“We can’t just turn that off and then do some physics”: A counter-storytelling analysis of introductory physics as a white, cis-heteropatriarchal space in undergraduate STEM education

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This paper presents findings from research about the experiences among 39 undergraduate queer and trans* (QT) students of color in STEM majors that illustrate how introductory physics reinforces white cis-heteropatriarchy. Two cases of Black queer STEM students’ counter-stories highlight how uncertainty about faculty bias, lack of identity-conscious support, and stereotypes of ability shaped intersectional oppression in introductory physics courses. The counter-stories also exemplified agency in managing oppression as physics students, including strategic concealment of their queer identities. The paper concludes with implications for pedagogical practice in introductory physics to advance queer and intersectional justice for QT students of color.
I. INTRODUCTORY PHYSICS: A SITE FOR INTERSECTIONAL PER ON QUEER ISSUES

A. Queer experiences and intersectionality in PER

An emerging body of work in PER centers queer and trans* (QT) physicists’ experiences [1, 2]. Cisheteronormative climates across physics departments shape oppressive experiences for undergraduate QT students, including encounters of homophobic remarks, lack of queer-affirming faculty support, and sexual harassment [1, 3]. Some physicists conceal their queer identities to avoid being subjected to exclusionary behaviors. This work also highlights how QT physicists of color uniquely experience racialized aspects of queer oppression [4], which lays a foundation for future PER exploring intersections of race, gender, and sexuality.

Another strand of emerging PER explores issues of intersectionality among racially minoritized physicists, particularly women of color [5-7]. Intersectionality refers to unique forms of oppression and agency at the juncture of racism and other interlocking systems of power [8]. This body of PER has captured gendered racism that women of color manage in physics, such as being academically undermined [9], excluded from study groups [7], and pressured to conform their behavior and appearance to the dominant image of a white male physicist [10]. Findings also noted agency among women of color physicists to protect their intersectional identities and academic success, including the formation of racially diverse study groups [7], engagement in educational activism [9], and tactical forms of resistance through self-expression like fragmenting their identities and intentionally behaving stereotypically [6, 10].

A subset of intersectional PER centers experiences of undergraduate cisgender bisexual Hispanic women [6, 11, 12]. Findings revealed how white cisheteropatriarchy -- a systemic form of oppression at intersections of racism, patriarchy, and cisheteronormativity -- shaped participants’ undergraduate physics experiences. Bisexual Hispanic women fragmented their queer identities to avoid homophobic exclusion in classrooms [11] and used self-affirmations to strengthen their physics identities when stereotyped as lacking ability in the discipline [12]. While this work importantly disrupted the overall silence about QT physicists of color, there is room for intersectional analyses in future PER that explores physics experiences with more diverse samples in terms of race and gender identities, including trans* and nonbinary students. Such research can nuance intersectional knowledge about queer-affirming experiences in undergraduate physics [13].

B. Racial and gender equity in introductory physics

Introductory physics courses, which are required for physics and several other STEM majors, have disproportionately high rates of students from historically marginalized groups dropping and failing [14, 15]. These courses, therefore, are important contexts in PER for addressing pervasive equity issues in undergraduate STEM about retention and students’ sense of belonging. To date, equity-oriented PER on introductory courses has largely pursued quantitative analyses to examine gaps in student achievement and self-efficacy specific to race and gender [14-16]. Instruction was found to play a critical role in reinforcing and disrupting inequitable physics learning opportunities. Some studies showed how student-centered instruction that incorporated learning assistant support [16] and active learning opportunities (e.g., groupwork) [17] reduced racial and gender gaps. At the same time, other studies documented how instruction, couched in the myth of physics as a “culture of no culture” [18], failed to account for how student learning is situated in broader sociopolitical realities. Such instruction, even when adopting reform-oriented practices, reinforced inequities [19, 20]. These findings capture how instructional reform, without attention to variation in classroom experiences among students from historically marginalized groups, does not guarantee equity. Thus, there is a need for future PER on introductory physics that centers minoritized learners’ perspectives to inform equitable instruction.

An intersectional approach to equity-oriented PER on student experiences in introductory physics is needed [16, 20]. To illustrate, a study on mechanisms of whiteness in an introductory physics classroom with reform-oriented instruction [20] used intersectionality to interpret how gendered social norms reinforced a racialized-gendered distribution of contributions during a groupwork episode. The researchers reasoned that two women’s different interactional patterns with the only male group member reflected culturally-mediated relationships with heteropatriarchal systems. Namely, the Hispanic woman regularly supported the male peer positioned at the center of the collaboration, whereas the white woman often challenged his work. This finding illustrates how intersectional analyses can shed light on racialized and gendered mechanisms of instruction that shape variation in classroom experiences, which nuance quantitative insights on racial and gender equity gaps in introductory physics.

