Using multiracial feminist theory to advance physics education research

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Educational researchers and policy makers regularly emphasize the need to encourage more students to pursue and persist in science, technology, engineering, and mathematics (STEM). Although the representation of women is improving in some STEM fields, women in physics remain underrepresented in both undergraduate study and later careers. The purpose of this position paper is to discuss why researchers in physics education should continue to take up gender as an important part of the research agenda. Recent evidence indicates that women and women of color continue to be underrepresented in physics. Both past and present research suggests that women have been and continue to be underrepresented in the physical sciences and related careers. Women of color are even more underrepresented. These trends suggest that physics education is not gender neutral and that further change must occur in order for more women to find success in the field of physics. The idea that underrepresentation is inherently problematic is questioned. Women's underrepresentation in the field of physics becomes a problem when (a) women are dissuaded, (b) women are driven out, and (c) women's absence has negative effects on broader societal goals (e.g., equal opportunity, quality education, generation of knowledge, economic growth). Evidence exists to support the idea that these three conditions are present today; thus, women's underrepresentation in physics is a problem that should be further interrogated. Therefore, researchers in physics education must continue to take up gender in our work, and multicultural feminist theory is one framework that should be employed to advance this aim. The author suggests that multicultural feminist theory can play a major role in the future of physics education research. The theory's relationship with and advantages over other theories are discussed. Implications for physics education researchers are delineated. Support for this argument will be drawn from recent scholarship, including a 2014 literature review on underrepresented students in STEM. Sources will include published journal articles and dissertations about women and women of color in both physics and STEM.

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I. INTRODUCTION

Educational researchers and policy makers regularly emphasize the need to encourage more students to pursue and persist in science, technology, engineering, and mathematics (STEM). Many point to gender as the most influential social factor in choosing and persisting in these fields. Women are more likely to graduate with degrees in education, arts, humanities, social sciences, and law, whereas men are more likely to graduate from natural sciences, mathematics, and engineering departments even among women who pursue and persist in post-secondary and graduate-level physics, very few pursue careers in academia [1]. This trend occurs across the globe and has changed surprisingly little despite increased efforts to support women in traditionally male-dominated fields. Gender segregation exists in most disciplines, but has historically been most evident in STEM [2]. Although the representation of women is improving in some STEM fields, such as biological science, women in physical science remain underrepresented in both post-secondary study and later careers.

It is clear that gender should remain a major category of analysis in physics education research, but it is not the only social construct that should be considered. While researchers in physics education continue to take up gender as a critical part of the research agenda, the purpose of this paper is to argue that race and ethnicity should be considered alongside gender to fully explore, explain, and improve the patterns of inequity that currently exist in physics education.

One way to move beyond gender and include race is to utilize multiracial feminist theory. Multiracial feminist scholars challenge traditionally homogenous White feminist viewpoints to include the voices of women of color [3]. Scholars Maxine Baca Zinn and Bonnie Thornton Dill describe the multiracial feminist perspective as "an attempt to go beyond a mere recognition of diversity and difference among women to examine structures of domination, specifically the importance of race in understanding the social construction of gender" [4]. The multiracial feminist lens raises questions about physics education that are otherwise obscured by a singular focus on gender.

First, this position paper will review recent evidence that indicates that women, particularly women from certain racial and ethnic groups, continue to be underrepresented in physics. Evidence of underrepresentation, for both women in general and women of color, is unequivocal. The intersectionality of gender and race and the effects of these social constructs on participation in post-secondary physics are impossible to ignore.

Next, the idea that this underrepresentation is inherently problematic is questioned and explored. Here, it is argued that young girls are being dissuaded from entering physics at a higher rate than boys are. Girls' decisions to participate (or not to participate) in physics are influenced by social, cultural, and educational factors. Further, the author contends that women who choose physics in post-secondary study are subsequently pushed out at a higher rate than men are. Classroom climate, curriculum, and even lack of role models are among the reasons women choose to leave physics. This trend of gender inequity causes negative effects for groups beyond women alone.

