

Identity and power in physics teachers' discourse about equity

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Gutiérrez's equity framework, derived from mathematics education research, defines equity in terms of four dimensions: *access*, *achievement*, *identity*, and *power*. *Access* and *achievement* yield outcomes that reify the *status quo* while *identity* and *power* transform schooling to redistribute power. We use Gutiérrez's equity framework to study discourse about equity from 36 high school physics teachers who participated in an equity-focused professional development workshop. We found that the teachers' equity discourse often includes aspects of the identity dimension, yet teachers tend to frame identity using what we call a deficit lens. That is, although teachers agree that student identity matters in equity work, they often treat student identity as a way to support *access* and *achievement* and as a reflection of why students are not "successful." In Gutiérrez's words, this means centering equity work on teaching students to "play the game." We also found that the power dimension, which supports students in "changing the game," tends to be rare in teachers' discourse about equity and is often presented with varied interpretations. Our findings then suggest that teachers' equity framings of identity and power reflect physics education scholarship and dominant narratives, which leads to the call for a collective effort to challenge and reframe identity in physics in relation to power.

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I. INTRODUCTION

Physics has consistently underenrolled and infrequently graduated women¹ and People of Color across all levels (high

school physics students, physics teachers, and undergraduates) [2]. In response, physics teaching and teacher education have increasingly centered issues of representation and made efforts to shift the demographics of the field toward more gender and racial diversity. Examples of such efforts include measuring and seeking to close "*achievement gaps*"² with different interventions [4–8]; highlighting the experiences of minoritized people in physics [9–13]; making equity, inclusion, and diversity discourse an integral part of physics

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¹Reports on gender representation in physics frequently frame gender in terms of a male/female binary, overlooking transgender, and nonbinary identities. Furthermore, studies conducted by U.S. federal agencies and professional societies often omit LGBTQIA + demographic questions in their surveys, resulting in a lack of data on LGBTQIA + individuals in science, technology, engineering, and mathematics (STEM) fields. As a result, critical questions, such as whether LGBTQIA + individuals are underrepresented in STEM, remain unanswered [1].

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²The term "achievement gap" is frequently used by scholars and educators to frame issues of equity. However, Gutiérrez [3] critiques this focus, arguing that it often overemphasizes student socioeconomic backgrounds as the primary cause of achievement disparities, rather than addressing the root cause of systemic inequities. While the term "achievement gap" is used throughout the paper, we want to highlight the dangers in the deficit orientation of this approach—one that risks perpetuating a deficit framing of marginalized students.

curricula and science classrooms [14–21]; and providing focused, organized support to empower women and Students of Color in both recruitment and retention ([22,23]).³

The existence of such variety in equity approaches can be attributed, at least in part, to how the (very) definition of equity is itself varied in the community of physics and stakeholders [24,25]. These scholars offer diverse views of equity that fundamentally differ in their assertions about the sources of inequality or inequity and what the ultimate goals of equity should be. For example, equity work that is grounded in the inherent differences among students entering physics, including their backgrounds, abilities, etc., often emphasizes the role of educators in providing appropriate support and access to learning and frames the goal of equity as improving student outcomes or closing “achievement gaps” between groups of students [3,26]. Other scholarship considers systemic power structures (race/racism, sex/sexism, ability/ableism, etc.) in educational institutions, advocating for shifting equity in science education to center on the critical development of student identity, cultural resources, and community practices [27–33].

Gutiérrez [32,33] developed a framework that characterizes different definitions of equity along four dimensions: *access*, *achievement*, *identity*, and *power*. Gutiérrez’s framework is helpful for organizing and evaluating different approaches in terms of their impact. Namely, approaches that prioritize *access* and *achievement* align with dominant narratives of equity that help marginalized people enter and stay in the field. Approaches that prioritize *identity* and *power* align with critical narratives of equity that support marginalized people’s participation in the field in ways that fully embrace their identities and support them in shaping the discipline itself. While remarking on the importance of educators attending to all four dimensions to achieve true equity, she also emphasizes that the ultimate goal of equity is the redistribution of power—“power in the classroom, power in future schooling, power in one’s everyday life, and power in a global society” [32] (p. 5). She argues that though learning dominant (physics) knowledge may be necessary for students to critically analyze the world and may help mitigate some of the challenges posed by socioeconomic disparities, achieving in the dominant frame is not by itself sufficient for redistributing power. Other scholars [30,34] add to this interplay, acknowledging that “changing the game” of (physics) education—restructuring the field—will take time, and so supporting minoritized students in “playing the game” in the meantime remediates some (though not all) of the harm done by mainstream academics, which

structurally maintains racism and other forms of domination. In our work, we adopt Gutiérrez’s [32] vision of an equity approach that aims toward redistribution of power. That is, power-transforming equity in education must move beyond *access* and *achievement*. We argue that providing access to opportunities and materials and closing the “achievement gap” is an act of harm reduction, but it continues to reify the *status quo* that causes harm to marginalized communities in the first place. What we hope for is a physics teaching and learning that is unhooked from any forms of racial supremacy—one that cultivates a space wherein participants can become knowledge owners in a way that does not force them into a culture of physics as it is already defined but instead allows their empowered presence to transform the culture and the practice of the discipline.

In our study, we apply Gutiérrez’s framework to characterize high school physics teachers’ discourse about equity, specifically on issues of power and identity. Our interest in teachers’ perspectives on equity stems from the limited research available on their conceptions of equity [26,35,36] and from the understanding that their perspectives on equity clearly shape their teaching practices [26,37]. Thus, it is important for teacher educators and designers of professional development (PD) programs to pay more attention to teachers’ discussions of equity in order to better inform the development of PD programs and initiatives aimed at promoting equity in their teaching. At a time when physics teachers are increasingly encouraged to include issues of equity in their teaching [38], and when many states are enacting legislation that prohibits discussions of equity along the critical axis defined by Gutiérrez [39], it is crucial for educators and researchers to critically examine the evolving landscapes of equity and the influence of mainstream discourse. This is especially important in physics education, where the underrepresentation of Students of Colors and women remains a persistent issue. That is, if we envision equitable physics education that goes beyond merely increasing the numbers of underrepresented physics participants to one that empowers students to make meaningful connections with physics learning and build a socially just future for their communities, we need educators who bring critical lenses to bear and shape equity work toward power redistribution. Learning about where teachers are in the equity landscape provides us insights into the gaps in directives from policy and scholarship, helping us respond to teachers’ needs accordingly and to move collectively toward this goal as a community of educators, aiming beyond *access* and *achievement*.

II. THEORETICAL BACKGROUND

A. Gutiérrez’s equity framework

Gutiérrez proposes a framework that defines equity along four dimensions: *access*, *achievement*, *identity*, and *power* (Fig. 1). *Access* refers to equity efforts that cultivate

³In this work, we focus on the inequities at the intersection of race and gender, while also recognizing the interconnected systems of oppression, including racism, sexism, classism, ableism, homophobia, and more, that shape American lives. Our focus reflects the social and cultural context of the study, which is conducted in the U.S., where most entrenched inequities trace back to racism as their root cause.

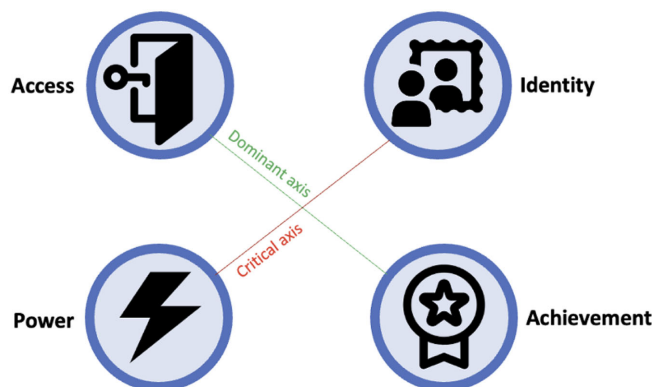


FIG. 1. Four dimensions of equity (recreated from Gutiérrez [32]).

the conditions under which all students can participate in knowledge acquisition by having access to quality teachers and curricula, infrastructure for learning inside and outside of the classroom, and classroom environments that invite student participation. Equity in terms of *achievement* is measured by tangible outcomes such as student scores on standardized assessments and retention in the educational pipeline. In Gutiérrez’s framework, these measurements are indicators that progress is being made toward a more equitable system than the current one, in which there are multiple, measurable disparities in outcomes due to racism, classism, patriarchy, etc. [33].

Gutiérrez includes *identity* in her equity framework to point to the need for supporting *all* students to be their whole selves in learning contexts. That means the learning context should help students grow and become better “in their own eyes” by responding to the historical, societal, and political contexts in which they are living and allowing learning to draw upon students’ cultural and linguistic resources [33] (p. 19). In other words, the identity dimension of equity highlights an educational environment that supports learners in developing cultural consciousness that empowers students to learn differently. This is critical because marginalized learners are often required to leave part of their identity outside of schooling contexts in order to fit in [9,12]. Equity in terms of *power* refers to social transformation in the classroom (e.g., who gets to talk, who decides the curriculum, etc.) and in the discipline. This means that the discipline itself becomes a space in which students are allowed to ask different questions for different interests, to use learned knowledge as a tool to analyze and address societal issues, to propose alternative notions of knowledge, and to rethink the discipline as a more “humanistic enterprise” [32] (p. 6).

