

Nepantla in Physics Education Research

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Physics identity is an essential topic in Physics Education Research, PER. Historically this research has examined how physics identities form for primarily white, male undergraduate students in calculus-based physics classes at Tier I institutions. More recent research has begun to consider the experiences of marginalized populations, such as students of color, women, and members of the LGBTQIA+ community. Nepantla is a theoretical framework that explicitly explores how individuals navigate opposing identities and realities. Physics students from marginalized groups are navigating multiple, often conflicting identities. Therefore, this paper asks how applying the theoretical framework of Nepantla to PER contributes to the physics identity conversation by providing insight into how individuals in marginalized populations are able to navigate their multiple identities. This paper looks at how Nepantla has been used as a theoretical framework in other areas of STEM-Ed, then applies Nepantla to existing research within PER. The results suggest that the theoretical framework of Nepantla contributes to understanding how Nepantler@s both navigate the system and change the system.

I. INTRODUCTION

Physics students in marginalized groups navigate multiple, often conflicting identities. Studies on how these students navigate their multiple identities can provide insight into barriers to becoming a physicist [1] as well as provide recommendations for improvements departments and institutions can make to support these students [2, 3]. Although these studies center the students' experiences, the focus is on identifying the systemic issues these students face. One theoretical framework that explores how individuals navigate opposing identities and realities is *Nepantla* [4–7]. In the *Nepantla* framework, the systemic oppression is assumed, and the focus is on how individuals work within this system to carve space for themselves and others. As the path of the individual is not the focus of other critical frameworks, prior research has not highlighted the work individuals in marginalized communities do to create new spaces. This paper asks what new and complementary insights are gained from applying the theoretical framework of *Nepantla* to Physics Education Research, PER. To answer this question, first, this paper reviews research on physics identity and provides background on the theoretical framework of *Nepantla*. Next, the paper explores how *Nepantla* has been used as a theoretical framework in other areas of Science, Technology, Engineering and Math Education, STEM-Ed. Finally, *Nepantla* is applied to existing research within PER. The results demonstrate that using the lens of *Nepantla* to understand how physicists who belong to marginalized groups navigate their multiple identities provides beneficial insight to both individuals and institutions that are part of the physics community. In particular, we observe that individuals are able to be successful both by working within the system and by changing the system, thereby creating new ways of being a physicist.

II. BACKGROUND AND FRAMEWORK

A. Physics Identity

Physics identity is an important area of research in Physics Education Research, PER. Questions about physics identity include how physics identities form [8, 9] and how physics identity and sense of belonging in the physics community affect persistence and success [10–12]. Often this research involves undergraduate students in calculus-based physics courses at Tier I institutions [13], where the demographics are primarily white and male [10]. Some of this research is focused on the experiences of marginalized populations, such as students of color [14], women [15], and members of the LGBTQIA+ community [16]. Even so, these populations remain understudied [10]. This is problematic in that the white and masculine culture of physics [17] is often unwelcoming [12] or outright hostile [1, 2] to members of marginalized communities. The research on marginalized populations usually focuses on women and students of color,

primarily Black and Latin@ [18]. There is minimal research on other marginalized populations, including members of the LGBTQIA+ community and disabled individuals [10, 19].

B. *Nepantla* as a Theoretical Framework

Early research on minoritized populations in physics used deficit frameworks, comparing minority groups to dominant populations [20]. Deficit frameworks are problematic in that they view the minoritized population as deficient. This perspective often has negative consequences for the students, preventing them from accessing the educational opportunities provided to the dominant population [21]. Current research more often uses “critical” frameworks that focus on the systemic structures that disadvantage minoritized populations [10]. By centering the experiences of the student, critical frameworks provide a better lens for studying minoritized populations by asking questions that disrupt the status quo, creating more equitable spaces [22].

Nepantla is a critical framework that is applied to individuals with multiple, often conflicting, identities. *Nepantla* differs from other critical frameworks in that it focuses on the actions of the individual rather than the institution. *Nepantla* means “in-between space” [5]. As a liminal space, *Nepantla* is both and neither. Individuals must pass through *Nepantla* as they navigate their multiple and conflicting identities. This space of imbalance allows individuals the opportunity to create something that was unimaginable before. When *Nepantler@s* [18] navigate this space, they create the possibility for new realities [5–7]. Individuals in marginalized groups who are also physicists or are becoming physicists are required to navigate multiple identities to succeed in physics. As they navigate these spaces, they must change themselves and/or their realities. They may minimize parts of their identities to fit into the white masculine culture of physics or create a new reality where they celebrate their intersectionalities. In addition, *Nepantler@s* can open new possibilities for their students and others who enter *Nepantla* [6, 23, 24]. While the rewards of creating a new reality through *Nepantla* are great, there are significant risks to being a *Nepantler@*. *Nepantler@s* risk rejection, misunderstandings, and isolation as the act of navigating *Nepantla* is one of disruptive change [5]. This paper hypothesizes that while navigating *Nepantla*, individuals who exist in the margins may provide openings for others to navigate conflicting identities, resulting in a more diverse and humane culture in physics.