Finally, the paper points to the use of multiracial feminist theory as a framework that can and should be employed to advance research on the reasons for and interventions to improve inequity in post-secondary physics. Multiracial feminist theory can point physics education researchers toward the understanding necessary to explore the multiple systems of domination currently plaguing post-secondary physics. This theoretical framework will allow physics education researchers to move beyond the study of gender alone to explore the diverse array of experiences in physics classrooms and careers.

II. EVIDENCE OF UNDERREPRESENTATION

Patterns of underrepresentation among women in physics are clear and disheartening. Further, patterns of underrepresentation among women from specific racial and ethnic groups are also problematic. These patterns suggest that gender is indeed an important social factor that influences major choice and persistence, but that its intersectionality with other social factors, particularly race, better explains the problem of women's underrepresentation in physics.

A. Underrepresentation of Women

Recent research indicates that women continue to be underrepresented in the physical sciences and related careers. In 2013, women constituted 55% of the total number of full-time undergraduate students enrolled in degree-granting post-secondary institutions [5], but according to the National Science Foundation (NSF), women still earn less than 40% of physical science degrees at the bachelor's, master's, and doctoral levels [6]. Among STEM department chairs at leading research universities, most are aware that they continue to grant more STEM degrees to men than to women with each academic year [7]. These trends suggest that a number of systemic and educational influences continue to work against the success of women in post-secondary physics.

B. Underrepresentation of ALANA Women

Gender, of course, is not the only social identity that influences participation in physics. Recent evidence also indicates that several racial and ethnic groups, specifically African American, Latina, South East Asian, and Native American (ALANA) students [8], are disproportionately represented. ALANA women, like women as a whole group, have been substantially underrepresented in science and engineering relative to their representation in the overall population. Educational attainment in STEM among ALANA women lags behind that of their White female and minority male peers [9]. Women from these underrepresented groups earned just over 5% of bachelor's degrees in physics in 2010 [6].

ALANA women represent a unique group that experiences the challenges of both female gender and underrepresented racial and ethnic status. In describing the experiences of ALANA women in STEM fields, Malcom and colleagues [10] used the term "double bind" to convey the idea that these individuals face oppression and discrimination based on both their gender as well as their racial identity. This "double bind" occurs as the factors of gender and race work simultaneously to produce distinct experiences for ALANA women in STEM classrooms [9].

The underrepresentation of ALANA women also illuminates the differences between what is deemed normal and abnormal; ALANA women doubly violate the social norms regarding who (e.g., which racial and ethnic groups) can participate in STEM as well as the norms of femininity [11]. For instance, it is socially acceptable and rather common for a White male to have a job in physics. It is somewhat unique for a person of color to hold a similar job, as it violates the racial norms of United States society. It is also unique for a woman to hold a job in physics, as it is often considered masculine to do so. It is *particularly* rare for a woman of color to hold the same job, as she violates norms of both racial power hierarchies and femininity.

III. UNDERREPRESENTATION AS PROBLEMATIC

Scholars have wondered for years about whether we need women in physics and, if so, what we might do to bring more women to the field [12]. Is this gender inequity inherently problematic? Maybe it's not. Perhaps girls choose to avoid physics simply because it doesn't interest them. Perhaps women leave their dreams of studying physics behind because they don't have the skills to succeed. Perhaps an increase in women studying physics would simply lead to unhappy and unsuccessful students and physicists. As readers will see below, the literature does not support these arguments. The lack of women in physics is a manifestation of inequitable circumstances and leads to socially unjust outcomes for women and society as a whole.

Women's underrepresentation in the field of physics is a problem because girls in K-12 schools are dissuaded from entering physics, and women who choose to major in physics are pushed out upon arrival. Furthermore, women's absence is not only inequitable, but has negative effects on broader societal goals including equal opportunity [13] quality education [14], knowledge generation [9], and economic growth [15]. Evidence exists in the research literature to support all of these claims.