According to Gutiérrez, *access* and *achievement* comprise the dominant axis, where *access* is a precursor to *achievement*. This axis prepares students to participate economically in society—“playing the game”—yet reifies a *status quo* that fails to address past injustices. *Identity* and

power, on the other hand, make up the critical axis, where *identity* is a precursor to *power*. This axis ensures that students’ resources and experiences are acknowledged in ways that help them become critical citizens who can “change the game.” Equity along the critical axis, therefore, should support the interrogation and disruption of what has been normalized in schooling. Gutiérrez recognizes the inherent tension here between the dominant and critical axes, while emphasizing that in order to “change the game,” students must often be prepared to “play the game.”

Gutiérrez’s framing of equity is consistent with scholarship that explicitly challenges science education, which tends to depoliticize and naturalize inequities, instead calling for an orientation of equity toward social justice [28,31,40,41]. Much of the work in physics education continues to treat equity as equality (or sameness) [24,42], failing to address systemic inequities beyond issues of representation, inclusion, and achievement [43,44]. Because physics has historically been narrated as meritocratic, objective, and politically neutral [9], naming racism and patriarchy as sources of inequity *within* the field would require challenging these dominant narratives. Choosing not to challenge these dominant narratives, we argue, maintains the *status quo* where physics remains one of the least diverse fields in the sciences [45].

Gutiérrez offers a valuable conceptual framework to map out the landscape of equity within educator communities. Previous studies on early-career mathematics teachers’ conceptions of equity show that teachers are comfortable thinking about the dominant axis of equity (i.e., *access* and *achievement*) while being challenged by the *identity* and *power* dimensions [35,36]. In many cases, deficit views on others’ differences persist among educators [46]. These challenges range from a lack of knowledge about students and communities to the perception of teaching as socio-politically neutral, a lack of awareness of equity beyond *access* and *achievement* [36], and a lack of emphasis on *identity* and *power* dimensions in disciplinary training within teacher preparation programs [35]. When applying Gutiérrez’s equity framework to the physics context, similar patterns were observed: physics teachers tended to frame equity primarily through *access* and *achievement*, often reflecting the perspectives found in mainstream educational discourse and literature [47]. Building on this work, our study continues to explore how physics teachers’ conceptions of equity align with (or fail to align with) the dimensions of *identity* and *power*. We aim to contribute to the existing literature on teacher education by offering insights from the physics discipline while also addressing gaps in the physics education research regarding teachers’ equity practices. Specifically, our study showcases examples of teachers’ critical framings of equity as well as the tensions that emerge from teachers’ discourse. In the following section, we will examine how issues of identity and power are (or are not) addressed in physics education through the lens of Gutiérrez’s equity framework.

B. Identity and power in physics education research

One of the main points of convergence among various equity approaches in physics education is the relevance of the *identity* of physics participants. Research has found that physics participants' identities and their identity development profoundly connect to all aspects of being in physics, including a sense of belonging, experiences with stereotyping, levels of interest, opportunities, success, self-efficacy, career choice, and retention. [10–12,48–51]. For example, a student's identity—particularly in terms of how it affects their perception of themselves as physicists—shapes both their pursuit of and persistence in the field [10,50]. Other scholars suggest that students' identities should not be perceived as static but instead as ever-growing and shifting under the impact of schooling contexts, curricula, teachers' identities, and choice of instruction [52–54].

While identity markers like race and gender are commonly discussed in physics education literature, much of this work defines identity through fixed demographic categories, often emphasizing differences in student participation across these markers. Such efforts have primarily been used to illustrate persistent “achievement gaps” between female and male physics students and/or between Students of Color and white students⁴ [56,57]. However, without a critical analysis of the *status quo*, this approach is likely to lead teachers and school administrations to pathologize minoritized students, placing the onus on the students and their families for failing to perform as well as the dominant groups [58]. In many cases, this achievement-based work implies a need to fix “deficits” in marginalized students' preparation and ability while failing to name, let alone address, the racism and patriarchy endemic to the field.

A growing body of work posits that the existence of “achievement gaps” might be linked to students' perceptions of themselves and their identities. For example, female students often experience low self-efficacy [59], stereotype threat [51], and feelings of being unrecognized or not belonging [48,49]. Without addressing the power dimensions of physics and schooling, such studies may yield implications that are interpreted in deficit terms—i.e., that *all* female students are less equipped to participate in physics than male students and are perceived solely in the light of needing more instructional help to engage in physics and keep up with their male peers. Gutiérrez

and Román-Dixon [60] predicted the pitfalls of equity efforts that attempt to address student identity by aiming to close the “achievement gap.” These pitfalls include relying on the underlying assumptions that marginalized students are not relevant foci of analysis or storytelling unless compared with dominant groups; that the best marginalized students can do is perform at the level of dominant groups; and/or that the current curriculum is what all students should aspire to learn and achieve [60].

In addition to framing identity in terms of demographic categories, recent research has moved to investigate student *experiences* by using identity as an analytic lens. A central theme in this literature is the development of learners' *physics identities*, defined by Carlone and Johnson [61] and further developed by Hazari and colleagues as one's perceptions of their ability to perform and understand physics, their perceived recognition as a physics person by others, and their interest in physics [13,62]. This framework has been adopted to study specific factors that impact the extent to which learners identify with physics [50], as well as how identifying with physics impacts their participation and career decisions [13,62].

The approach toward equity in this body of work has demonstrated that minoritized students often feel tensions between their cultural identities and their physics identity, which has led to educational interventions aimed at increasing marginalized physics learners' positive identification with the physics community [62,63]. However, in their review of physics education research on physics identity, Johansson and Larsson [58] highlight the risks of focusing solely on measuring students' physics identity. They critique this approach for framing marginalized students as lacking a physics identity without critically examining the culture of physics itself. This perspective often implies that minoritized students must develop a physics identity while absolving the field of any responsibility for exclusion. Additionally, this work can fail to capture student perspectives and agency in resisting certain physics identities and rejecting those associated with the current physics community [58].

Building from work on *physics identity*, Hyater-Adams *et al.* [64,65] developed a critical physics identity framework that contextualizes physics identity within the social context of race and racism. Recent studies have brought marginalized physicists' voices and experiences to the forefront, showing that being racialized, gendered, etc., and being a physicist are inseparable [11,66–69]. This growing body of research has highlighted the ways that racism, classism, patriarchy, heterosexism, ableism, and fatphobia influence students' experiences of becoming a physicist and shape how they identify with the field, illustrating the critical observation that becoming a physicist requires more from marginalized participants than abstract, intellectual labor.

In contrast to research on developing physics identity and closing the “achievement gap,” the work around critical

⁴In this paper, we choose not to capitalize white and do choose to capitalize Black, Latinx, Indigenous, and Students or People of Color. This choice is informed by critical scholarship and activism, such as that by Dumas [55]. Dumas writes that Black is a “self-determined name of a racialized social group that shares a specific set of histories, cultural processes, and imagined and performed kinships” [55] (pp. 12–13). The notion of white, on the other hand, is a socially constructed category that was created for the purposes of dominance and exclusion; it “does not describe a group with a sense of common experiences or kinship outside of acts of colonization or terror” [55] (p. 13).

physics identity explicitly challenges the assimilation-oriented approach of diversity, inclusion, and equity in physics education. That is, when the only goal of equity is to turn marginalized students into physicists—or to keep them in the field as it currently is—the purpose of a student learning physics is to *be transformed into* a physicist as a physicist is currently defined. This stance is often preferred over directly troubling or reconstructing physics norms, culture, and practice. In the traditional paradigm, the way to become a physicist is by being less unique, less “cultural,” less embodied, less “other,” and more “correct,” more disciplined, more objective (and objectlike) [68–70]. The work of Hyater-Adams and colleagues begins to challenge this by reaching toward Gutiérrez’s critical axis of equity (*identity* and *power* dimensions) and troubling the deceptively neutral, political-free nature of physics as a field. By attending to historical, societal, and political contexts that shape the field of physics, we can approach a critical understanding of marginalized students’ experiences, find an alternative explanation for the underrepresentation of these students, and discover a transformative solution to restructure physics learning and teaching.

While physics education research has begun to examine physics identity, conceptually and experientially, little has been done in the context of teacher education and professional development, with a few exceptions [52,71]. Teachers are typically expected to *recreate* physics culture in their classrooms or participate in the work of assimilating students toward physics culture; they are expected to give students access to it and achieve within it but not create a local culture that is distinct [72]. Thus, it is challenging for teachers to address equity along the *identity* dimension, and even more difficult for teachers to engage in equity practices that explicitly address power in the classroom and in the discipline. Yet teachers remain central actors in students’ experiences of and decision making about physics as something they can pursue.

