Broadening the Science of Broadening Participation in STEM Through Critical Mixed-Methodologies and Intersectionality Frameworks

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Abstract

If we wish to see our STEM (science, technology, engineering, and mathematics) broadening participation efforts affect change, we must also critically reflect upon and broaden our scientific approaches to studying STEM participation, adopting methodologies and frameworks that most appropriately fit the problems and questions at hand. In this article, we discuss how critical mixed-methodological approaches and intersectionality frameworks offer the possibility of a science of broadening participation that deeply understands, contextualizes, and addresses complex barriers to STEM inclusion. First, we describe the suggested approaches and frameworks, illustrating how they allow us to improve how we collect, measure, interpret, and analyze data. Next, we provide some specific examples of how such approaches and frameworks have enriched our scientific work. Last, we offer some final recommendations for researchers seeking to broaden the science of broadening participation in STEM.

Keywords: STEM, intersectionality, critical methodology, participation

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The lack of diversity in science, technology, engineering, and mathematics (STEM) fields is well documented and widely acknowledged, with researchers, scientific agencies, policy makers, organizational leaders, practitioners, and more working for nearly half a century to broaden participation to little avail (AAUW, 2015; Izzo & Bauer, 2015; Metcalf, 2016; National Science Board, 2016). While progress has been made in some areas and for some fields, improvements in numeric representation alone have yet to eradicate disparities in STEM. For example, in fields, such as the life sciences, where degree attainment for women and people of color has dramatically improved, a whole host of cultural and systemic biases and barriers remain (Metcalf, 2016). These pervasively impact core aspects of STEM career pathways, including exam performance, classroom inclusion, sense of scientific identity, fit, self-efficacy, evaluation, recognition, funding, access to resources, opportunities for advancement and leadership, workplace interactions, and more (AAUW, 2015; Lincoln et al., 2012; Milkman et al., 2015; Metcalf, 2016; Moss-Racusin et al., 2012). Likewise, social factors, like gender, race, and ethnicity, have heavily been studied, but largely in isolation from one another, while others, like sexuality and disability, have remained mostly absent from the research, policy, and practice of broadening participation.

If we wish to see our efforts to broaden participation in STEM affect change, we must also critically reflect upon and broaden our scientific approaches to studying STEM participation, adopting methodologies and frameworks that most appropriately fit the problems and questions at hand. As scientific researchers exploring the topic of broadening participation in STEM, a primary focus of the work we do should be to understand, as best as possible, the experiences of the people whose participation we seek to broaden. However, our methodological and analytical approaches are often guilty of the same exclusion issues our work seeks to address. Typical approaches, heavily quantitative, regularly mask the experiences of women of color, drop the responses of indigenous participants, merge racial groups in problematic ways, and rarely inquire about LGBTQ+ or disabled scientists or engineers, largely because of our choices to prioritize and value statistical significance over meaning. In this *Cult of Statistical Significance*, we focus on *how much* of certain phenomena are occurring at the expense of asking *whether* or *why* they do, overlooking important pieces of the broadening participation puzzle (Zilak & McCloskey, 2011).

In this article, we discuss how critical mixed-methodological approaches and intersectionality frameworks offer the possibility of a science of broadening participation that deeply understands, contextualizes, and addresses complex barriers to STEM inclusion. First, we describe the suggested approaches and frameworks, illustrating how they allow us to improve how we collect, measure, interpret, and analyze data. Next, we provide some specific examples of how such approaches and frameworks have enriched our scientific work. Last, we offer some final recommendations for researchers seeking to broaden the science of broadening participation in STEM.

Intersectionality Frameworks and the Promise of Critical Mixed-Methodologies

One key research paradigm that has yet to fully be adopted by the broadening participation research community is intersectionality (Hunt et al., 2012). Intersectionality is a well-established contextual framework for examining the complex ways in which multiple systems of oppression deeply intertwine to influence experiences and opportunities (Bowleg, 2012; Cho et al., 2013; Collins, 2015; Crenshaw, 1989; 1991; Griffin & Museus, 2011; Warner & Shields, 2013). Intersectionality is rooted in the research and activism of women of color extending back to the mid-1800s as Sojourner Truth drew attention to white and black women's differential experiences of oppression and racism within the suffragist movement in her famous, "Ain't I a Woman" speech. Throughout U.S. history, observing the notable absence of people of color in feminist movements and gender research and women in race-based activism and scholarship, women of color like bell hooks, Patricia Hill Collins, Kimberlé Crenshaw, Gloria Anzaldúa, Cherríe Moraga, and more have called for such advocacy work to look deeper at who we exclude (Hull et al., 1982).