A. Girls are dissuaded in K-12

First, it appears that girls are dissuaded from even considering physics as a field of study. The pre-collegiate experience, including family relationships, academic preparation, and high school counseling, can have a significant impact on the pathway to physics for women, particularly ALANA women.

A large body of research suggests that girls' and women's perceptions of STEM and themselves as practitioners in STEM profoundly influence decisions to participate (or not to participate) in these fields [16]. A lack of positive experiences with science and mathematics in childhood can affect later educational and career decisions [13]. These social-psychological theories suggest that teachers, counselors, peers, parents, the general public, and the media can have a substantial impact on the way STEM fields, including physics, are perceived as being suitable for girls.

There also exists a strong cultural pressure for girls and women to conform to traditional gender roles in their educational, professional, and personal lives [13], and these expectations often limit women's career choices to traditional roles [10]. For example, math-proficient women disproportionately prefer to pursue careers in non-math-intensive fields (e.g., education) rather than pursue careers in STEM (e.g., physics) [17]. These career choices often have nothing to do with a lack of ability. Women with high math competence are more likely to also have high verbal competence, which leads to a greater choice of fields of study [17]. Careers in STEM, particularly academic careers, are not perceived to be flexible enough for marriage, children, and care of elderly parents [18]. Thus, girls and women who have the choice between a career in a STEM field and a career in a non-STEM field often choose the latter.

Researchers also suggest that girls often lack academic preparation for science majors and careers [13]. Differences in high school preparation explain substantial variation in the selection of a STEM or non-STEM major [19]. Lack of academic rigor in secondary school can make undergraduate-level work difficult, and ALANA women, due to their particularly marginalized status, are more likely to encounter this problem than are other underrepresented groups [10]. Lack of previous mastery experiences in relevant academic areas could certainly affect women's and ALANA women's decisions not to choose physics.

B. Women are pushed out of post-secondary physics

Some women, however, do find themselves in physics classrooms and careers. Education scholars posit that these very women who so steadfastly decided to enter the male-dominated world of physics are subsequently pushed out. Hall and Sandler [20] for instance, were the first to point out that many women experience a “chilly climate” in undergraduate classrooms, or an environment that conveys the message that women are less capable and less serious compared to their male peers. This may leave women feeling less confident than their male classmates and less likely to persist in STEM fields like physics.

Many women specifically cite feelings of psychological alienation or depression as reasons for leaving STEM fields [21]. These negative feelings may be caused by negative interactions with faculty and fellow students. For example, negative interactions with faculty, including subtle or inadvertent sexist comments or attitudes, discourage women from participating actively in classroom and advising settings [20, 21]. Women report that this negative classroom atmosphere is prompted by unfair treatment from their male peers in STEM courses and departments [22].

The current underrepresentation of women in physics classrooms has a reciprocal impact on women choosing to pursue or persist in physics. Previous persistence research suggests that women feel more comfortable in science and math classes when not dramatically outnumbered by men [21]. There is also a dearth of female scientists to serve as role models [13]. Thus, the absence of female role models as professors, advisors, graduate students, and undergraduate students may, in itself, contribute to lack of academic success and persistence for women in physics [23].

Researchers also posit that STEM curricula and instructional approaches are not well-matched to the learning styles and preferences of many female students [13]. This mismatch can be viewed as one aspect of the cultural incongruity that pushes women out of physics. For example, women tend to prefer to cover less material in greater depth [13] and prefer learning environments in which new material is contextualized within real-world situations [24]. Women also tend to prefer small, interactive classes with many hands-on demonstrations and group activities [25]. Unfortunately, many women characterize introductory physics courses as large, broad, lecture-based, and impersonal [21]. This mismatch might account for part of the increased dropout rate among women in physics.