In this study, we take up Gutiérrez’s equity framework as a guiding analytic lens to explore the following central question: In what ways does the discourse among physics teachers about equity foreground student identity and power? Our data come from two equity-focused PD courses. In coding teacher discourse about equity in both datasets, we found that the *power* dimension is consistently uncommon. The ways teachers conceptualize power are variable and idiosyncratic compared to other dimensions in Gutiérrez’s framework. Additionally, we found that although student identity is commonly brought up in teacher discourse about equity, there is a marked tension between foregrounding students’ identities along the *identity* dimension of equity and framing students’ identities from a deficit perspective (i.e., as creating obstacles to learning physics and thus impediments to academic achievement).

III. RESEARCH CONTEXT

The data presented in this paper come from two teacher professional development (PD) workshops that took place in August 2020 and August 2021. The workshops were part of a larger project—“Professional Development for Teaching and Learning about Energy and Equity in High School Physics”—which aimed to create a model that supports secondary science teachers in integrating science concepts and equity education. To us, a model for energy and equity is responsive to a key epistemological issue: that science concepts and knowledge are neither culture-free nor socially neutral but rather are created and sustained by people in specific times and places for the purposes of addressing specific social needs and empowering particular people or groups of people (see [73,74] for examples of energy concept development and its sociopolitical roots and impacts). The primary goals of the PD workshops are to support teachers in building an understanding of energy as a historically and politically situated science concept to empower them to bring a sociopolitical analysis to equity in their energy lessons. The aim is to support them in developing instructional materials that teach energy to their students in a more contextual manner.

The 2020 workshop was one week long, and the 2021 workshop was two weeks long; both were held by remote video conference. Both workshops shared similar content and structure, including presentations from facilitators, whole group discussions, smaller breakout discussions and activities, and individual work and reflection. An additional week was added to the 2021 workshop to support teachers in designing and sharing an energy lesson within the PD community. A total of 23 high school physics teachers (22 from the U.S. and 1 from Canada) participated in the workshop in 2020 and 19 in 2021. All participants who applied to the program were eager to further incorporate equity in their classrooms and consented to participate in research. Details of participants’ self-reported demographics and backgrounds are provided in Supplemental Material [75].

The data for the analysis are drawn from teachers’ group discourse about equity in the workshops. In both contexts, the teachers engaged in overt discourse about equity, specifically what equity means to them in their practice. The first teachers’ equity discourse took place on day 1 of the 2020 workshop with all 23 participants. After the teachers had introduced themselves and co-constructed community agreements, the co-lead facilitator posed the question: “What is equity to you?” and individual teachers were invited and given 1–2 min to share their responses in alphabetical order. The video data were transcribed using an artificial intelligence transcription service, and both the video and the transcripts are used for data analysis.

The second teachers’ equity discourse took place on day 4 of the 2021 workshop with 13 participants (6 were absent), during which the teachers were asked to provide

written reflections synchronously on what equity means to them *before* Gutiérrez’s equity framework [32,33] was introduced for further discussion. This equity personal reflection came after the teachers had an introduction and practiced land acknowledgment (day 1), discussed the role of positionality as it relates to their teaching (day 2), explored a model for energy [76–78] and energy tracking diagrams [79] (day 3), and conducted an equity-oriented application of energy tracking diagrams through climate change and “energy stories” [80] (day 4). We acknowledge that there are differences in the context of the two datasets, but our study is not focused on the differences between the two contexts, i.e., how the contexts of the data collections affect teachers’ definitions of equity. Rather, we are studying similar patterns with respect to how equity is discussed around the dimensions of *identity* and *power* as defined by Gutiérrez. In fact, similar patterns emerged across the two different datasets (including discussion of student identity that aligned with the dominant axis and the rarity of *power* discussion). This strengthened our argument that these conceptions of equity are ingrained and dominant in the physics educator community.

IV. METHODS

We performed a discourse analysis [81] on a total of 36 teachers’ verbal and written definitions of equity during the PD. We adopted Fairclough’s [82] critical approach to discourse analysis where discourse “both reflects and produces the ideas and assumptions relating to the ways in which personal identities, social relations and knowledge systems are constituted through social practice” [83] (p. 204). In our study, critical discourse analysis guides us to seek meaning beyond the structures of the utterances and to contextualize teachers’ equity discourse in both the personal and the physics educator community contexts. That is, through analyzing teachers’ discourse, we begin to understand teachers’ collective equity conceptions in light of how they are shaped by the larger community and society around them.

We followed the steps outlined in [84] to code the teachers’ definitions of equity in terms of the four dimensions of *access*, *achievement*, *identity*, and *power* as Gutiérrez posits them. Coding allows us to quantify how common each dimension of equity (defined by Gutiérrez) was among the discourse of the teachers in the context of our PDs, as well as to notice any qualitative themes that emerged from the coding. Gutiérrez called for caution in the analysis of equity discourse—for example, when teachers say they want to *empower* students, they may mean they want to help them *achieve* in class rather than challenge dominant knowledge and culture or apply learned knowledge to solve problems in their communities [32]. As part of our discourse analysis [81], we treated individual teachers’ whole statements as units of coding and sought to understand the main themes of their responses rather than coding on a line-by-line or word-by-word basis. We paid attention to the cohesion and

connections between utterances and any assumptions and meanings that may underlie their responses.

The authors, T. H. and L. C. B., coded all 36 responses in 2 rounds: we first coded the verbal responses from 2020 dataset and then we coded the written responses from 2021 dataset. After reconsidering Gutiérrez’s equity framework, the two authors independently coded all verbal responses then met to discuss our agreement and resolve any disagreements. This process was repeated several times until we fully agreed on our coding. Then, we revised and finalized the codebook (Table I). Verbal responses were often more detailed and contextualized, which provided us insights to refine our codebook of equity dimensions placed within physics teaching contexts. In the second round, we applied the codebook to analyze the written responses. The final coding results were shared with the other authors to seek validity. All authors participated partly or fully in the PDs as facilitators and therefore were familiar with the data. Table I includes example quotes drawn from teachers’ verbal and written responses in our data that were given the code for each corresponding dimension.

In our pilot study [47], we reported our findings that teachers’ ideas of equity foreground *access* and *achievement* dimensions in identifiable, saturated patterns. In this study, we found that responses coded as *power* were not only rare compared to other dimensions but also varied in their meanings. Thus, we decided to present their interpretations instead of themes. On the other hand, we noticed that when teachers spoke of or wrote about identity, their statements often clustered around two aspects of identity, which emphasized that *every* student’s lived experiences matter and that (under)representation along particular identity markers matters (see Table I, teachers’ quotes in *identity* dimension). Although these themes align with *some* aspects of Gutiérrez’s *identity* dimension, we found that it was also common that teachers spoke or wrote about identity in ways that were *not* fully aligned with Gutiérrez’s definition of *identity* and her critical axis but were rather connected to the dominant axis of *access* and *achievement*. These tensions occurred even in responses that were given the identity code. We found it more compelling to showcase and elaborate on such critical, nuanced tensions in the *identity* dimension for this study.

Positionality

Trà Huỳnh is an able-bodied, physics Ph.D., Asian immigrant, cisgender woman who was born and raised in a middle-class family in Vietnam and is the first in her family to go to college and pursue higher education. Growing up, sexism, classism, and colorism were central to her lived experiences, but she was not conscious of global white supremacy and anti-Blackness due to living in a racially homogenous context such as Vietnam and her privilege in identifying with the majority ethnicity. Her lived experience began to center around racism when she moved to the U.S. to pursue graduate school, which

TABLE I. Descriptors of equity dimensions and examples of teachers' quotes drawn from our data that are coded in each dimension.

Code	Descriptors	Teachers' quotes
Access	Ensuring students have resources they need for learning. This can include material resources (e.g., access to physics classes, rigorous curriculum, learning materials: lab equipment and textbooks) and access to a conducive learning environment (e.g., where students feel a sense of belonging to participate in the classroom.)	"I work in the same low-income community that I grew up in, and there was always this issue of access to ideas. [Equity] was providing them that access to materials but also to new ideas that they never had experiences to." "Kids cannot learn unless they feel like they belong in class, so [equity is] creating a sense of everybody does belong and everybody is bringing something."
Achievement	Specific, actualized achievement in physics (e.g., high test scores, taking advanced physics classes, mastery of materials, success in future educational and career pursuits) and general notions of success and the importance of students' success.	"Equity in my classroom is showing all kids that they can be successful." "Equity means I would see more students taking upper division science classes and not just the white male students."
Identity	Attending to students' assets and lived experiences by building on students' ideas and increasing representation in classroom content. Recognizing and addressing the complex interactions between their students' identities, school, physics, and society, which cause disparity, bias, stereotypes, etc.	"I hope to view it as a way to take advantage of all students' backgrounds, cultures, and experiences through the use of scientific practices, instead of the performances that typically make up physics education (such as performing lab practicals or calculations)." "I try to provide examples of historical figures that shaped the field of physics that were non-European."
Power	Social transformation, including disrupting power dynamics in the classroom, analyzing societal issues using physics knowledge, and critiquing the objective notions of physics knowledge.	"I think a lot of my job as a teacher is to call attention to things and expose students to ideas (Indigenous ways of thought, systemic bias issues, etc.) that they would not have been exposed to in a 'traditional' classroom or one where equity work was not a focus."

heightened during the Covid-19 pandemic and the wave of Asian hate. Entering physics education research around physicist identities, Critical Race Theory, and antiracist work by Scholars of Color has helped her define and make sense of her experiences. Her learning journey is filled with struggles to abolish her assimilated mindset, unlearn what is being normalized, and connect what she learned with her experiences as Vietnamese, both in the contexts of the U.S. and her home country. Her point of view is different from that of Asian Americans and Americans of Asian heritage, yet the feeling of being excluded is shared when it comes to social justice issues in the U.S. context.

