Leveraging queer epistemic subjectivity to advance justice through physics teaching

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In this paper, we advocate for inclusion of queer and trans* (QT) students in physics by promoting epistemic diversity. We draw on literature documenting racial epistemic oppression and research exploring the experiences of QT students of color in STEM to build theory around intersectional, coalition-building epistemic justice for queer inclusion. We highlight the affordances of physics teaching that embraces queer epistemic subjectivity (ways of thinking shaped by the lived experience of transgressing regulatory categories of sexuality and gender), and offer implications for instructors that cultivate appreciation for diverse approaches to physics learning in the classroom.

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I. INTRODUCTION

What unique perspectives do queer[1] and trans* (QT) students bring to a physics class? This question, even while its origins are steeped in controversy, has untapped potential for instructors striving to affirm queer humanities. For example, a bigender student may experience themself as having both masculine and feminine attributes, with one facet of their gender better describing their behavior in certain times and contexts. For such a student, the duality of light as having both features of a wave and a particle dependent on context may not defy common sense as it does for many.

The importance of diverse perspectives in physics has been explored in equity-focused work related to race that interrogates 'objectivity,' 'universality' and other epistemological values as invisibly supporting the reproduction of whiteness [2, 3]. For this reason, there is a move towards recognizing physics as a *subjective* field with values, aims, and practices that are shaped by the interests and experiences of actors therein [4]. Rather than contributing to bias in physics, naming this subjectivity inhibits the reproduction of white supremacy by making visible white sense-making [3] embedded in physics *epistemologies* (i.e., customary ways of thinking and producing knowledge). This creates opportunities to recognize alternative ways of thinking and knowing as legitimate and valuable. In doing so, we foster *epistemic diversity* that expands opportunities for physics classrooms and communities to benefit from a wide cache of ideas.

In this paper, we take up interrogating epistemological conventions in physics with respect to queer experiences in the context of teaching and learning. Analogous to prior work that critiques structural racism in physics through the framing of white subjectivity as objective and universal [2, 3], here we examine how epistemologies of physics valorizing simple, universal, and decontextualized laws may reproduce cisheteronormative[2] ways of thinking and knowing to stifle advancement in physics. We bring an intersectional and coalition-building stance to this investigation in two ways. First, we recognize that systems of racism and cisheteropatriarchy are co-constructed and mutually reinforcing, with aspects of white supremacy culture deployed to reinforce the centrality and supremacy of cisheterosexual identities [6, 7]. For example, whiteness organizes social life into centers and margins in ways that can naturalize gendered inequities of participation in physics classrooms [3]. Second, in considering these issues, we draw on our work exploring the experiences of QT students of color in STEM [8, 9] whose perspectives are centered as knowledge sources for advancing intersectional justice through physics classroom teaching.

II. EPISTEMIC OPPRESSION IN PHYSICS

The field of physics holds epistemic privilege that limits its receptivity to unconventional ways of thinking. Fletcher and Brownstein [10] discuss how skill in physics is often more highly valued than other disciplinary skills, such as musical talent. They argue that this aspect of the disciplinary culture heightens the risk of dismissing ways of thinking that are unconventional, including ways that students from nondominant cultures may approach the subject. Furthermore, they discuss how physics is often seen as foundational to other subjects (e.g., physicists may frame chemistry as an application of physics). For these reasons, physicists may be uniquely inclined to apply epistemological conventions in the discipline to understand the world at large, including as a way of understanding social phenomena. The privileging of physics epistemologies, thus, becomes a vehicle for dominance; disciplinary ways of thinking deemed acceptable by a largely homogeneous population with social privilege are legitimated as a way of understanding social inequity in physics as we further elaborate later. Simultaneously, ways of thinking common to other disciplines or historically disadvantaged groups are marginalized or dismissed both within and outside of the physics classroom.