Intersectionality frameworks allow us to do just that. Intersectionality helps us understand how our experiences and the social identities that inform them are connected to systems of power, privilege, and oppression (Crenshaw, 1991). It guides us in situating and interpreting experience within various social, political, economic, environmental, and historical contexts. It provides room to critically interrogate identity politics and the very categories used to represent lived experience to better understand the porous, complex, and transient nature of individual and social senses of identity within systemic context. It allows us to make visible similarity across difference and difference across similarity.

Because of its capacity to situate and deeply understand individual and group experiences within a larger, systemic context, intersectionality has become a widely used framework in law, humanities, and the social sciences and continues to grow in popularity. For example, in a search of the term "intersectionality" among peer-reviewed journal article titles and abstracts in Google Scholar, we found that during the past thirty-five years, approximately 38,600 scholarly publications have used the term “intersectionality,” with the majority published over the last ten years (Figure 1).

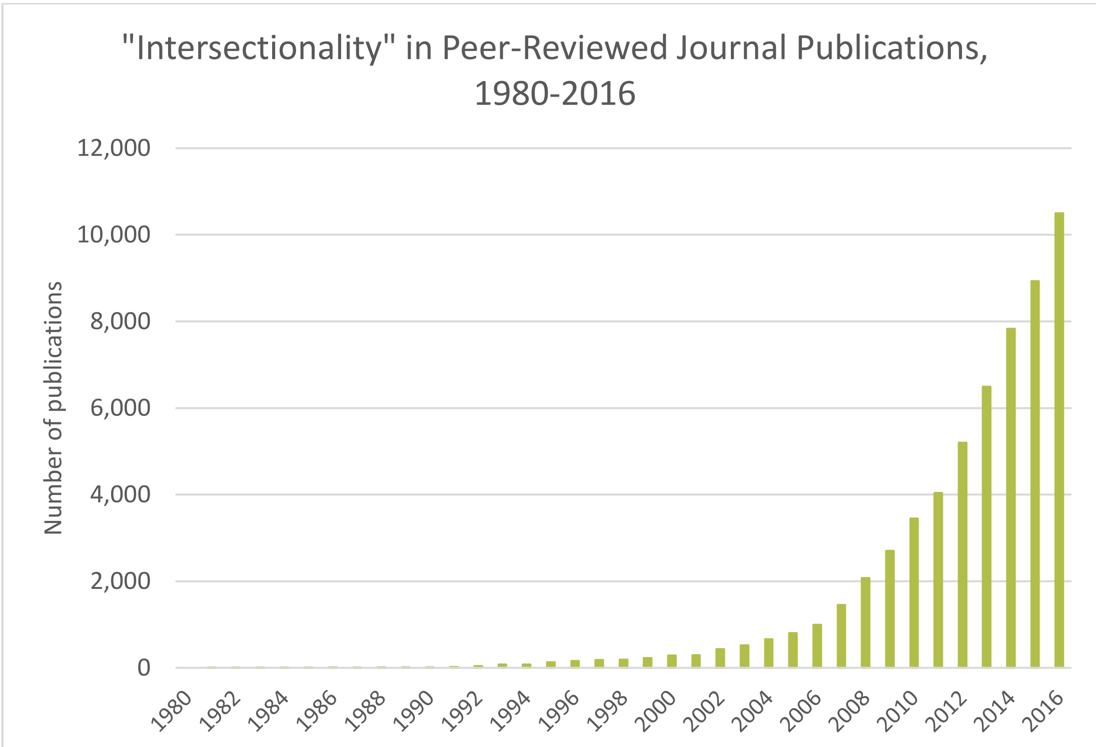

Figure 1: “Intersectionality” in Peer-Reviewed Journal Publications, 1980-2016

However, this growth is just beginning to extend to the study of STEM. Using Quid, a qualitative data visualization, natural language processing, and analytic tool, we reviewed a representative subsample of 2,876 papers published in Elsevier’s Scopus database since 1993 discussing intersectionality in their titles, abstracts, and/or keywords. Among these papers, only 77 (2.7%) were about STEM, 52 of which were about STEM workplaces (1.8%, Figure 2). In addition, scholars have incorporated some social categories more regularly than others in the sample. This is especially true for studies of STEM workplaces, where intersectionality scholars have focused on gender, race, and ethnicity, but rarely incorporate nationality, age, socioeconomic class, religion, or sexuality into the mix. Notably, no studies in this sample included disability.