Lauren C. Bauman is a cisgender, white woman. She was born and raised in a privileged, upper-middle-class family in Canada. She grew up in a homogeneously white, race-evasive context where positionality, privilege, and oppression were rarely discussed. She has been heavily shaped by her positive experiences in educational spaces. She received her bachelor's degree from a small liberal arts college that valued an interdisciplinary curriculum. Although she primarily studied physics, it was during this time that she took courses and was immersed in a community that encouraged her to think more critically about her own positionality, privilege, and marginalization across dimensions of race, gender, ability, and class in what is a deeply unjust world. She recognizes her position as primarily a learner in this space

and approaches this role with a commitment to reflection and self-awareness. She sees this work as part of her continued commitment to learn, amplify the voices and lived experiences of others, and support equity-oriented work in all parts of life.

Amy D. Robertson is a chronically ill and disabled physics Ph.D., wealthy, white, cisgender woman. Robertson's sense of identity and power within physics learning and professional spaces has been deeply shaped by both her privilege and her minoritized status. As a white, wealthy woman who grew up in a small upper-middle-class suburb with substantial investment in public education, Robertson was consistently affirmed for fully participating in—and identifying with—science. At the same time, as a disabled woman, Robertson was often in a position of needing to substantiate her belongingness with identity performances that resembled those of white, nondisabled men. Her analytic lens in this paper is shaped by these experiences. Robertson's position of power within white-dominant culture and the hegemony of whiteness made power structures imperceptible to her for most of her life, and her marginalization as a disabled woman has shaped her capacity to identify oppressive dynamics at work in physics teaching and learning spaces.

Rachel E. Scherr is a leader of the Energy and Equity Project, which provides the context for this paper's research. Her efforts include creating a model for secondary

science teacher development centered on understanding energy as a historically and politically situated science concept, as well as supporting a culturally diverse team in constructing knowledge with full view of their race, ethnicity, nationality, gender, religious commitments, social class, ability status, and other features of social identity that may be important to them. Scherr is an able-bodied, cisgender woman. Her identity as a white-passing Jewish person has contributed to her awareness that schooling and popular culture normally ignore or tokenize nondominant cultures.

V. RESULTS

A. Finding 1: The power dimension is rare and intermittent in teachers' conceptions of equity

1. The power dimension is rare in teachers' discussions of equity, whereas access, achievement, and identity dimensions are commonly present in teachers' discourse about equity

Figure 2 shows the frequency of each equity dimension in teacher discourse about equity. An equity dimension's frequency is the number of individuals whose definition of equity included that dimension, rather than how often that dimension is identified within each teacher's response. The breakdown by each dataset is provided in Supplemental Material [75].

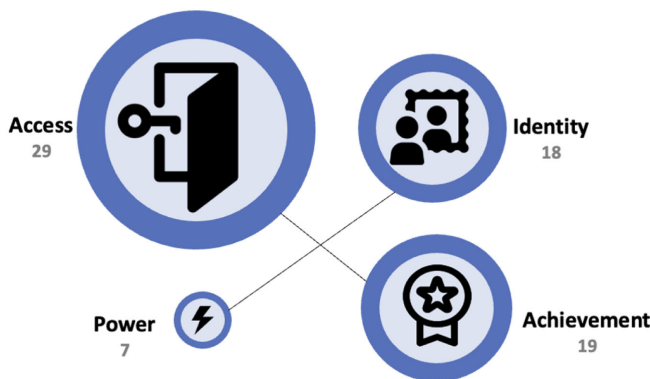


FIG. 2. Frequencies of *access*, *achievement*, *identity*, and *power* dimensions in teachers' conceptions of equity in two years of PD ($N = 36$). The sizes of the symbols (diameters and thickness of the line) are scaled to the frequencies of the dimensions in teacher discourse.

As shown in Fig. 2, all four dimensions of equity are present when teachers define equity across two separate years of our PD. The *access* dimension was consistently most frequent and the *power* dimension consistently the least frequent, with the *identity* and *achievement* dimensions being variably frequent and approximately equal when added across the two years. The variations in frequency of the *achievement* and *identity* dimensions across two years may be attributed to the data context. While discussions about equity occurred on the first day in the 2020 workshop, discussions about equity took place on day 4 of the 2021 workshop, preceded by a discussion on positionality on day 2, which may have prompted teachers' attention to identity in the following discussions.

2. The power dimension comes up intermittently in teacher discourse, whereas the access, achievement, and identity dimensions persist throughout the discourse

In addition to the frequency of each dimension, the entire group verbal conversation in the 2020 dataset allows us to examine the persistence of each dimension (or the lack thereof) in the teachers' collective discourse. In this setting, 23 teachers were given time to self-reflect and then were invited to share, in turn, what equity meant to them. Figure 3 represents the dimensions of equity we coded for each talk turn as one measure of the salience and persistence of each dimension across the conversation. As Fig. 3 highlights, the *access*, *achievement*, and *identity* dimensions of equity are brought up within the first two talk turns, whereas the *power* dimension emerges in the eighth talk turn. We might expect that in group conversational settings, the content of later talk turns would be influenced by the content in earlier talk turns—e.g., we might expect that once *power* dimension is brought up, follow-up responses might be more likely to include the power dimension, making the power dimension more common later in the conversation. However, there is not a clear indication that the emergence of the *power* dimension initiates a stable pattern of use among teachers. Even after the *power* dimension is introduced, the group of teachers continues to recenter equity ideas in the *access*, *achievement*, and *identity* dimensions. We contend that the rare and unstable presence of the *power* dimension in teacher discourse about equity reflects a lack of take-up of this dimension among teachers in this context, and that this

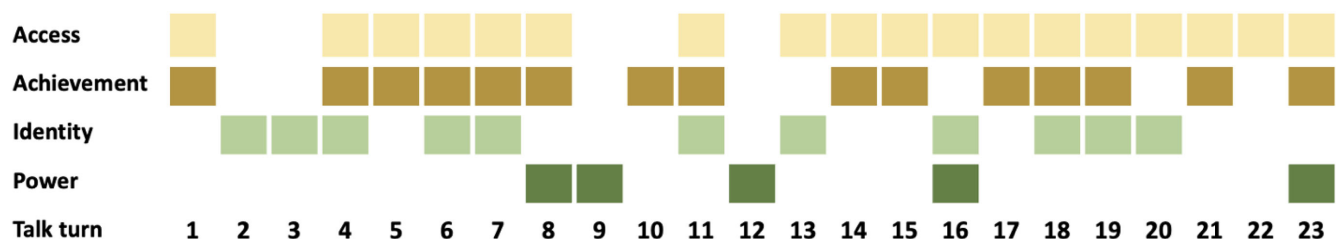


FIG. 3. The dimensions of equity that showed up in each talk turn. Each talk turn represents one teacher's complete response.

lack of take-up can be at least partially attributed to the ways science education research has foregrounded the dominant axis of equity.

B. Finding 2: Teachers use a variety of meanings for power

Among the 36 teacher participants, only 7 responses to the question, “What does equity mean to you?” were coded as including equity ideas aligned with the *power* dimension. Among these responses, we found three different interpretations of equity as it relates to power. Interpretation A centers around creating space for discussing relevant injustices in physics classrooms. Interpretation B focuses on the disruption of normalized power dynamics in physics classroom between teachers and students. Interpretation C focuses on the interrogation of the physics canon and educational system. The variability in the interpretation of power, where only one or two teachers share a definition, contrasts with the clustering of ideas about access and achievement that we identified in our earlier work, where most teachers shared particular meanings of *access* or *achievement* [47]. There, teachers’ ideas about *access* and *achievement* largely reflected (the same) themes from broader educational literature, suggesting that such literature shapes teacher discourse about equity.