C. *Nepantla* in STEM-Ed

While the framework of *Nepantla* adds to the conversation regarding how individuals in marginalized populations are able to become physicists, *Nepantla* continues to be an underutilized framework in STEM-Ed. The notable exception is Rochelle Gutiérrez [6, 25] who uses *Nepantla* as a

framework in her Math Education Research and has called for Nepantla research in PER [26]. Gutiérrez [26] describes how pre-service math teachers use the framework of Nepantla both to support their students in gaining mathematical skills and to work towards dismantling the systems of oppression ingrained in mathematics. Gutiérrez calls for Physics Education researchers to do the same with their work in physics.

In addition to using Nepantla as a lens for her Math-Ed research, Gutiérrez [6] has contributed to the theory of Nepantla and the ways in which it should be used in STEM-Ed. Nepantla is used as a way to interrogate Whiteness. When initially confronted with white privilege, white individuals often seek to resolve their discomfort quickly. However, the culture of white supremacy that exists in mathematics, and STEM in general, cannot be easily solved by “getting it” and moving on. Instead, it is essential to remain in the unpleasant space of Nepantla. It is only through embodying this discomfort that meaningful change can be made. Gutiérrez calls this “nesting in Nepantla” (p. 263). In this way, Nepantla is a permanent space of liminality, and the tension inherent in this place of being and not-being allows students, teachers, and researchers alike to be able to “play the game” and “change the game” (p. 259). We play the game by learning how to be successful in a potentially hostile reality. We change the game by changing this reality to become more open and create space for others to enter the newly constructed reality.

Others who have used Nepantla as a framework for research in STEM-Ed include McWhirter and Cinamon [27] and Aguilar-Valdez, LópezLeiva, Roberts-Harris, Torres-Velásquez, Lobo, and Westby [24]. McWhirter and Cinamon use Nepantla as a way to shed light on the “leaky pipeline” (p. 2) in STEM amongst women and underrepresented minorities. Their research observes how STEM professionals and academics can become Nepantler@s and use aspects of their non-STEM identities to create new realities for themselves. Aguilar-Valdez et al. describes the “path of *conocimiento*,” in which individuals experience a rupture (*arrebato*) that forces them into Nepantla. By passing through Nepantla, they are able to repair the rupture and enter into a state of *conocimiento* or “knowing.” In this research, Aguilar-Valdez et al. observe how STEM teachers enter Nepantla and use this to create a path for their students to more fully participate in their class activities. Physicists engaging in Nepantla can also forge new pathways for themselves and others.

III. APPLYING NEPANTLA TO PER

A. Methods

This paper seeks to answer the question, what new and complementary insights are gained from applying the theoretical framework of Nepantla to PER? In order to answer this question, a literature search for research that examined the experiences of physicists and physics students from minoritized populations was conducted. As the intent is to reex-

amine the evidence presented in the paper, it was essential to select qualitative research studies. From this selection criteria, three papers emerged. The selected papers applied critical frameworks to the studies. The use of critical frameworks and qualitative methods for data collection and analysis is essential in that it allows for reanalysis of the words and stories told by the participants using the lens of Nepantla and further allows for comparison between the Nepantla framework and findings by the authors.

Before applying the lens of Nepantla to the selected studies, it was necessary to grapple with the Nepantla framework. My understanding of Nepantla and what it means to be a Nepantler@ is influenced by my identity and experiences. When navigating conflicting identities, such as being *femme* presenting in physics, being *queer* in physics, or being *neurodiverse* in physics, there is no *conocimiento*, no reconciliation of identities to arrive at a state of “knowing;” there is only *arrebato*, the “rupture” of conflicting identities. Until the entire white-supremacist, capitalistic patriarchy [28] is dismantled, there is no belonging. There are places that are more or less safe; there are ways of being that are more or less true to oneself. There is no full embrace of both one’s reality and one’s intersectionality. Individuals continuously renegotiate their world and their place in that world. Therefore, this paper applies a framework of Nepantla that is consistent with Gutiérrez [6]: a permanent space of liminality. In this framework, Nepantler@s nest in Nepantla, balancing on tenuous ground. Through this tension Nepantler@s are able to both be successful in physics and challenge the culture of physics, creating space for themselves and others.