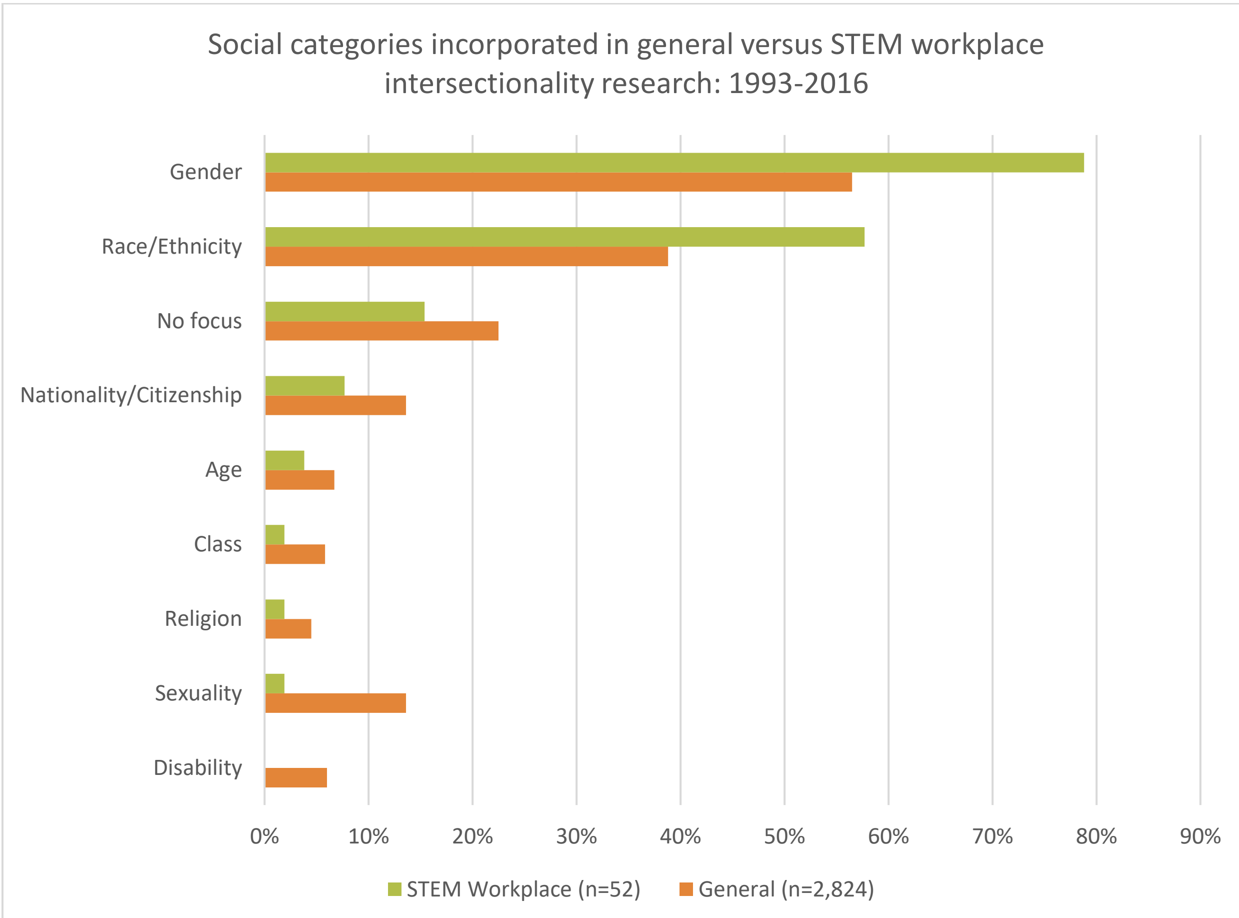

Figure 2: Social categories incorporated in general versus STEM workplace intersectionality research

One reason, aside from lack of awareness, researchers have not yet adopted intersectionality frameworks for studying STEM participation is that is poses methodological challenges. Studying STEM participation through an intersectionality framework requires that we select "modes of analysis best suited to address how multiple identities shape the lived experience…to examine the as-yet unanswered questions intersectionality generates" (Griffin & Museus, 2011). Hancock explains that we "cannot rely on the same old data, or more precisely, data collected in the same old unitary way" (2007, p. 66). Instead, the complexity of intersectionality, the need to situate data within context, and the emphasis on creating change through our broadening participation research necessitates multiple forms of data and analysis and a critical methodological approach (Baez, 2007; Griffin & Museus, 2011; Metcalf, 2016; Trahan, 2011).

Critical mixed-methodological approaches offer just that. The "critical" in this approach suggests a methodology that is self-reflective, connected to social justice aims, and revealing of "hidden power arrangements, oppressive practices, and ways of thinking" to transform unjust social structures (Baez, 2007, p.19). The "mixed" indicates the use of both quantitative and qualitative data collection and analytic techniques. Critical qualitative-, quantitative-, and mixed-methodologies are tied to emancipatory goals that pay close attention to the use and reproduction of language, knowledge, power, and oppression. They ask that we engage holistically in the many dynamic nuances, histories, and contexts involved in the relationship between concepts and subjects. For instance, these critical methodological approaches call us to interrogate the relationship between the concept "woman," the people who identify with that concept, and the surrounding social, political, historical, institutional, and economic contexts.