1. Interpretation A: Equity is discussing injustices in physics classrooms

Within teachers’ discussion of equity, they sometimes say that they want to take opportunities in physics classroom environments to discuss and address systemic issues. For example, Lisa said:

This is the thing that I want to talk about more in my classroom. I want to be able to talk about systems and question them and collaborate with my students and do it in a productive way so that we recognize there are inequities in systems, but then talk about how we can address them, how we can try to change them [Lisa].

Lisa emphasizes her desire to create space in her classroom where she can have productive conversations with her students to not only bring awareness to social injustices but also empower her students to make change. Another teacher, Riley, said:

[...] the one piece, I think that stands out, that I haven’t heard as much is talking to students. And if we are talking about energy, like who has access to resources in the community in the United States? In the world? Where are the resources? Who has access to power? Who has privilege? What’s the inequality? [...] I think it’s a really important lens for students entering into

science and thinking about the larger world [Riley].

Similar to Lisa’s response, Riley’s quote expresses an approach to equity, which emphasizes the role of the physics classroom in supporting students to examine social justice issues. While Lisa’s ideas regarding social justice issues in physics class are broad and not specified, Riley included in their suggestion specific ideas that build on disciplinary topics, i.e., who has access to power and privilege as these pertain to energy resources.

2. Interpretation B: Equity is disrupting power dynamics in the physics classroom

One teacher, Maggie, foregrounded the disruption of power dynamics in order to create an inclusive learning environment in her answer to the question of what equity means to her. After sharing how she previously focused on access and achievement, Maggie stated:

But the shift in my thinking recently has been, what does that look like in my classroom, in the dynamic between me and my students. It’s like, I can talk about inclusion, but if I’m still the teacher and I’m still expecting compliance to my way of doing things, then I’m not really listening and collaborating with my students to build our classroom space, to build our learning space. [...] Like, am I truly valuing student voices in my classroom? And is that an equitable space for everybody? And how do I disrupt the expectations of who has power, who’s the smart kids or who’s whatever, when they come into my classroom, what stereotypes everybody’s internalized before they got there [Maggie].

Maggie shares how her conceptions of equity have evolved to examine taken-for-granted classroom dynamics. Specifically, Maggie reflects on teacher-student relationships and dynamics, critiquing the commonly stated expression of “valuing student voices” without disrupting the normative expectation of student compliance in class. For Maggie, equity should be reflected in collaborative classroom building by both teacher and students, rather than in a classroom that is powered solely by the teacher. Maggie’s ideas about equity along the *power* dimension rest on the way she examines the classroom *status quo* and reimagines new dynamics for equitable classrooms. This is distinguished from inclusion-typed approaches that conform to power hierarchies between teachers and students.

3. Interpretation C: Equity is interrogating the status quo

Teachers occasionally named the importance of interrogating what has been normalized in physics knowledge and educational systems. For example, Leslie stated:

So a lot of the times when I'm talking about equity, it's seen as a personal affront to the people that I'm speaking to. So instead of approaching it and having to immediately encounter the idea of privilege and fragility, that is so ingrained with a lot of us, I usually start with asking the question, just why. So when we're looking at our textbook, why is it written this way? Why are we reading these theories, these hypotheses, instead of something else, and building on that to get to the point where we start to realize, or at least my class starts to realize, that there is something already built into this fabric of our, um, very observational, very data-driven science, that isn't either of those things, where they're seeing that the same, um, ethnicities are being heralded as the breakers of these norms and all of this stuff. And I'm like, well then why are all of them from England in the exact same time period. Doesn't that seem suspicious? And then we start expanding outward. And it's like, what I found is that that's a way to start getting them to ask more of what they're seeing and what they're learning, which gives me a way in, and that's what's hardest for me a lot of the time [Leslie].

Leslie describes an equity approach that she thinks is especially important for her predominantly white, wealthy context. For her audience, Leslie stated that conversations around privilege and white fragility can be ineffective entry points. Instead, Leslie would approach conversations regarding the *status quo* by questioning the nature of science. Using examples of astronomy texts and contents, she encourages her students to interrogate the myth of the neutrality of physics, questioning the representation of scientists in textbooks and challenging the bias-free notion of knowledge.

Additionally, teachers' ideas of equity included the power dimension in ways that pointed to the role of schooling in perpetuating injustices. For example, a written response stated:

I think equity in physics means recognizing past wrongs (unequal access to education, opportunities, etc.) and actively working to call attention to those issues and correct them by elevating voices and ideas that have been marginalized. I think a lot of my job as a teacher is to call attention to things and expose students to ideas (indigenous ways of thought, systemic bias issues, etc) that they would not have been exposed to in a 'traditional' classroom or one where equity work was not a focus.

In this statement, the teacher expresses equity notions that are concerned with access, specifically recognizing

systemic "unequal access" and "opportunities" and alleviating those disparities by centering marginalized "voices and ideas." In addition, the teacher critically addresses the role of "traditional" schooling in perpetuating inequities by continuing to marginalize certain ways of knowing. The teacher concludes that the role of a teacher for equity discussions extends to the *power* dimensions to enhance students' awareness and exposure to different knowledge systems and societal issues. Both Leslie and the teacher foreground the *power* dimension in their critical reflections on the discipline and the schooling system, especially underscoring the ways systemic inequities are reproduced through dominant knowledge construction.

Our findings show that the *power* dimension is not only rare in teachers' discourse about equity but also varies in meaning. This contrasts with how discourse about the *access* and *achievement* dimensions was found to be relatively similar to one another and consistent with the literature. Among the seven teachers' responses coded with the *power* dimension, we observe various ways in which they conceptualize it. This lack of consensus, along with the rarity of equity ideas in *power* dimensions, reflects the existing PER literature's focus on access, achievement, and identity in equity initiatives [85,86].

C. Finding 3: There is tension between deficit and critical framings of students' identities in teacher discourse about equity

We were careful in our interpretation of teachers' use of the *identity* dimension as they discussed equity. While many teachers referred to students' "identities" and "backgrounds" as part of their responses to define equity, they did not necessarily use language consistent with the *identity* dimension as defined by Gutiérrez. That is, though teachers recognized the relevance of students' identities to their learning, they mostly linked students' identities with issues of *access* and *achievement*, rather than discussing ways to empower students toward social transformation consistent with their identities. For example, Vivian was concerned with identity as pertaining to achievement:

If there was an effect on equity [in my school], we would see more students taking upper division science classes, more students feeling like they could compete in those classes, more students becoming scientists, and not just the white male students. So even though [my] high school is pretty diverse high school, um, there's still major issues of inequity there. Um, and, uh, I think that can happen in my classroom by complicated push-pull or setting high standards for everybody, and also helping students that need whatever they need, um, in order to reach those standards. [Vivian]

Vivian recognizes the differences in achievement among groups of students in her local context, specifically with the underrepresentation of non-white-male students in upper-division physics courses. Although she notes that equity is more than diversity, toward the end of her statement, Vivian indicates that her role as an instructor is to set high standards for *every* student and provide them “whatever they need [...] to reach those standards.” Vivian’s conception of equity here is consistent with mainstream literature and discourses, where it is assumed that providing more access will help marginalized students succeed and persist in physics, and that achieving as high in physics as the dominant group of students is something that marginalized students should aspire to (and, by extension, that teachers should aspire to help them with). This assumption overlooks the systemic barriers that continue marginalizing certain groups of students in the field of physics. Aligned with Gutiérrez’s equity framework, such instances where teachers mention identities in ways that only trace back to achievement and access, such as Vivian’s statement, are *not* coded as the *identity* dimension in our analysis. This is similar to Gutiérrez’s example of teachers using the language of “power” exclusively to refer to empowering students toward high achievement [32]. In the case of teachers using the language of “identity,” rather than framing students’ identities and knowledge as assets for expanding the discipline, they frame students’ identities solely in relation to the discipline identity and what they need to achieve externally set standards. Such instances exemplify a deficit framing of student identity in equity discourse.

Among responses that were coded with the *identity* dimension, we found that teachers’ responses foreground the *identity* dimension in two clustered patterns. Teachers emphasize the need to (i) build on students’ identities and lived experiences and to (ii) increase the representation of marginalized identities in science. In both cases, teachers’ definitions of equity align with Gutiérrez’s identity dimension as they recognize the importance of identity as a resource for learning and the impacts of social forces on students’ identity development. However, even in the responses that foreground the *identity* dimension, we often observe the tension between a critical framing and a deficit framing of student identity, that is between a framing of identity as a source for social change versus identity as subject to change.