Although the epistemologies of physics are intangible, issues of epistemic diversity have concrete implications for equity in physics. For example,

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[1] We use *queer* to describe the collection of all marginalized sexual and gender nonconforming identities, including trans* identities. We use *trans** to describe individuals whose gender identities do not align with their sex assigned at birth, regardless of whether they pursue medical gender-affirming treatment and whether they identify with binary or non-binary genders [1]. We honor that not all individuals who meet these definitions self-identify as queer or trans*.

[2] *Cisheteronormative* is used to describe social and cultural structures that implicitly or explicitly position heterosexual and cisgender identities (people whose assigned sex at birth aligns with their gender identity) as normal. We also use the related term *cisheteropatriarchy* to describe the western system of oppression that marginalizes cisgender women as well as queer and trans* people through masculine dominance and cisheteronormativity [5].

Prescod-Weinstein [2] identified epistemic double standards with regard to whose observations and reasoning are legitimated. Prescod-Weinstein notes that despite physics holding values of empiricism, Black women physicists, who bring a lifetime of empirical evidence about gendered racism, have their perspectives routinely dismissed while string theorists, who are largely white men, receive funding for research that lacks empirical support. Similarly, Robertson and Hairston [3] discuss how epistemologies of physics may justify "bad faith arguments" (p. 17) that dismiss evidence of social marginalization in the physics classroom through disciplinary conventions of favoring simplistic explanations or maintaining skepticism when counter-arguments are available. Examples such as these illustrate how broader social inequities implicitly shape what are seen as legitimate ways of thinking in the practice of physics, and, by proxy, who is a legitimate physicist.

Physics education research has begun to interrogate epistemological norms as limiting advancement in physics while perpetuating an exclusionary culture in the discipline. For example, Traxler and colleagues [11] trouble the assumption that the performance and experiences of white men in physics should be the benchmarks of success, and suggest that science conducted by women may draw different conclusions than those found by men who predominate the field. Rosa [12] discusses Black women physicists' reconciliation of physics epistemologies and their religious beliefs to maintain their connection to the Black Church as an identity-affirming resource. Drawing from standpoint theory and critical race theory, Rodriguez and colleagues [13] posit that individuals from historically marginalized groups bring a unique lens to scientific inquiries that enrich our collective understanding. For example, the authors provide the example of a Latine student who may experience a sense of double consciousness in terms of their Latine identity and their physics identity in a white-normed environment. This double consciousness brings a distinct lens to their knowledge production. Valuing such epistemic affordances is vital for the persistence and wellbeing of minoritized students in physics, for whom seeing themselves as physicists plays a central role in cultivating a holistic sense of belonging in the field [14]. Recreating physics as a domain that cultivates epistemic diversity is, thus, central to justice within physics classrooms and the broader scientific community. Building on this foundational work, this piece takes a deep dive into epistemic justice for QT students.

III. EQUITY INITIATIVES IN PHYSICS INSTRUCTION

Efforts to improve equity in physics education have often focused on minimizing equity gaps experienced among students of color and white cisgender women. Many interventions have recrafted pedagogical practices by incorporating group work that mitigates marginalizing peer dynamics [15,16] and integrating affirmation activities that lessen the influence of stereotype threat [17, 18]. As with issues of race, values of 'objectivity' and 'neutrality' in STEM can render sexuality and gender irrelevant or inappropriate for STEM contexts, and can pressure QT students to fragment or conceal their queer identities in order to assimilate [9, 19, 20]. However, common equity-oriented strategies, such as organizing groups to mitigate the degree to which marginalized students experience isolation from peers who identify similarly, can fall short in actualizing equity for QT students given the potential invisibility of queerness.