The following analysis begins by describing the selected research studies and the framework employed by the authors. Next, the framework of Nepantla is applied to the research. Finally, the results of the Nepantla framework are compared to the original results of the selected studies.

B. Case 1: Body projects of young women of color in physics: Intersections of gender, race, and science

Ong [1] studies the experiences of undergraduate women of color who are majoring in physics. The framework is *Body Theory*, in which individuals with conflicting identities modify their appearances in order to be accepted. This results in fragmentation when individuals deny parts of their identities to fit in, i.e., dressing and acting less feminine and more “white” to participate in physics or multiplicity, where they display all parts of their identity, i.e., being Black, being a woman, and being a physicist [29]. The results of this study found that women who minimized their identities to fit in to physics did so at personal cost and women who embraced their identities suffered professionally.

Ong provides multiple examples of ways that the physics students in her study either engaged in fragmentation or multiplicity in navigating their identities as physicists and women of color. One student describes how she has learned to speak

more masculinely to participate in physics.

What I learned from my male classmates is, don't even say, "This is what I thought." Say "This is the way it is." Fortunately or unfortunately, I learned to speak some of it. Because for me, it was a survival mechanism. I see the older women in the field and I see they've appropriated [the language] as their own. And I'm against that because I think that goes against my very nature as a female. I don't feel that... The words that indicate you're not confident—I think, I am not sure, but—That's such a part of scientific thought, to have some space, but that's not part of the male ego. But it's very much a part of how I think. (pp. 605-606)

Ong provides this as an example of fragmentation, the student cannot speak in a way that is natural to her. Viewing this through the lens of Nepantla, by appropriating a more masculine way of speaking, the "older women" are Nepantler@s, who have carved out a space for younger women to have the opportunity to become physicists. In addition, by challenging the reality created by the older Nepantler@s, the younger women can become Nepantler@s themselves, opening more space for the Nepantler@s who will follow them in turn.

As an example of multiplicity, Ong describes a woman who wore dull shapeless clothing for several semesters. Because she felt this was a denial of her femininity, the student began dressing in pink. Unfortunately, in embracing her whole self, the student suffers professionally, in that soon after her change in attire, another student hung a pin-up poster in a communal office space. She felt this timing was not coincidental and was hurt by the overt hostility in her department.

Viewing these situations from a Nepantla lens, we see that the rupture, *arrebato*, occurs when the women of color in the study enter physics and find their multiple identities as women, physicists, and non-white individuals are in conflict. This *arrebato* differs from Body Theory's fragmentation; fragmentation is a way to reconcile the conflicting identities, *arrebato* is the rupture that occurs when confronted with these conflicting identities. This conflict forces the participants to enter Nepantla. If marginalized individuals were able to embrace their multiple identities fully, this would be similar to Body Theory's multiplicity. However, the unwelcoming and hostile environment of physics [1, 2] prevents this from occurring. While the participants may find a temporary place of balance, subsequent shifts in their realities will force them back into Nepantla, where they will need to renegotiate their identities again. They are nesting in Nepantla, continuously carving out a space for themselves and others.

C. Case 2: Educational pathways of Black women physicists: Stories of experiencing and overcoming obstacles in life.

Rosa and Mensah [3] use Critical Race Theory, CRT, to analyze how Black women who hold Ph.D.s have navigated their identities to become successful physicists. They focus on three aspects of CRT: the permanence of racism; counterstorytelling to give voice to individuals who are often silenced; and interest convergence—the recognition that cultural changes beneficial to marginalized populations only occur if these changes are beneficial to white people. This paper uses counterstorytelling to identify common experiences, including overcoming obstacles. Next, it looks through the lenses of the permanence of racism and interest convergence to critically examine how these women overcame barriers. Through this lens, they found that women often chose physics because of educational opportunities, however, they subsequently felt isolated in their departments. Rosa and Mensah recommended that departments continue to provide opportunities for potential students and support and transparency for students already matriculated.

Applying Nepantla to the experiences described by Rosa and Mensah provides a complementary analysis to the lens of CRT, in that CRT looks at the systemic racism, and the Nepantla framework considers how individuals work within this system. The CRT framework examines the culture of physics and recognizes that because of white-supremacist ideology, physics culture is inherently hostile to Black women. Nepantla begins with the existence of conflicting identities and examines the experiences of these individuals to question how they are able to navigate this space. For example, one theme that emerged in Rosa's and Mensah's research is the experience of isolation in the academy. One way this presented was that the participants were excluded from study groups due to their identities as women and as Black students. This exclusion resulted in the students struggling more than their classmates and having less confidence in their abilities because they did not know that the other students were working together to solve their homework sets and study for exams. One participant describes how she realized the importance of the study groups when transferring graduate schools and did not wait to be invited to join one. Instead, she made sure to attend all the department events, and if she heard her classmates talking about a study group, she would tell them that she would join them. Her *arrebato* experience was that of not being involved in this critical aspect of graduate school. By entering Nepantla, she changed herself so that she no longer felt she needed to be asked to join a study group and changed the culture of physics in her department by normalizing the inclusion of Black women in study groups. She embodies the concepts of "playing the game/changing the game" [6] (p. 259). She became a Nepantler@, opening paths for others to also engage in physics as Black women.