Pairing quantitative (e.g. surveys) and qualitative (e.g. open-ended questions, interviews, policy documents) elements together under this critical and intersectional lens allows us to see patterns on a larger scale while also situating those patterns and our study designs in context, deepening our understanding of respondents' experiences and the impact of our work. The quantitative components of critical mixed-methodological studies can be highly influential over policy and programmatic decisions, especially in large-scale studies. As such, conducting the quantitative aspects of our work from a critical perspective is especially necessary to avoid perpetuating inequities and further marginalizing or erasing the experiences of historically marginalized communities. Such an approach guides us in a study design that is purposeful in how we collect, measure, analyze, and interpret data – one that looks deeply at our survey design and the purpose and context surround each survey item and element; reflects on the construction of variables and whether they adequately capture the experiences and identities of our participants; and the potential interpretations and consequences of those interpretations for respondents, communities, policy making, and future research (Metcalf, 2016). Taken together, a critical mixed-methodological approach pushes us to acknowledge how past and present research, including our own, might be limited in accounting for those very experiences we seek to understand most in our efforts to broaden STEM participation. It empowers us to work beyond research and data limitations to construct new measures, find new ways to engage with and interpret data, and be intentional and transparent in our scientific scholarship.

A note on context.

A big piece of investigating the "whether" and the "why" in critical STEM participation research is positioning the data that we gather within relevant, yet vastly different social, economic, historical, disciplinary, geographic, institutional, and political contexts. When it comes to STEM inclusion and participation, these contexts play a large role in shaping experiences. Even though the different aspects of social identities and the systems that inform them are inseparable in practice, some elements may feel more salient in certain contexts than in others. For example, when a Latina who uses a wheelchair is unable to access her physics colleague's third floor office because there is no elevator, she may, in that moment, be more aware of the inaccessibility of her workplace than other identity-related issues. In another moment, as her colleague asks about her husband when she's married to a woman, she may more strongly feel tensions related to some combination of gender, sexuality, or race. These shifting contexts require us to situate the information and data we collect about STEM experiences appropriately and as holistically as possible. Yet, with so many different social categories open for inquiry, discerning how and when to collect and disseminate data on which social categories and contextual elements is no easy task.

The unique social and historical context surrounding science itself creates additional difficulties when sharing our research findings. As a brief overview, from the beginning of the 18th century until long after the conclusion of World War II, biologists, biomedical practitioners, and technologists used the bodies of non-Europeans, women, Jews, LGB people, disabled people, and other socially, economically, and politically marginalized groups to "discover" and "prove" their scientific inferiority (Kaplan & Rogers, 2001; Schiebinger, 1990). Some scientists viewed people with disabilities as a sickness or a medical condition[1] to be treated or to be euthanized; they believed these groups would be unable to have a quality life or contribute to society (Myers et al., 2014).

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[1] This medical model that views disabled people as at a deficit due to physiological difference, diagnosis, injury, or impairment is still the dominant model in science today. Scientific work and workplaces using this model primarily aim to "fix" disabled people and often frame individual accommodations as "special needs." Researchers using sociocultural models of disability, however, demonstrate that it is the environment that disables people with impairments through its very design. Proponents of this view of disability argue that scientific workplaces can and should work to remove the physical, social, and emotional barriers of the environment, allowing *all* employees to succeed.

Women, people of color, impoverished people, LGBT people, and people with disabilities have served as test subjects for science many times since. From 1932-1972, scientific researchers conducted the Tuskegee Syphilis Experiments, studying the natural progression of untreated syphilis on rural black men without their consent and who thought they were receiving free health care from the government (Corbie-Smith, 1999). In 1951, Henrietta Lacks, an African American woman from rural Virginia, had a tumor biopsied as she was undergoing treatment for cervical cancer. Without her permission or compensation, her cells were cultured and used to create the HeLa cell line, which remains a primary source of data in medical research today (Callaway, 2013).

Throughout this period, LGBT people were considered mentally ill and were subject to myriad experiments, surgeries, and experimental therapies that aimed to "cure" homosexuality, intersexed bodies, and gender identity nonconformity (Kessler, 1990). It was not until 1973 that the American Psychiatric Association removed homosexuality from its list of disorders. As recent as 2013, *the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)* revised gender identity disorder to gender dysphoria, marking a shift away from pathologizing transgender people because of their identities and to diagnosing based on the experience of distress related to identity (Elaut et al., 2016; Lev, 2016).

Our checkered scientific history of positioning certain populations as scientifically inferior or pathological, restricting their autonomy, choice, and consent, and explicitly excluding them from learning or working in STEM has great impact in the contemporary moment where these ideas continue in a much more implicit way. For example, recent research on bias in STEM shows how our past beliefs about inferiority influence present attitudes about scientific talent.