For example, common among our participants was the implied belief that students’ identities are relevant for their learning, often framed in a way similar to a constructivist treatment of students’ *ideas* as relevant for their learning that is foundational in physics education [87]. Specifically, constructivism perceives students’ ideas as relevant and significant for teachers to pick instructional strategies that drive them. That is, identities (and prior learning) shape what students know and have experienced, and understanding students’ identities, ideas, and interests can help teachers to identify how to support them in learning science. For example, Elise stated:

... kids experience the world, and that’s what they’re bringing in is their knowledge. And that’s what we build upon and we get closer to a scientific consensus. And so I kind of think of that as asking a kid what they know and what they need so that I can provide for them what they need to get closer to the scientific consensus, or if it’s just about life in general, because I worked at an alternative school, what they need so that they can feel right with themselves. So, um, that’s kind of where I think equity is, is not telling someone they’re wrong necessarily, but that their life experiences have value. And then we’re going to build with those. [Elise]

Elise first acknowledges that students bring valuable prior experiences to physics class, which she believes should serve as a starting point for building learning. However, we observe a tension in the way Elise views the goals that students’ lived experiences serve. On one hand, she connects students’ experiences with access to and achievement of already established “scientific consensus,” citing the importance of “asking a kid what they know and what they need so that [she] can provide for them what they need to get closer to the scientific consensus.” Here, students’ lived experiences are framed as inputs for schooling to help shape them toward a disciplinary identity. It appears to us that this way of acknowledging students’ lived experiences as relevant to learning mainstream knowledge provides a safe way for teachers to talk about students’ identities without challenging the subjective, political nature of scientific knowledge [58]. In treating students’ experiences as a starting point along a trajectory toward canonical understandings, the idea is fundamentally one of assimilation, not transformation. Teachers respond to students’ identities, ideas, and interests to help them “play the game” of learning, but without inviting students to “change the game” of what is being learned. On the other hand, toward the end of her statement, Elise recognizes that learning goals can be just about “life in general,” i.e., “feel[ing] right” with oneself. In this case, learning is shaped by students’ prior experiences, toward self-development. Here, Elise begins to challenge the default assumption that academic success is the sole aim of education, a perspective that is more aligned with Gutiérrez’s *identity* dimension of equity.

In addition to a tension in *leveraging* student identity toward learning goals, we also observe a tension in reacting to underrepresentation and the *status quo*. Specifically, the teachers often expressed concern about students experiencing the existing curriculum differently, based on differences in their identities. For example, Chris considered students’ cultural experiences in relation to physics learning in the following statement:

I think when I’m thinking about equity, uh, I think about the first year I was teaching [...] physics

and my students were mainly English language learners. [...] Um, and so I think one of the really important things is to make sure that everybody has a common definition of words that we're using and concepts that we're introducing them to, to give them experience. Because I mean, I think the main reason why guys do better than girls in the classroom comes more to, um, you know, that they're more involved in sports. Or that they're more physically active, that they see things actually move. And so they have a more intuitive sense. Or perhaps they have people in their life that get them, um, you know, outside the classroom and interested in things that other people don't, and that this creates a kind of an unequal level that people are starting from. And so how do you get everybody to the same basic level where you are asking the same question to the students so that they're able to answer in a way, um, to demonstrate what their knowledge of, of the physics is, um, and you know, just working with different populations of students and, and the, the definitions and ideas that they come to think with in a different way that, that equity also, it's a conversation, it's a dialogue. It's making sure that, that, everybody's on the same page and then constantly updating that, um, to make sure that continues. [Chris]

Here, Chris expresses concern about how different lived experiences set individuals at different paces for success in physics, especially when the physics curricula do not equitably represent the diversity of students' cultural experiences. Although they begin to challenge conventions, Chris emphasizes the importance of bringing everyone to the same place so that students can equally access learning and so that their learning of physics can be fairly assessed ("... how do you get everybody to the same basic level where you are asking the same question to the students so that they're able to answer in a way, um, to demonstrate what their knowledge of, of the physics is"). In this way, although Chris has profound awareness of the systemic flaws in physics education that disadvantage certain students, including female and bilingual students, they mainly focus on modifying the assessment to help counter their perception of students' deficits. Chris' reaction is to seek solutions in the *individuals*—that is, individual teachers making efforts to offset educational inequities for individual students. We argue that teachers like Chris are restricted in the power and imagination required to extend equity solutions into the *power* dimension. That is, one can miss a possibility to build on students' strengths of having lived the world differently to redefine the learning of physics.

Overall, we found that discussing student identity does not inherently address underlying power structures, as Gutiérrez's definition of equity along the *identity*

dimension suggests. Even in cases where teachers defined equity in ways that align with the *identity* dimension, significant tensions exist. First, there exists a tension between acknowledging students' diverse, prior experiences while also perceiving these experiences as predetermined (dis)advantages and shortcomings for learning. This tension becomes especially evident when teachers aim to build on students' prior experiences but do not regard those experiences as equally important as mastering physics knowledge or as valuable in their own right, unless already aligned with disciplinary knowledge. Instead, prior experiences are often seen as inputs to shape pedagogical strategies that mold students into images deemed desirable by the discipline and society. Second, there exists a tension between teachers recognizing systemic barriers that hinder student participation in physics and their inclination to address these issues on an individual basis. This tension is embodied in the ways in which teachers struggle to challenge the *status quo* in the existing schooling structures, often resorting (consciously or unconsciously) to personal efforts to recreate dominant values and cultures in the physics classroom.

As long as attaining a physics identity and achieving as highly as dominant students remain the end goals, it will be very difficult—maybe impossible—for teachers' equity efforts to turn away from a schooling that fixes students, i.e., an assimilationist approach, and instead direct itself toward to an education that empowers social transformation. We propose that the rarity of the *power* dimension in teachers' discourse about equity results from the dominant view in which students' identities are subject to conversion. This pattern reflects dominant physics education discourses where the central question remains: how to help students become more like physicists, as physicists have historically been defined.

VI. DISCUSSION AND CONCLUSION

Our study aims to characterize high school physics teachers' discourse about equity along Gutiérrez's dimensions of *identity* and *power*. We found that physics teachers encounter significant difficulties in (re)imagining equity in terms of *power* and *identity*. Specifically, equity conceptions in the *power* dimension are rare and varied among the teachers, mostly based on their individual lived and teaching experiences, as teachers' conceptualizations of student identity move back and forth between deficit and critical framings. This finding contrasts with teachers frequently referencing and even agreeing on the meanings of equity along the *access* and *achievement* dimensions. Specifically, our study shows that teachers in our sample tended to focus on their perception of students' cultural deficits when describing the roles of schooling and teaching (i.e., to compensate for marginalized students' lack of resources and cultural disadvantages). That is, it appears to be difficult for teachers to access alternative views of

students and their families and communities, specifically from a strength-based and knowledge-generator position. Our findings align with the patterns found in previous studies, wherein the *access* and *achievement* dimensions are found more frequently activated by educators as they consider equity [35,36] and that deficit views of students and their communities persist [46]. Theorizing from Gutiérrez’s equity framework, we argue that the difficulties in activating an equity conception aligned with *identity*—a dimension that is a precursor to *power*—contribute to the rarity of the *power* dimension in teachers’ discourse overall.

Our findings are based on a snapshot of discourse from a small sample of teachers who selected to participate in our professional development programs. Our sample included a disproportionately large number of (white) women high school physics teachers; at the same time, the underrepresentation of Black and Latinx teachers in our sample reflects the demographics of national high school physics teachers in the U.S. In some ways, our findings overrepresent equity-oriented mindsets from self-applied teacher participants. We believe that teachers’ conceptions of equity are fluid and context-dependent and think that it is important to further explore how teachers’ local teaching context and the PD contexts impact teachers’ conception of equity, how teachers’ conceptions of equity continue to change as a result of their experience and agency, and furthermore, how their conceptions of equity shape their practices.

Our analysis does not aim to assess where individual teachers stand in their adjustments to an equity approach. Instead, we view teachers’ collective conceptions of equity as a reflection of the broader ideologies and progress within physics education regarding equity. We want to point out that teachers’ conception of identity is reflective of the ways mainstream physics education scholarship and initiatives center student identity in equity efforts, mainly considering identity as input that informs strategies for *access* and *achievement* [85,86]. Thus, if we want to support teachers in taking up the critical dimensions of Gutiérrez’s equity framework, we argue that physics education research must engage with critical perspectives on equity. This requires building on existing work that centers the lived experiences of People of Color in physics and problematized physics identity. Scholars such as

Prescod-Weinstein [69], Hyater-Adams *et al.* [64,65], Rosa and Mensah [66], Fries-Britt *et al.* [67], Ong [9,68], and others have paved the way in this regard. In a field like physics, we suggest that challenging the presumed neutrality and objectivity of physics can be a key entry point for exploring power dynamics and fostering cultural transformation.

In a physics classroom, critical discussions can address the *status quo* and power disparities in society at large (e.g., see the Underrepresentation Curriculum [21]) or they can situate around specific physics concepts (e.g., see Refs. [37,80] for examples relating to energy concepts). At the institutional level, we must resist recentering *access* and *achievement* within the discourse on *identity* and *power* in DEI initiatives. Rather, we advocate for positioning *access* and *achievement* in the critical axis—that is, to confront and dismantle the structures that cause systemic gaps in student populations and render learning inaccessible in the first place [29,88]. For the scholarship of physics education research, Gutiérrez’s equity framework challenges us to critically (re)examine our foundational assumptions of equity. It calls for a shift in our identity research agenda, urging us to move beyond merely addressing bias and stereotypes in educational settings. Instead, we must ask deeper questions about power and identity, such as What does it mean for students to be knowledge generators within learning communities.