Grade-point average (GPA) is a strong predictor for persistence in STEM fields such as physics. Girls tend to have higher grades than do boys in high school, which facilitates entry into STEM fields [2]. However, academic self-assessments among women continue to impede their pursuit of STEM majors and careers later in life. Mathematics self-efficacy is particularly important to the field of physics, with its heavy emphasis on formulas and calculation. Undergraduate men report higher mathematics self-efficacy than do women, but there are no statistically significant gender differences in mathematics grades [26]. Thus, despite the fact that GPA is a strong predictor for persistence, women often underestimate their likelihood of success in fields such as physics.

The pedagogy of science classes is also thought to favor male students. Science teachers tend to reinforce girls’ negative attitudes about science by devaluing the contributions of female students and overemphasizing rote learning [13]. These implicit biases against women in science classrooms may certainly have an impact on women's decisions not to persist in physics.

An inherent masculine worldview exists in scientific epistemology [13]. For years, scientific research was used to support the notion that women had inferior mental capacity to men. Theories of feminist science are often left out of curricula because they pose a threat to traditional "objective" science as proposed by prominent male scientists [13]. Apparently, the existence of women in the sciences, including physics, threatens the discipline itself.

Physics education is not gender neutral, and further change must occur in order for more women to find, pursue, and persist in the field of physics. For many of the reasons above, women are more likely to leave physics than men. After declaring a physics major, more than 50% of women switch out of physics, while only 30% of men do [27]. Further, physics education is not race neutral. After declaring a physics major, more than 60% of Hispanic students and 70% of Black students switch out of physics, while approximately 30% of White students do [27]. It is critical to consider the combination of gender and racial factors that push students out of post-secondary physics.

Risk factors for ALANA women often parallel those for women in physics. For instance, ALANA women rarely encounter supportive faculty role models; more often they are met with condescending professors with low expectations for their achievement [10]. The same could be said for women and ALANA students more generally. ALANA women, however, encounter even fewer role models than other students do in their undergraduate, graduate, and professional work.

During college, institutional demographics and culture may have a profound impact on the experiences of ALANA women. African American female science graduates at a predominantly White institution reported that they operated in a "different world" from other-race students [28]. That is, these women experienced boundaries and expectations based on their gender and racial identities in their field of study. Social and intellectual exclusion from physics may certainly discourage ALANA women.

Some social identities may confer additional risk of switching or dropping out for ALANA women in STEM fields. For instance, ALANA women who are also transfer students feel that they are treated as though they do not belong in science due to their age, ethnicity, gender, and peer and instructor preconceptions that transfer students are not well prepared [29]. Atop an already doubly oppressed status, an ALANA woman's multiple identities could have an even more dramatic effect on her decision to leave physics.

C. Women's absence has negative effects

Scholars and researchers assert that women (and ALANA women)'s absence from physics has significant negative effects on societal goals such as equal opportunity, quality education, generation of knowledge, and even economic growth. Women's underrepresentation in physics is problematic because it limits the scope of knowledge produced in STEM fields and produces unethical power hierarchies in educational and occupational spheres.

First, inequity in physics prohibits equal opportunity, or equal access, to study and work for all individuals [13]. Research suggests that structural differentiation in educational and occupational spheres contributes to social class inequality [30]. STEM fields, including physics, are also considered lucrative and respectable to work in [6]. Thus, promoting persistence for women and ALANA women in physics is a step toward equity of opportunity, respect, and income.

Greater diversity of perspectives in physics fields can only increase the collective knowledge base [13]. Diversity is desired both in educational institutions and in the workplace, as diverse worldviews can be particularly useful in solving complex problems [14]. Evidence suggests that the relation between diversity and student problem solving skills is significant even at the classroom level [31]. In physics, diversity in both gender and racial identity can bring in fresh viewpoints and unique ideas to promote problem solving and innovation [32].

A substantial number of intelligent, talented women and ALANA women are choosing fields other than STEM, and our societal institutions and local communities are missing out on their potential contributions [13]. Many STEM department heads agree that increasing the number of women students in STEM education is an important national priority [7]. We need to find ways to fully realize the potential of this untapped resource of underrepresented students [9].