This work finds that the extent to which a field attributes success to innate intelligence or brilliance accurately predicts the representation of women and underrepresented minorities in those fields as these groups are stereotyped as not possessing natural talent (Leslie et al. 2015; Storage et al. 2016).

Acknowledging the continuation of our biased and exclusionary past can even create values conflict for researchers and their audiences. Scientists and engineers, even those who study STEM workplaces, may struggle with looking at those aspects of our historical context that are contrary to scientific values of objectivity and ethical research conduct. This can make situating our research and interpreting the resulting data within this context difficult. It also introduces challenges when presenting research to audiences of scientists and engineers who may refute the findings or experiences of marginalized and/or small social groups because they call into question the objectivity and meritocracy of STEM (Castilla & Bernard, 2010; Uhlmann & Cohen, 2007).

This resistance is sometimes so strong that, in these moments, scientists and engineers have even favored fake research that confirms their beliefs that there is no bias in science over legitimate evidence to the contrary (Handley et al., 2015). In publishing and presenting our own work, scientists and engineers, regardless of gender, have simultaneously critiqued areas with small sample sizes or absence of statistical significance while relying on their own individual experiences, a sample size of one, to counter the evidence presented. While this pattern happens with STEM workplace diversity research overall, using intersectionality frameworks increases the regularity with which smaller sample sizes occur and magnifies this challenge.

Critical Intersectionality Research in Practice

In this section, we offer a few examples from our own work of how the suggested approaches have provided new insights on STEM participation research in several key topic areas.

Workplace entry and retention.

Much of the broadening STEM participation research explores key transition and retention points throughout STEM careers. From a workplace perspective, one area of emphasis within this research is equity in obtaining and maintaining a job in one's field after graduating from college. Findings focus primarily on gender and regularly attribute women's higher rate of departure from their STEM fields for jobs seemingly unrelated to their degrees to family-related reasons, such as child bearing and rearing responsibilities (Dean & Koster, 2014; Jean et al., 2015). In this body of work, researchers explain the implications for STEM and the nation, where concerns about workforce shortages abound, and for hiring committees and institutions, who regularly report difficulty in recruiting women, especially women of color, to their candidate pools (Gibbs et al., 2016; Metcalf, 2016).

Using a critical intersectionality approach, we can look more deeply at the assumptions within this body of work, see the systemic tension between gender role expectations and career expectations, and ask which women, if any, are leaving their fields of study because of this tension and under what conditions. Even using pre-existing, national-level data, where we do not have influence over the survey design and implementation, taking a critical intersectionality approach allows us to ask these questions analytically. For example, in exploring this topic using the 2015 National Science Foundation Scientists and Engineers Statistical Data System (SESTAT), a primary data source for informing STEM participation research, policy, and practice, we found that women, as a whole, are more likely than men to report family-related rationales behind their decisions to take a job unrelated to their degrees. However, not only is this rationale only one among many offered, but when we apply an intersectionality framework we see a much more complex story about STEM field attrition that begins to shed light on how workplace and disciplinary cultures interact with social structures related to race, gender, and disability (Figures 3 and 4).