In cases where queerness is engaged in STEM, there is a risk of positioning queerness as an add-on, rather than as shaping disciplinary ways of thinking. For example, in undergraduate engineering, Boudreau and colleagues [21] presented two cases of transgender students' engagement with a project-based engineering curriculum focused on developing recommendations for gender-neutral bathrooms on campus. This curriculum mediated the two students' exploration of their gender identities and empowered students as change agents using engineering as a tool for social justice. While this curriculum design welcomed the students' identities and perspectives as transgender students on campus, it may be incomplete in affirming trans* students as scientists. How the students' transgender experiences informed their approach to engineering principles was not discussed, leaving room to interpret their transness as something that must be abandoned when engaging in the epistemological practices of engineering. With research on educational justice advocating for recognition of QT experiences as rich sites of knowledge production [22, 23], the interrogation of epistemological conventions in physics presents an opportunity to consider what possibilities, both social and scientific, may be made available by welcoming queer ways of thinking and being.

Instructional interventions addressing issues of epistemic diversity are limited. Such efforts have included modeling instruction that flexibly allows for concept development and using a variety of representational tools [15]. Another set of efforts involved explicitly introducing socially critical perspectives into the physics curriculum by examining issues of racial and gender representation, implicit bias, stereotype threat, and other factors that expose physics as a site of social inequity [4, 24-26]. Critical examination of social issues in physics has included questioning values of objectivity and other epistemological conventions. As an example, physics classrooms considered the value of racial subjectivity by grappling with the question raised in the Fisher vs. UT-Austin affirmative action case: "What unique perspective does a minority student bring to a physics class?" [4, 25]. Despite its intent to dismiss the importance of diversity [27], questions such as these can stimulate consideration for the importance of diverse perspectives in transforming scientific thought. Recognition of this importance can stimulate a shift from a deficit-based perspective that racially minoritized students need additional support to a perspective that recognizes minoritized students' lived experiences as valuable intellectual resources in the physics classroom. However, such questions have not yet been engaged with respect to QT identities.

IV. CONCEPTUALIZING AFFORDANCES OF QUEER EPISTEMIC SUBJECTIVITY

There is a longstanding joke in which a physicist approaches an issue of milk production on a farm by reducing the complexity of the problem by assuming a spherical cow. Although taken to a degree of absurdity, this classic joke speaks to a dominant epistemological value of simplification in physics, which guides seeking approximations to facilitate ease of computation, even when doing so hinders application to reality. Reducing the complexity of problems can also involve decontextualizing (e.g., assuming objects in a vacuum) or ignoring interactions and interrelatedness (e.g., considering a 'closed system'). Whether by examination of extreme cases, or by prioritizing 'back of the envelope' computations, problem solving that involves dramatic reductions to a problem's complexity are standard in the disciplinary enculturation that takes place in introductory physics classrooms.

Epistemological conventions of physics that seek to reduce complexity and mitigate the influence of context make QT students vulnerable to erasure given the propensity for physics epistemologies to be applied to social realms. For example, QT students of color report experiencing STEM classroom discourse as marginalizing when instructors appeal to analogies involving cisheterosexual attraction or marriage to explain scientific concepts involving parity, such as positive and negative charges [28]. Considering how parity is common across physics concepts (e.g., magnetism), such instructional instances that marginalize QT students are likely to occur in physics classrooms. These perspectives on instruction illustrate how epistemologies of physics that value simplification and categorization can be appropriated to social realms that position queer experiences as aberrant.

In relation to sexuality and gender, queer theory recognizes that simplifications and categorizations serve a regulatory ideal that functions to classify QT persons as abject or other [29]. Furthermore, queer theorists de-naturalize the axes through which such classifications are performed (e.g., drawing attention to the gender of sexual partners as an arbitrary organizational feature used to define sexual identity) [30]. Such perspectives define a queer epistemology. Building on this, Hall [31] describes the requirement of individuals to claim an intelligible sexuality or gender identity as a form of epistemic harm. This harm can be seen in QT students' physics experiences. For example, in a study of climate experiences among LGBT physicists, Barthelemy and colleagues [32] shared the testimony of a trans student whose gender-related emotional fatigue in a trans-exclusive environment troubled their access to instructional support: "I would rather come down to a place where I'm just a student. Just you not being able to figure me out doesn't really need to qualify whether I can be educated here." Leaving room for understandings, both social and physical, that exceed definition or categorization is, thus, necessary for physics instruction that affirms QT students.