Insights about QT students in introductory physics are missing in PER. Future intersectional analyses in this area can bring classroom teaching to the center in research on QT students’ experiences and inform identity-affirming practices in a course context with significant influence on STEM major persistence. Contributing to such needed work in PER, this paper presents findings from a study that my research team conducted alongside undergraduate QT students of color in STEM majors to depict functions of white cisheteropatriarchy in introductory physics courses.
II. STUDY DESIGN

The present study comes from a larger body of work about intersectionality of STEM experiences among 39 QT students of color at historically white and minority-serving universities [21, 22]. Data included a STEM autobiography, journaling, individual interviews, and group interviews.

Our research team used the framework of STEM Education as a White, Cisheteropatriarchal Space [21-24] to guide data analysis. Each framework dimension corresponds to a level at which white cisheteropatriarchy operates and can be disrupted in STEM education. The ideological dimension addresses beliefs, norms, and values (e.g., epistemological values of objectivity and abstractness in physics [20, 25]) that organize educational practices. The institutional dimension corresponds to structural features that constrain equitable opportunities for achievement and participation, such as lack of queer representation across curricula [26] and departments’ use of introductory courses to weed out students ‘not cut out’ for STEM [16, 27]. The relational dimension addresses intersectional forms of oppression and agency in navigating racialized, cisheteronormative educational contexts, such as sexualization and exoticization of queer women of color [28] and coping strategies of fragmenting identities [6, 29].

Our team inductively coded data for ideological, institutional, and relational influences of white cisheteropatriarchy on STEM experiences of oppression, support, and agency. We synthesized codes to develop an analytical narrative for each participant through counter-storytelling [30] – a methodology of centering racially minoritized individuals’ experiences as knowledge sources for disrupting racism and interlocking systems of power. Our analysis generated themes about intersectionality of experiences across the counter-stories. To sharpen our analysis, we invited each participant to complete a member check. More details about study recruitment, data sources, and data analysis can be found elsewhere [21, 22]. Our team included faculty and student members with robust diversity in terms of race (African American, Latin*, biracial, white), gender (cisgender, nonbinary, transmasculine), and sexuality (bisexual, gay, lesbian, queer, heterosexual). We approached the research with critical reflexivity and awareness of our areas of social privilege and oppression.

III. FINDINGS

This section presents a cross-case analysis of two counter-stories, which were illustrative of how introductory physics as a white, cisheteropatriarchal space shaped queer students’ experiences. Below are backgrounds for the focal participants followed by three themes from our analysis.

Leila (any pronouns) is a Black asexual (or ace) woman in their junior year studying earth and environmental science. Niyah (she/they), a Black pansexual, polyamorous woman/femme/nonbinary person, was in their fifth year of college and changed their major from chemistry to geography and environmental science. Both students were enrolled at large research universities and took introductory physics courses as requirements for their majors. Leila described how her negative experience in the physics course made the subject less appealing, “My physics class was definitely the worst experience in STEM that I’ve had thus far. I’m not excited to take more physics next semester.” Niyah failed physics and re-took it twice. She viewed the physics department as "notoriously uninclusive" and a barrier to "becoming a really good Black queer science teacher."

A. Uncertainty about biases from physics faculty

Both Black queer students reflected on uncertainty about potentially biased interactions with physics faculty. Leila felt a sense of hypervisibility in the physics classroom due to the underrepresentation of women and Black students, “I already feel singled out in the first place because, nine times out of ten, I’m the only Black person in the room.” This racialized-gendered hypervisibility was exacerbated when she felt spotlighted during the first day of class, which Leila identified as their most negative STEM experience:

The professor made every person stand up, say their major, and what high school they went to. When it got to me, I was saying those things and he kept saying, ‘Speak louder and louder.’ I was speaking super loud... He then, to the class, said ‘Your kids are never going to hear you,’ and the whole class laughed. It really hurt ‘cause it was the first day and I did not want to make a scene.