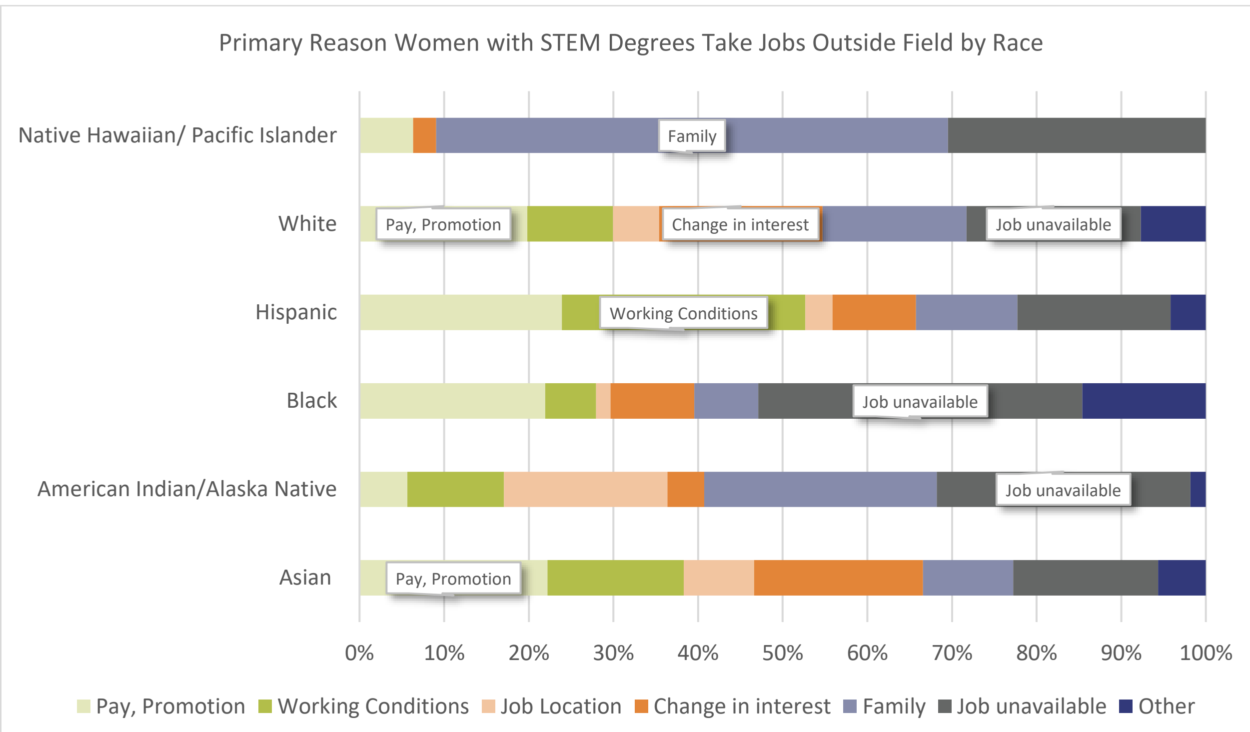

Figure 3: Primary Reason Women with STEM Degrees Take Jobs Outside Field by Race. Original analysis. National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2015. Available at http://www.nsf.gov/statistics/sestat/.

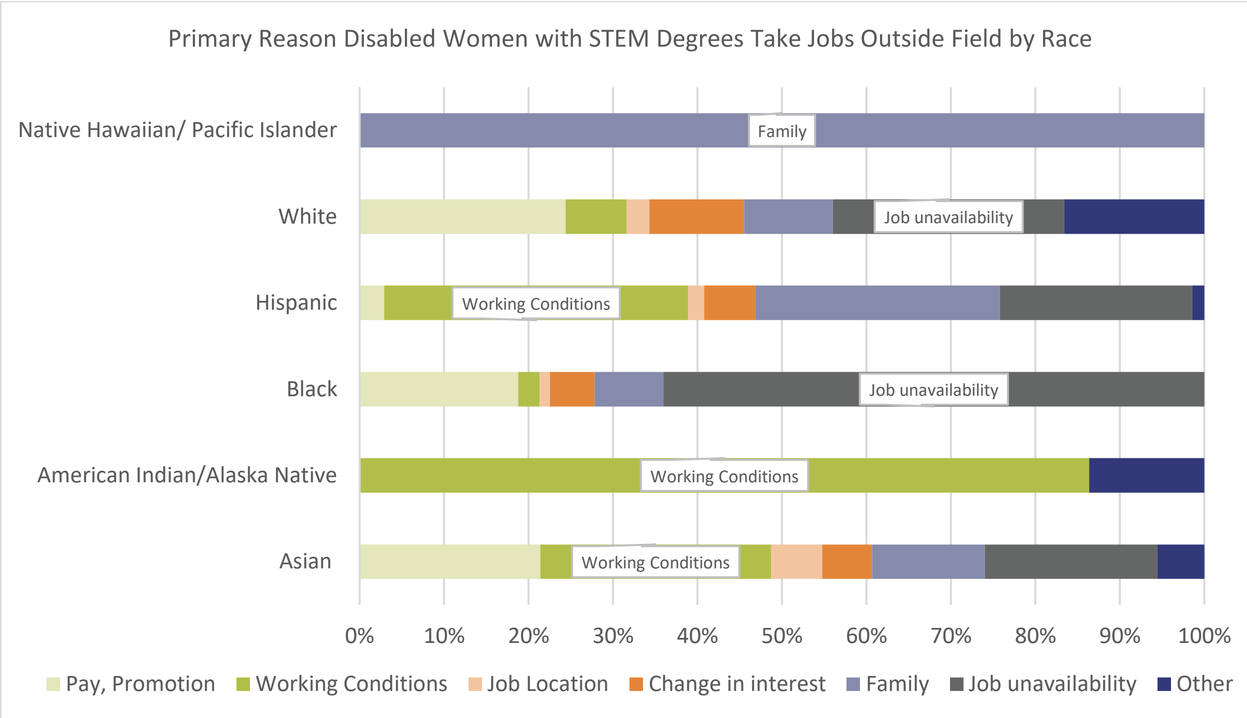

Figure 4: Primary Reason Disabled Women with STEM Degrees Take Jobs Outside Field by Race. Original analysis. National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2015. Available at http://www.nsf.gov/statistics/sestat/.