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DATA AVAILABILITY

The data that support the findings of this article are not publicly available upon publication because it is not technically feasible and/or the cost of preparing, depositing, and hosting the data would be prohibitive within the terms of this research project. The data are available from the authors upon reasonable request.

[1] T.J. Atherton, R.S. Barthelemy, W. Deconinck, M.L. Falk, S. Garmon, E. Long, M. Plisch, E.H. Simmons, and K. Reeves, *LGBT Climate in Physics: Building an Inclusive Community* (American Physical Society, College Park, MD, 2016).

[2] American Physical Society, Physics bachelor’s degrees by gender and race/ethnicity, <https://www.aps.org/learning-center/statistics/diversity> [accessed August 25, 2025].

[3] R. Gutiérrez, A “gap-gazing” fetish in mathematics education, *J. Res. Math. Educ.* **39**, 357 (2008).

- [4] M. Lorenzo, C. H. Crouch, and E. Mazur, Reducing the gender gap in the physics classroom, *Am. J. Phys.* **74**, 118 (2006).
- [5] A. Miyake, L. E. Kost-Smith, N. D. Finkelstein, S. J. Pollock, G. L. Cohen, and T. A. Ito, Reducing the gender achievement gap in college science: A classroom study of values affirmation, *Science* **330**, 1234 (2010).
- [6] S. Salehi, E. Burkholder, G. P. Lepage, S. Pollock, and C. Wieman, Demographic gaps or preparation gaps?: The large impact of incoming preparation on performance of students in introductory physics, *Phys. Rev. Phys. Educ. Res.* **15**, 020114 (2019).
- [7] S. J. Pollock, N. D. Finkelstein, and L. E. Kost, Reducing the gender gap in the physics classroom: How sufficient is interactive engagement?, *Phys. Rev. ST Phys. Educ. Res.* **3**, 010107 (2007).
- [8] E. Brewé, V. Sawtelle, L. H. Kramer, G. E. O'Brien, I. Rodriguez, and P. Pamelá, Toward equity through participation in modeling instruction in introductory university physics, *Phys. Rev. ST Phys. Educ. Res.* **6**, 010106 (2010).
- [9] M. Ong, *The Double Bind in Physics Education: Intersectionality, Equity, and Belonging for Women of Color* (Harvard Education Press, Cambridge, MA, 2023).
- [10] D. Doucette and C. Singh, Why are there so few women in physics? Reflections on the experiences of two women, *Phys. Teach.* **58**, 297 (2020).
- [11] X. R. Quichocho, J. Conn, E. M. Schipull, and E. W. Close, Who does physics? Understanding the composition of physicists through the lens of women of color and LGBTQ + women physicists, *presented at PER Conf. 2019, Provo, UT*, 10.1119/perc.2019.pr.Quichocho.
- [12] X. R. Quichocho, E. M. Schipull, and E. W. Close, Understanding physics identity development through the identity performances of black, indigenous, and women of color and LGBTQ + women in physics, *presented at PER Conf. 2020, Virtual Conference*, 10.1119/perc.2020.pr.Quichocho.
- [13] Z. Hazari, G. Sonner, P. M. Sadler, and M.-C. Shanahan, Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study, *J. Res. Sci. Teach.* **47**, 978 (2010).
- [14] A. R. Daane, S. R. Decker, and V. Sawtelle, Teaching about racial equity in introductory physics courses, *Phys. Teach.* **55**, 328 (2017).
- [15] A. R. Daane and V. Sawtelle, Student discourse about equity in an introductory college physics course, in *Physics, presented at PER Conf. 2016, Sacramento, CA*, 10.1119/perc.2016.pr.017.
- [16] M.-E. Baylor, J. R. Hoehn, and N. Finkelstein, Infusing equity, diversity, and inclusion throughout our physics curriculum: (Re)defining what it means to be a physicist, *Phys. Teach.* **60**, 172 (2022).
- [17] J. R. Hoehn and N. D. Finkelstein, Fostering inclusion and teaching equity in a modern physics for engineers course, in *Proceedings of the 2020 ASEE Virtual Annual Conference Content Access* (2020), <https://peer.asee.org/fostering-inclusion-and-teaching-equity-in-a-modern-physics-for-engineers-course>.
- [18] C. Dalton and J. Hudgings, Integrating equity: Curricular development and student experiences in an intermediate-level college physics major course, *Phys. Teach.* **58**, 545 (2020).
- [19] M. Rifkin, Addressing underrepresentation: Physics teaching for all, *Phys. Teach.* **54**, 72 (2016).
- [20] M. Rifkin, Who does science?, *Sci. Teach.* **87**, 24 (2020).
- [21] The underrepresentation curriculum, <https://underrep.com/> [accessed August 25, 2025].
- [22] TEAM UP, <https://www.teamuptogether.org/>, [accessed August 25, 2025].
- [23] STEP UP, <https://engage.aps.org/stepup/home> [accessed August 25, 2025].
- [24] S. J. Lynch, *Equity and Science Education Reform* (Routledge, Mahwah, NJ, 2000).
- [25] I. Rodriguez, E. Brewé, V. Sawtelle, and L. H. Kramer, Impact of equity models and statistical measures on interpretations of educational reform, *Phys. Rev. ST Phys. Educ. Res.* **8**, 020103 (2012).
- [26] T. Russo-Tait, Science faculty conceptions of equity and their association to teaching practices, *Sci. Educ.* **107**, 427 (2023).
- [27] M. Bang and D. Medin, Cultural processes in science education: Supporting the navigation of multiple epistemologies, *Sci. Educ.* **94**, 1008 (2010).
- [28] T. M. Philip and F. S. Azevedo, Everyday science learning and equity: Mapping the contested terrain, *Sci. Educ.* **101**, 526 (2017).
- [29] G. Ladson-Billings, But that's just good teaching! The case for culturally relevant pedagogy, *Theory Pract.* **34**, 159 (1995).
- [30] G. J. Ladson-Billings, Chapter 7: Preparing teachers for diverse student populations: A critical race theory perspective, *Rev. Res. Educ.* **24**, 211 (1999).
- [31] D. Morales-Doyle, There is no equity in a vacuum: On the importance of historical, political, and moral considerations in science education, *Cult. Stud. Sci. Educ.* **14**, 485 (2019).
- [32] R. Gutiérrez, Framing equity: Helping students "play the game" and "change the game", *Teach. Excellence Equity Math.* **1**, 4 (2009).
- [33] R. Gutiérrez, Context matters: How should we conceptualize equity in mathematics education?, in *Equity in Discourse for Mathematics Education: Theories, Practices, and Policies* (Springer, New York, 2011), pp. 17–33.
- [34] M. Cochran-Smith, Uncertain allies: Understanding the boundaries of race and teaching, *Harv. Educ. Rev.* **65**, 541 (1995).
- [35] A. Mintos, A. J. Hoffman, E. Kersey, J. Newton, and D. Smith, Learning about issues of equity in secondary mathematics teacher education programs, *J. Math. Teach. Educ.* **22**, 433 (2019).
- [36] L. H. Rubel, Equity-directed instructional practices: Beyond the dominant perspective, *J. Urban Math. Educ.* **10**, 66 (2017).
- [37] A. D. Robertson, T. Huynh, C. Mathis, L. C. Bauman, and R. E. Scherr, Teacher learning about the integration of energy and equity: A case study, *Phys. Rev. Phys. Educ. Res.* **19**, 010136 (2023).
- [38] National Research Council, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Academies Press, New York, 2012).