Additionally, access and success among underrepresented populations in STEM are critically important to U.S. economic competitiveness in the global economy as well as equity in higher education [15]. STEM industries that rely on quality graduates are faced with a lack of eligible candidates, particularly from underrepresented groups. In order to remain economically and academically competitive and equitable, it is important that physics education be open to all students.

Finally, students who are not underrepresented in physics are also affected by disproportionality. Whether overt or subtle, differential treatment based on gender, race, or ethnic background is far from innocuous. Its cumulative effects can be damaging to individual students and the educational process as a whole. For example, men who experience STEM courses that are inhospitable to women may find it difficult to perceive women as equal peers, to work with them in collaborative learning situations, and to offer them support as colleagues in academic or professional settings [20]. A diverse student body is a first step toward the broader goal of inclusion for all students [33]. This diversity requires moving beyond the typical White male group of physics scholars and expanding opportunities to other groups.

Despite the obviously unique position of ALANA women in physical science, there remains a dearth of scholarship that examines the overlapping effects of gender and race [19]. This lack of research is likely because ALANA women are so dramatically underrepresented in physics, which limits researchers' abilities to draw reasonable conclusions about this population. Scholars also lack a theoretical framework that allows the simultaneous examination of gender and race.

IV. MULTIRACIAL FEMINIST THEORY

The trends explored above require a theoretical narrative to make sense of the complex dynamics between gender, race, and physics education. Scholars continue to find, analyze, and question the underrepresentation of women (particularly ALANA women) in physics; the problem of inequity has not disappeared. Therefore, researchers in physics education must continue to take up gender in our work, and multiracial feminist theory is one framework that should be employed to advance this aim**.** Multiracial feminist theory can play a major role in the future of physics education research, as it acknowledges the need to challenge systems of domination beyond gender alone.

Multiracial feminism offers "a body of knowledge situating women and men in multiple systems of domination" [4]. The multiracial feminist perspective is an attempt to go beyond a mere recognition of gendered diversity to examine societal power structures, specifically the importance of understanding social constructions of racial and ethnic identities to understand social constructions of gender [4]. This examination of more than one system of social domination places multiracial feminist theory ahead of other theories that attempt to theorize gender alone, leaving out the women of color who are so often excluded from both physics and feminism.

Multiracial feminist theory encompasses the scholarly perspectives of women of color, or ALANA women [4]. These women are labeled "marginal intellectuals" [4], and they are the same groups of women who are so dramatically underrepresented in academia as well as the physical sciences. Thus, the multiracial feminist viewpoint goes beyond the more traditional feminisms to include the voices of women from more than just a White, highly educated, middle-class background.

Other scholars refer to this and similar feminist perspectives as "U.S. Third World feminisms" [34] "indigenous feminisms" [35], or "multicultural feminism" [36]. The purpose for choosing the term multiracial over others is to place an emphasis on the importance of race in the United States social context and system of power. This theoretical perspective allows for the analysis of difference within a rather heterogeneous group of individuals: women. Multiracial feminists look beyond these individual differences toward broader social categories such as race and class upon which opportunity structures in the United States context are built [4].

In the United States, the social construction of race, as well as the meanings and ideologies that accompany it, is a fundamental principle in the organization of individuals into groups [4]. Race is an influential identity for both men and women, for all class groups, for children, and for adults. The pervasiveness of racial stratification should be questioned, particularly in relation to educational outcomes.

Scholars note that socioeconomic and class differences play an important role in choosing STEM careers among undergraduate students [37]. In a recent study [38], students' social identities (racial/ethnic, gender, and/or socioeconomic status), participatory trajectories (i.e., persistence or switching), and learning opportunities were all interrelated. Additionally, women who work more than ten hours per week or who have financial constraints have reduced persistence in STEM compared to men [27]. Different combinations of identities might influence STEM persistence in distinct ways for individual students. Multiracial feminist theory allows for the exploration of these multiple social identities in the present system of power and privilege.