This approach allows us to see that Native Hawaiian and Pacific Islander women (including those with and without disabilities) are the *only* group of women for the majority of whom family is the main reason they leave their STEM field for other job options. While family-related reasons are at the top of the list for white women as well, the rationale is evenly shared with pay and promotion and difficulty finding an available job in their degree fields. Inability to get hired into a job in their STEM field is paramount for many STEM women, particularly those belonging to multiple marginalized social categories: women with disabilities in the aggregate, white women with disabilities, and American Indian, Alaska Native, and black women, particularly black women with disabilities all select this rationale first. Working conditions also stand out, especially for Hispanic women with and without disabilities, American Indian and Alaska Native women with disabilities, and Asian women with disabilities.

Addressing the uneven family-related responsibilities held by women and providing comprehensive work-life policies for all STEM workers regardless of gender and familial status is important. However, this intersectionality-based look at field-level attrition in the workplace illustrates that the heavy investment in family-related policies is unlikely to have the desired influence on retention if other issues are not also addressed in tandem. Family-related reasons regularly take a back seat to finding an available field-specific job and working conditions for many women. Their experiences sit in stark contrast to what hiring committees report and suggest that additional barriers remain to the hiring process, especially for women of color, women with disabilities, and women of color with disabilities[2]. They also indicate a need to look more deeply into the conditions under which Hispanic women (with and without disabilities) and American Indian/Alaska Native women with disabilities conduct their STEM work and the environments in which work-life policies are enacted and practiced.

Workplace culture.

Recent research and media attention on STEM workplace culture has centered around gender-based and sexual harassment, with many prominent scholars and corporate leaders accused and resigning or being fired amid harassment scandal (Ayock et al., 2017; Benner, 2017;

[2] While not shown here, the issue of job unavailability features prominently in field-level retention choices of black men, Asian men with disabilities, and American Indian/Alaska Native men with disabilities. For American Indian/Alaska Native men in the aggregate, job location is also highly influential. Otherwise, pay and promotion is the major decider for men across all other racial and disability categories.

Clancy et al., 2017; Rothkopf, 2016; Williams & Massinger, 2016). This body of work demonstrates that gender-based and sexual harassment are widespread within and across STEM fields, with roughly a third of women experiencing these issues in their STEM environments (Williams et al., 2014). These data are not typically included in national-level STEM workforce data, despite the impact that experiences with harassment has on inclusion, retention, and individual well-being.

Much of the focus within conversations and research about harassment is on gender, narrowly defined. Very few articles incorporate the experiences of women of color and even fewer include LGBTQ+ scientists/engineers or other kinds of harassment. Those that incorporate intersectionality show a multitude of ways in which scientists and engineers from multiple minority groups encounter identity-based harassment. For example, survey research (n=424) on race, gender, and astronomy/planetary science demonstrated that women of color experience the highest rates of race- and gender- based harassment and assault in their STEM workplaces (Clancy et al., 2017). Women of color reported higher rates of feeling unsafe in their workplaces because of their gender or sex (40%) and race (28%).

In the only study of its kind, the American Physical Society's LGBT climate survey of physicists (n=324) found that LGBT women experienced harassment related to their gender or sexuality at three times the rate of LGBT men and for gender-nonconforming and transgender scientists, the rate was four and five times more, respectively (Atherton et al., 2016). The study's supplemental interviews showed LGBT physicists of color encountered additional, unique challenges with exclusionary behavior, like race-related harassment.

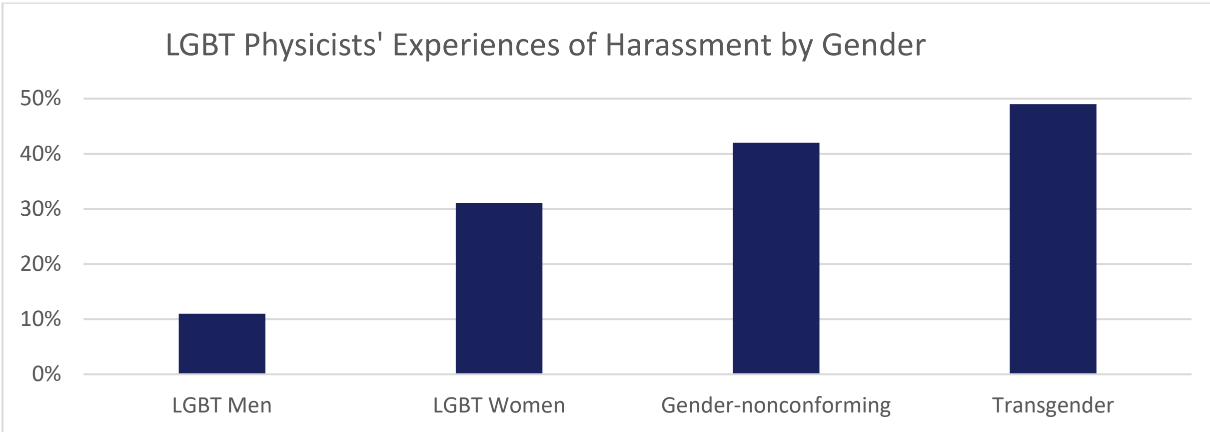

Figure 5: LGBT Physicists Experiences of Harassment by Gender. Source: Atherton et al., 2016