Leila grappled with uncertainty about racialized and gendered undertones of the professor’s behavior, “There was me and two other Black women in the class, but he didn’t say anything to them either. So I was like, ‘What did you mean by this whole situation?’”. Concerned about being the only queer person in STEM spaces where “people can have prejudices and make that harder for you,” Leila did not disclose being ace in physics to not exacerbate being spotlighted and avoid heteronormative biases, “I don’t want to say more, draw more attention to myself… It’s [asexuality] something I know in the back of my head. I wouldn’t want to even add more to who I am and how people see me.” Such cognitive labor from being spotlighted had a long-lasting impact on Leila’s engagement in physics, “And the whole rest of the semester, I just was going to keep my head down in the first place and do my work and leave. But it just felt like even more so I should do that because I don’t know what reaction that was.” Leila stopped talking to the professor after that and only sought help from TAs.
Niyah similarly questioned the presence of racial and
gendered bias in terms of which physics students received
more leniency from faculty. One of her professors (a white
man) expressed to his class how he valued when students
tried their best and would be willing to support them if any
struggles arose during the course. Niyah was committed to
showing their effort by frequently attending office hours
and sitting toward the front of the classroom. Despite
the professor’s claim to support students who are trying, he
did not support Niyah when she expressed concern about
failing the class. Because this was Niyah's third time taking
the course, a failing grade made them no longer qualified to
major in chemistry as an aspiring science teacher, “I failed
by one point and I got locked out of the major. I spoke with
the professor after to ask if I could do anything, because of
the gravity of that one point. He still pretty much just said
no.” Niyah later learned that peers were “getting more
passes and getting a little more leeway” than she did, which
made her uncertain if the professor’s decision reflected a
strict departmental policy as he had framed it or if it was a
form of racialized-gendered bias, “I did wonder, ‘What if I
was one of the white men that was in the class? Would he
have given me the one percent, or is this really a rule that
he's enforcing?’”. With queerness feeling like a “constant
looming threat” of facing homophobia from STEM faculty,
Niyah’s sense of vulnerability in the situation with the
physics professor was layered with “having that [being
queer] on [her] conscience constantly while trying to do
STEM.” This experience potentially charged with bias had
demoralizing impact on Niyah who felt physics held them
back from achieving their goal of becoming a teacher, “It's
really frustrating that I came in knowing what I wanted to
do and I am prevented from doing that thing because I
wasn't good at physics.” Leila’s and Niyah’s experiences
depict how cognitive labor due to uncertainty about biases
from physics faculty shaped perceptions of having limited
opportunities to participate in class and persist in STEM.

B. Asociality and lack of identity-conscious support

The counter-stories also illustrate a lack of identity-
conscious support from physics faculty, which Leila and
Niyah perceived as rooted in a culture of asociality in
STEM. Asociality is the depersonalized nature of STEM
interactional contexts that render personal and social issues
inappropriate or irrelevant [31, 32]. Both participants
described how professors seemed to lack consciousness
about the racialized nature of their experiences as Black
students, or “tone deaf” in their words. Leila shared how
their professor’s failure to recognize the hurt that came with
being spotlighted as making them regret not taking a
different physics course, “In my head, I was like ‘I should
have transferred to the life science one or a different type of
physics class. Because I was just like, ‘I don’t know if I can
handle a whole semester of this dude being tone deaf.’”
With social issues often more readily engaged in certain
STEM disciplines (e.g., life sciences), Leila’s
perspective can be interpreted as a wonder if asociality
would have been disrupted in a physics course for
students in other STEM majors and thus allow her
racialized experience as a Black woman to be seen.

Unlike the physics course, Leila received identity-
conscious support in their geology internship even with
its strong focus on scientific research. Leaders made
space to process ongoing protests after George Floyd’s
murder and checked in on Leila individually. Leila was
partnered with a nonbinary person, which they viewed
as an effort in “making [them] feel seen” as queer in
STEM. Such identity consciousness in the internship
created a space where “it was the first time [Leila] was
all together -- like Black woman, ace in STEM.”

Niyah also pointed to the asociality in STEM that
they experienced through a lack of identity-affirming
support from faculty for them as a Back queer person,
“In the classes where it’s not social sciences or
humanities... they [faculty] don’t feel like they have to
be socially responsive. They feel like, ‘If I go up there,
show them how to work these numbers and go home,
everything’s fine.’ So, I feel a lot more glossed over in
those spaces.” In offering an example of how “a lot of
[her] STEM professors are tone deaf,” Niyah shared
how another physics professor was insensitive to her
struggles of keeping up with coursework as a Black
person processing the Floyd murder and protests.

When I told her I was struggling because of the riots
and everything that was going on, she was like, ‘Well,
everyone is going through stuff. So, you still need to
turn in your assignments.’ A lot of professors can be
oblivious to the fact that the riots, they affect
everybody; but for Black students who are the subject
of the riots, it’s a lot harder. We can’t just turn that
off and then do some physics.

The asociality of STEM shaped Niyah’s perception of
why they were denied racially-conscious support from
faculty. Niyah’s attempt to receive such support was
met with “all students” discourse that discounted her
needs as a Black learner juggling success in physics
and a national uprising for racial justice. This
experience added to Niyah’s struggles of receiving
proper accommodations in physics for her depression,
which was a central part of their Black queer identity.
Niyah, thus, felt invisible due to faculty disregard in
physics for her whole personhood and coping with
mental health, “They [faculty] see it like, ‘You’re a
student, and you’re all of those things that don’t really
matter.’… I end up feeling invisible a lot.” The two
counter-stories illustrate how the culture of asociality
in Leila’s and Niyah’s physics courses made Black
queer humanities go unseen in faculty support.
C. Agency in concealment of Black queer identities

Leila’s and Niyah’s counter-stories depict agency through concealing their queerness to avoid physics peers’ oppressive judgments. Being read as Black women, both participants already felt subjected to racial and gender stereotypes of lacking ability in physics, so queer nondisclosure protected them from further marginalization.

