caring. In recognizing her students' academic histories and how these were shaped by broader social forces and persisting educational inequities, Sarah understood that showing relational and epistemic care alone was not enough. She understood that her attention to supporting them in navigating academia was an intentional act of resisting these broader patterns of inequity. In this light, the academic care that motivated Sarah's work is an essential dimension of her wider politicized caring, as she wanted to support her students in recognizing and working against unjust racialized expectations, and to support them in experiencing themselves as academically successful, even in a system that was not designed to support their success. We therefore argue that this academic dimension of care should not be ignored or trivialized when we work to characterize, appreciate, and support physics teachers' practices and efforts.

Sarah's goal was for her students to succeed in her physics class, in high school, and later in life—and this goal was ambitious given the limited success of schools like the one Sarah taught in to support the physics learning and academic success of students of color [63]. However, it is also important to acknowledge the limitations of Sarah's politicized care. She was preparing her students to challenge norms of "who can succeed in physics" and "who can succeed in school," however, we did not see her challenge the heteronormative, white nature of science [64]. Thus, in some ways, she was preparing her students to work within science as it is currently conducted, to assimilate into current science, but not to challenge those boundaries to make science more just. We understand Sarah to be engaging her students in the "culture of power" of science [56]. While that is an essential step toward more inclusive and just science, and it is laudable given the norms Sarah and her students face in high school physics in the southern United States, we must also acknowledge that this is only a first step.

We argue that it would be valuable for teachers and teacher educators to explore these three dimensions of politicized care, including the tensions and contradictions among them, when teaching physics to racially marginalized children. We posit that effective physics teaching of minoritized students requires a careful balance of these three dimensions of politicized care, as the sole emphasis on one form and a lack of attention to inherent tensions among these forms may eventually limit students' efforts and success as learners and social agents. Sarah has allowed us to see that physics teachers must be mindful of wider societal and instructional inequities to balance their care in

ways sensitive to their minoritized students as social, academic, and epistemic beings.

This study met the ethics requirements for human subjects research through the Institutional Review Board (IRB) No. IRB00000446.

DATA AVAILABILITY

The data that support the findings of this article are not publicly available because they contain sensitive personal information. The data are available from the authors upon reasonable request.

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