D. Case 3: Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions.

Barthelemy, McCormick, and Henderson [2] examine sexism in physics as experienced by women in graduate physics and astronomy programs. They use Feminist Standpoint Theory, FST, as their theoretical framework in which counter-narratives are used to center the perspective of the subaltern. The authors found three common experiences with sexism: neutral or positive experiences with gender; microaggressions such as objectification, sexist language, restrictive gender roles and assumptions of inferiority; and hostile sexism, such as violent behavior. They recommended that departments and institutions provide education about microaggressions and not tolerate hostile work environments.

The Nepantla framework provides complementary insight to the FST framework used by Barthelemy et al. Nepantla focuses on the ways that these women managed their identities as women and physicists in a hostile educational environment, whereas FST focuses on the environment itself. The FST framework offers evidence that sexism exists and harms the individuals subjected; the authors then recommend changes to the institution. The Nepantla framework honors these women's work to navigate their identities as women and physicists, illustrating possible pathways that other individuals could take. An example of how the Nepantla lens shifts the focus can be seen in the experience of a student who reported that she never bought into the myth that women couldn't do physics because her single-parent mother had an advanced STEM degree.

I grew up thinking of course women can do whatever men can do... and then I realized oh, that's because I already have [a] role model (p.020119-6).

The authors use this as an example of a neutral or positive experience with gender. From a Nepantla framework, we see that the student's mother was a Nepantler@, creating an expansive reality in which her daughter could also pursue a degree in STEM. This is important, in that it recognizes the mother for her work in paving the way for her daughter and demonstrates the importance of the work of Nepantler@s.

Part of the Nepantla framework is the risk inherent in becoming a Nepantler@. In this study, we see the Nepantler@s forced to engage in more extreme acts to be both women and physicists when confronted with hostile sexism. In one case, a fellow graduate student in charge of the lab prevented the study participant from working on her research. When she talked to her advisor about this, no changes were made. For this reason, she had to change research advisors to an advisor who worked in another field but had a reputation for supporting their female students. This changing of advisors allowed the student to be successful in physics, but changing advisors usually delays graduation. So, while she could protect her

physics identity, it caused her professional harm. This situation illustrates the harm individuals risk when existing in Nepantla. However, the Nepantla framework also claims that the risks are worth the cost; the changes these women made, the spaces they navigated, and the realities they created, can open up ways for them to embrace their multiple identities. Ultimately, as these graduate students navigate being women and physicists, they embody the work of the Nepantler@.

IV. DISCUSSION

The critical theories included in this paper: Body Theory, CRT, FST, and Nepantla are significant in that they center the experiences of the participants in the studies and address the systemic biases experienced by the participants. Nepantla differs from the other critical theories in subtle but important ways that result in Nepantla producing new and complementary insight into the experiences of marginalized populations in physics. Nepantla differs from the critical theories of CRT and FST in that it explores the experiences of individuals with conflicting identities. As we have seen, CRT and FST can be applied to individuals with conflicting identities, but it is not a requirement. Nepantla offers complimentary insight to the studies by Rosa and Mensa and Barthelemy et al. in that these authors use the results to offer suggestions to the institution whereas Nepantla provides insight into how the participants were able to navigate their multiple identities.

Body Theory is similar to Nepantla in that it focuses on how individuals navigate their conflicting identities, Nepantla provides a complementary lens by observing how these individuals create new realities that open space for others. By engaging in Nepantla, the participants in these studies have found an unstable balance in which they can create their own identities as physicists. This often involves making changes both to the institution and to themselves. These changes open pathways for others to participate in physics. In this way, Nepantla provides additional understanding that is empowering to the individual.

In this paper, we were able to apply the framework of Nepantla to existing PER research on the experiences of several minoritized populations in physics: undergraduate women of color, Black women with Ph.D.s, and women graduate students. Missing is research on the experiences of members of the LGBTQIA+ community, individuals with disabilities, other racialized populations, etc. Further research is needed in these areas. The framework of Nepantla promises to shed light on how members of these marginalized communities are able to navigate their identities creating space for themselves and for others.

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