Recalling physics classmates laughing after answering a question incorrectly in class, Leila felt that her peers reacted in this way “because of [her] being Black and phenotypically a woman.” Such deficit perceptions rooted in racial and gender stereotypes of ability motivated Leila to prove peers wrong and show she was a “better student than them,” with such efforts resulting in classmates regularly seeking her help with the physics course. To protect themself against more negative peer judgment, Leila did not disclose their ace identity, “I’m ace too, but I don’t share that outwardly because it’s one thing I can control. It’s not something people can see off me… I’m going to share that only if need be, and it rarely is.” Leila’s concealed queerness was a strategic away to navigate the physics classroom as a racialized and cisheteronormative space. Despite Leila’s Black queerness being rendered invisible, queer nondisclosure was self-preserving as she was already managing racialized-gendered perceptions of her ability.

Niyah also felt restricted in expressing her full identity as a physics student, which she referred to as being "incarcerated from [her] own experiences" as a Black queer person. They viewed the fast pace and high-stakes pressure of STEM courses as exposing peers’ biases that contributed to dehumanizing experiences during physics groupwork.  

“There’s a lot of pressure in STEM classes [calculus, chemistry, physics], and they move really fast. I don’t think people always treat each other like full humans. Sometimes it’s like ‘Oh, we’re in this group. Where's your answers? Do you have answers? I think that sheds a lot of light on people’s different biases. Because, who are you going to trust for your answer? Are you going to trust a Black woman who you’ve stereotyped to not know what she’s talking about, or are you going to trust other white men?"

Presenting as a Black woman, Niyah described being stereotyped as lacking STEM ability when group members disregarded her ideas. To navigate peer biases and protect their identity, Niyah “stopped offering [contributions] and waited for people to ask [them] to speak up.” Peer biases, along with Niyah’s Blackness going unacknowledged as previously discussed, informed her decision to not engage her nonbinary and pansexual identities in physics, “I think part of what makes me hide myself in STEM classes is a lot of times in groupwork, I felt like I wasn’t heard… It was just a lot of me being glossed over regardless of what I had to offer.” Niyah, as a result, felt their Black queer identity was invisible and "trapped in STEM classrooms" where they could not express themself freely, "I avoid it [queer identity] in classes where I feel like my personhood isn't even being recognized. If I'm not gaining respect as a Black woman, I don't feel like it would be a safe enough space for me to say that I was nonbinary or anything like that." Leila’s and Niyah’s experiences depict tactically concealing their queer identities to avoid another layer of oppression on top of managing gendered racism in physics peer interactions.

IV. CONCLUSION

Themes across Leila’s and Niyah’s counter-stories capture interplay between ideological, institutional, and relational forces that shape introductory physics as a white, cisheteropatriarchal space. The first theme shows how perceptions of racial and gender bias (ideological) created tensions in faculty interactions (relational) that reinforced inequitable access to classroom participation and STEM persistence (institutional). Leila and Niyah felt their queerness exacerbated racialized-gendered tensions. The second theme depicts asociality, anchored in epistemological values of objectivity and abstractness in physics (ideological), that shaped classrooms as ‘neutral’ spaces void of faculty support with consciousness for participants’ Black queer identities (relational). Such erasure through instruction neglected participants’ social realities and upheld dehumanizing inflexibility in response to students’ struggles (institutional).

Our analysis also conveys Leila’s and Niyah’s agency in navigating introductory physics as a white, cisheteropatriarchal space. The third theme accounts for agency through concealment of queer identities and strategic nonparticipation (e.g., withholding ideas during groupwork). Such agency (relational) reflected how participants managed racial and gender stereotypes of physics ability (ideological) that influenced peer interactions in groupwork and other participation opportunities in classrooms (institution).

Findings raise implications for practice in undergraduate physics. Professional development for faculty must incorporate opportunities to interrogate biases in their pedagogy. As a disruption of asociality, faculty can use surveys or autobiographies at the start of a course to learn about students’ whole identities. This collection of student information (e.g., pronouns, mental health accommodations, relationship with physics) sends an early and explicit message that students’ identities are valued and relevant. Faculty can co-develop norms of classroom participation with students that alleviate tensions for QT students of color in navigating groupwork and other interactional opportunities. The norms should be framed with an explicit goal of challenging exclusionary views of ability and assumptions of cisheteronormativity.