- [39] D. Stovall and S. Annamma, Opinion: Using critical race theory to understand the backlash against it, *Hechinger Rep.* **29** (2021), <https://hechingerreport.org/opinion-using-critical-race-theory-to-understand-the-backlash-against-it/>.
- [40] A. J. Rodriguez and D. Morrison, Expanding and enacting transformative meanings of equity, diversity and social justice in science education, *Cult. Stud. Sci. Educ.* **14**, 265 (2019).
- [41] A. Szostkowski and B. Upadhyay, Looking forward by looking back: Equity in science education as socially just and morally healing action, *Cult. Stud. Sci. Educ.* **14**, 335 (2019).
- [42] O. Lee, Equity implications based on the conceptions of science achievement in major reform documents, *Rev. Educ. Res.* **69**, 83 (1999).
- [43] R. M. Thomson, Advancing equity, diversity, and inclusion: A how-to guide, *Phys. Today* **75**, No. 1, 42 (2022).
- [44] B. Van Dusen and J. Nissen, Equity in college physics student learning: A critical quantitative intersectionality investigation, *J. Res. Sci. Teach.* **57**, 33 (2020).
- [45] G. Ladson-Billings, Just what is critical race theory and what's it doing in a nice field like education?, *Int. J. Qual. Stud. Educ.* **11**, 7 (1998).
- [46] R. McGraw, A. Fernandes, J. A. Wolfe, and B. Jarnutowski, Unpacking mathematics preservice teachers' conceptions of equity, *Math. Educ. Res. J.* **36**, 645 (2024).
- [47] T. Huynh, L. C. Bauman, A. D. Robertson, and R. E. Scherr, Physics teachers' conceptions of equity: Access and achievement, *Front. Educ.* **8**, 1099480 (2023).
- [48] S. Cwik and C. Singh, Not feeling recognized as a physics person by instructors and teaching assistants is correlated with female students' lower grades, *Phys. Rev. Phys. Educ. Res.* **18**, 010138 (2022).
- [49] S. Cwik and C. Singh, Students' sense of belonging in introductory physics course for bioscience majors predicts their grade, *Phys. Rev. Phys. Educ. Res.* **18**, 010139 (2022).
- [50] Z. Y. Kalender, E. Marshman, C. D. Schunn, T. J. Nokes-Malach, and C. Singh, Gendered patterns in the construction of physics identity from motivational factors, *Phys. Rev. Phys. Educ. Res.* **15**, 020119 (2019).
- [51] A. Maries, I. N. Karim, and C. Singh, The impact of stereotype threat on gender gap in introductory physics, *presented at PER Conf. 2017, Cincinnati, OH*, 10.1119/perc.2017.pr.059.
- [52] C. Mathis, A. R. Daane, B. Rodriguez, J. Hernandez, and T. Huynh, How instructors can view knowledge to implement culturally relevant pedagogy, *Phys. Rev. Phys. Educ. Res.* **19**, 010105 (2023).
- [53] Z. Hazari, C. Cass, and C. Beattie, Obscuring power structures in the physics classroom: Linking teacher positioning, student engagement, and physics identity development, *J. Res. Sci. Teach.* **52**, 735 (2015).
- [54] S. M. Lawrence and B. D. Tatum, Teachers in transition: The impact of antiracist professional development on classroom practice, *Teach. Coll. Rec.* **99**, 162 (1997).
- [55] M. J. Dumas, Against the dark: Antiblackness in education policy and discourse, *Theory Pract.* **55**, 11 (2016).
- [56] J. R. Cimpian, T. H. Kim, and Z. T. McDermott, Understanding persistent gender gaps in STEM, *Science* **368**, 1317 (2020).
- [57] P. L. Morgan, G. Farkas, M. M. Hillemeier, and S. Maczuga, Science achievement gaps begin very early, persist, and are largely explained by modifiable factors, *Educ. Res.* **45**, 18 (2016).
- [58] A. Johansson and J. Larsson, Identity perspectives in research on university physics education: What is the problem represented to be?, in *Science Identities: Theory, Method and Research* (Springer, Cham, 2023), p. 163.
- [59] T. Espinosa, K. Miller, I. Araujo, and E. Mazur, Reducing the gender gap in students' physics self-efficacy in a team- and project-based introductory physics class, *Phys. Rev. Phys. Educ. Res.* **15**, 010132 (2019).
- [60] R. Gutiérrez and E. Dixon-Román, Beyond gap gazing: How can thinking about education comprehensively help us (re)envision mathematics education?, in *Mapping Equity and Quality in Mathematics Education* (Springer, New York, 2011), pp. 21–34.
- [61] H. B. Carlone and A. Johnson, Understanding the science experiences of successful women of color: Science identity as an analytic lens, *J. Res. Sci. Teach.* **44**, 1187 (2007).
- [62] R. M. Lock, Z. Hazari, and G. Potvin, Impact of out-of-class science and engineering activities on physics identity and career intentions, *Phys. Rev. Phys. Educ. Res.* **15**, 020137 (2019).
- [63] E. W. Close, J. Conn, and H. G. Close, Becoming physics people: Development of integrated physics identity through the learning assistant experience, *Phys. Rev. Phys. Educ. Res.* **12**, 010109 (2016).
- [64] S. Hyater-Adams, C. Fracchiolla, N. Finkelstein, and K. Hinko, Critical look at physics identity: An operationalized framework for examining race and physics identity, *Phys. Rev. Phys. Educ. Res.* **14**, 010132 (2018).
- [65] S. Hyater-Adams, C. Fracchiolla, T. Williams, N. Finkelstein, and K. Hinko, Deconstructing black physics identity: Linking individual and social constructs using the critical physics identity framework, *Phys. Rev. Phys. Educ. Res.* **15**, 020115 (2019).
- [66] K. Rosa and F. M. Mensah, Educational pathways of black women physicists: Stories of experiencing and overcoming obstacles in life, *Phys. Rev. Phys. Educ. Res.* **12**, 020113 (2016).
- [67] S. Fries-Britt, J. Johnson, and B. Burt, Black students in physics, in *Living at the Intersections* (Information Age Publishing, Charlotte, NC, 2013), p. 21.
- [68] M. Ong, Body projects of young women of color in physics: Intersections of gender, race, and science, *Soc. Probl.* **52**, 593 (2005).
- [69] C. Prescod-Weinstein, *The Disordered Cosmos: A Journey into Dark Matter, Spacetime, and Dreams Deferred* (Hachette UK, 2021).
- [70] S. Harding, *Whose Science? Whose Knowledge?: Thinking from Women's Lives* (Cornell University Press, Ithaca, 1991).
- [71] C. Mathis and A. D. Robertson, The role of physics culture in shaping in-service physics teacher identities and framings of equity: Two case studies, *presented at PER Conf. 2021, Virtual Conference*, 10.1119/perc.2021.pr.Mathis.
- [72] P. Bourdieu, Cultural reproduction and social reproduction, in *Power and Ideology in Education*, edited by A. H. H. J. Karabel (Oxford University Press, New York, 1997).

- [73] C. Smith, *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain* (University of Chicago Press, Chicago, 1998).
- [74] E. A. Wrigley, Energy and the English industrial revolution, *Phil. Trans. R. Soc. A* **371**, 20110568 (2013).
- [75] See Supplemental Material at <http://link.aps.org/supplemental/10.1103/ynfb-rbx8> for the participants' self-reported information and the frequencies of each dimension in the 2020 and 2021 data.
- [76] K. E. Gray, M. C. Wittmann, S. Vokos, and R. E. Scherr, Drawings of energy: Evidence of the next generation science standards model of energy in diagrams, *Phys. Rev. Phys. Educ. Res.* **15**, 010129 (2019).
- [77] R. E. Scherr, H. G. Close, S. B. McKagan, and S. Vokos, Representing energy. I. Representing a substance ontology for energy, *Phys. Rev. ST Phys. Educ. Res.* **8**, 020114 (2012).
- [78] R. E. Scherr, H. G. Close, E. W. Close, and S. Vokos, Representing energy. II. Energy tracking representations, *Phys. Rev. ST Phys. Educ. Res.* **8**, 020115 (2012).
- [79] R. E. Scherr, B. W. Harrer, H. G. Close, A. R. Daane, L. S. DeWater, A. D. Robertson, L. Seeley, and S. Vokos, Energy tracking diagrams, *Phys. Teach.* **54**, 96 (2016).
- [80] R. E. Scherr, L. Seeley, and K. E. Gray, Energy in its material and social context: Power plants, *Phys. Teach.* **61**, 428 (2023).
- [81] J. P. Gee, *An Introduction to Discourse Analysis: Theory and Method* (Routledge, 2014).
- [82] N. Fairclough, Critical discourse analysis, organizational discourse and organizational change, in *Critical Discourse Analysis* (Routledge, London, 2013), pp. 347–373.
- [83] A. Ellerup Nielsen and H. Nørreklit, A discourse analysis of the disciplinary power of management coaching, *Soc. Bus. Rev.* **4**, 202 (2009).
- [84] W. C. Coates, J. Jordan, and S. O. Clarke, A practical guide for conducting qualitative research in medical education: Part 2—coding and thematic analysis, *AEM Educ. Train.* **5**, e10645 (2021).
- [85] Institute of Physics, Raising aspirations in physics: A review of research into barriers to STEM participation for students from disadvantaged backgrounds, Institute of Physics, London, 2014, <https://www.iop.org/sites/default/files/2021-03/raising-aspirations-in-physics.pdf> [accessed August 25, 2025].
- [86] National Science Foundation, Leading the world in discovery and innovation, STEM talent development and the delivery of benefits from research-NSF strategic plan for fiscal years (FY) 2022–2026, Report No. NSF 22-068, 2022, <https://www.nsf.gov/reports/planning/leading-world-discovery-innovation-stem-talent-development> [accessed August 25, 2025].
- [87] M. Watts and M. Pope, Thinking about thinking, learning about learning: Constructivism in physics education, *Phys. Educ.* **24**, 326 (1989).
- [88] J. A. Banks, Multicultural education: Historical development, dimensions, and practice, *Rev. Res. Educ.* **19**, 3 (1993).