Physics contains a plethora of topics that favor ways of thinking that allow for multiplicity and complexity. Returning to the example used to open our paper, when studying optics, students must learn that light can behave both like a wave and a particle, or, in fact, behaves neither like a classical particle or a classical wave. When exploring quantum mechanics, students must grapple with the idea that a particle's location in space is not determined precisely even when it is observed. Special relativity demands particular attention to context. Inquiries into dark matter are reliant on observing the effect of gravitational relationships rather than celestial objects themselves. With students' scientific preparation for these topics reliant on simplified and decontextualized problems, it is understandable that these topics are often experienced as challenging.

These examples are, arguably, queer physical phenomena, in that they defy categorization and are in flux based on time and context. The lived experience of transgressing regulatory categories of sexuality and gender may provide many QT students scaffolding from which to build their knowledge of these and other physics concepts in ways that affirm their experiences and identities, all while providing unique insights to the class at large. In this way, QT students bring *queer epistemic subjectivity* to their physics sensemaking. Embracing queer epistemic subjectivity through physics instruction has the potential to unlock new ways that build students' understanding of complex physical phenomena while advancing justice for QT students.

V. IMPLICATIONS FOR PHYSICS INSTRUCTION

In theorizing queer pedagogies, scholars have drawn on complexity theory in physics, positing that embracing these scientific understandings of the natural world as irreducibly complex and dynamic supports queer-affirming instruction that invites incomplete, multiplicitous, and changing knowledge [33, 34]. Such arguments hold promise that physics instruction can harness the innate complexity and creativity involved in the practice of the discipline to support queer epistemic subjectivity. For example, when exploring simplifications of complex problems, instructors can invite students to recognize that decisions surrounding which features to ignore or approximate are made subjectively (as are our simplifications of sexuality and gender). Instructors can emphasize how attending to purposefully omitted complexities may contribute to queer results that exceed the boundaries of calculation or expectation. In addition, instructors can create room for different problem solving approaches when setting norms for participation. For example, encouraging groups to generate multiple solutions or representations rather than to arrive at a consensus can mitigate perpetuating the myth that there is one right way to engage in thinking as physicists.

Instructors may experience tensions about embracing epistemic diversity in the classroom when students' success in physics is predicated on adherence to accepted epistemological practices. In other research areas related to equity and identity, however, it has been found that students from nondominant groups perform better on standard assessments when instruction is responsive to students' nondominant ways of thinking [e.g., 35]. Thus, fostering and affirming students' epistemic subjectivity is central to their success in science, even when proficiency in engaging conventional epistemological practices is the measure of achievement on formal assessments. For this reason, we encourage physics instructors to make space for queer epistemic subjectivity in physics teaching while also engaging students in critical dialogue about epistemological conventions in physics. Instructors can accomplish this by affirming students' diverse ways of thinking *and* discussing the importance of understanding conventional approaches to prepare for contexts in which students may find it necessary to conform to the culture of power [36] in physics.

VI. CONCLUSION

The light spectrum (i.e. rainbow) originated in physics and exemplifies a physical phenomenon that defies categorization. As such, it has come to symbolize pride, diversity, and fluidity of identity within the QT community. Connections such as these are numerous. However, physics education has yet to embrace queer epistemic subjectivity as a strength in scientific knowledge production. We urge instructors to recognize that accepted epistemological practices in physics are artificially bounded by systems of oppression, such as white supremacy and cisheteropatriarchy. Epistemic diversity provides students with a multitude of tools and perspectives when approaching the study of physics and can expand participation in physics among students minoritized by race, gender, and/or sexuality. Cultivating classroom environments that resist epistemological assimilation are necessary to actualize equity within physics classrooms.

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