A recent case study [39] explored the way that gender, race, and class influenced the development of legitimate science identities among three women of color (one Black, one Latina, and one Native American). These women had to navigate both the identities that they claim and the identities that are thrust upon them to be recognized as scientists in their respective fields. They encountered difficulties in authoring their own identities, structural constraints, and changes over time or in different spaces [39]. Women of color appear to have unique individual experiences in STEM fields such as physics, but they encounter similar struggles along the way. Multiracial feminism is one lens through which scholars can continue to understand and intervene within these patterns of experience.

V. CONCLUSION AND IMPLICATIONS FOR PHYSICS EDUCATION RESEARCHERS

Recent research indicates that women, particularly women from specific racial and ethnic groups, are underrepresented in physics even compared to other STEM fields [6]. Women are also more likely to leave physics than men, and ALANA students are more likely to switch out of physics than White students [27]. This underrepresentation is indeed problematic. The underrepresentation of women in physics is quite obviously linked with social factors and identities beyond gender alone. These social factors and identities, including race and ethnicity, can no longer be ignored for the comfort of researchers and to the detriment of physics education. Thus, physics education researchers can and should continue to explore issues of underrepresentation from a multiracial feminist perspective. Multiracial feminist theory can help physics education researchers to understand and consider multiple systems of domination in the search for understanding and improving patterns of participation in post-secondary physics.

It is only through the examination and transformation of educational systems from systems of power and privilege to systems of equity and social justice that we might see true change in patterns of underrepresentation in physics education. Individual student experiences are indeed valuable, but the experiences of individual students – the neighbor's daughter who majored in physics, or the one female physics professor at the university – cloud understanding of the bigger picture. The goal of eliminating inequity and achieving parity in physics education must be achieved via systematic, rather than individual, change.

The research frameworks put forth by other authors in this issue can and should be expanded to explore systems of domination beyond gender that include race. The interventions suggested will likely be effective for encouraging participation and persistence of women in post-secondary physics. Improving women's sense of belonging and reducing women's stereotype threat in physics classrooms is an excellent first step, but it is not enough. These same social and cognitive principles can be utilized in interventions to improve outcomes for students of all racial and ethnic backgrounds in physics education.

Other authors in this issue also question the White male standard of performance and the present binary model of gender. In questioning systems of domination where White men are placed in the most prestigious and powerful roles, multiracial feminist theory also critiques the current performance standard in physics. The combination of gendered and racial stereotyping is even more problematic for the growing number of students who do not fit into the White male category. The present binary (assigned at birth by sex) view of gender is dramatically detrimental to individuals at all points on the gender continuum. Societal stereotyping of gendered (i.e., "masculine" and "feminine") roles can influence major choice, persistence to graduation, and career outcomes in physics. An individual's decision to choose and persist in physics is influenced by many things. A multiracial feminist lens allows researchers to consider and explore these influences as a system rather than a single binary variable.

Multiracial feminist theory will help physics researchers to fill this gaping hole left by the gender-only lens. In the United States social and educational context, race is a pervasive and influential construct that is too often ignored in research studies and publications about inequity. Even the most well-intentioned academics view race as a difficult and uncomfortable topic to address. There needs to be a shift away from thinking of inequity as an issue for women, for minority students, for someone else to study. All kinds of inequity, particularly gender and racial inequity, are detrimental to societal goals. Inequity, in physics and beyond, is everyone's problem.

Further research in physics education must consider both gender as well as race to evaluate current trends and determine effective interventions. Physics education researchers should focus on the exploration of the perspectives of women, including ALANA women, and their diverse array of experiences in physics classrooms and careers. It is only through the thorough analysis of these experiences that researchers can begin to understand the current state of physics education and move forward to a more inclusive, welcoming model of educating tomorrow's physicists.

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