In our 2016 survey (n=327) of members of the Association for Women in Science (AWIS), we offered categorical response options in combination with open-ended qualitative questions to gather additional context about respondents' workplace experiences. This work queried members about their level of comfort in sharing, discussing, or disclosing different aspects of who they are in their STEM workplaces to gauge the level of inclusivity and belonging they experienced.

Roughly 90% of straight women and 100% of men (all of whom identify as straight) reported feeling comfortable sharing their gender and/or sexual identity in their STEM workplaces. In contrast, a quarter of gender minorities felt at least somewhat uncomfortable disclosing these aspects of themselves and nearly 40% of LGBTQ women expressed discomfort in revealing their LGBTQ status at work (Figure 6).

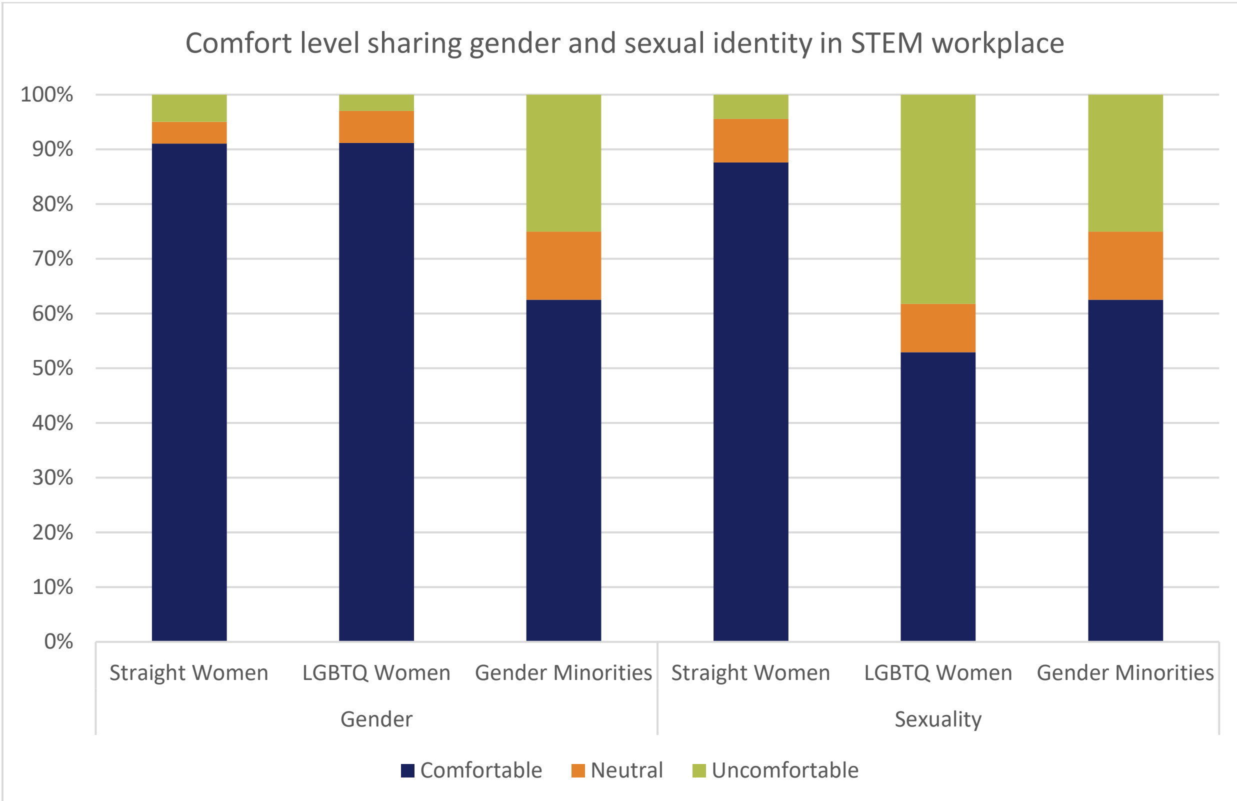

Figure 6: Comfort level sharing gender and sexual identity in STEM workplace

In addition, in the open-ended responses, participants shared more about why and in what contexts they feel uncomfortable. For example, a tenured biosciences faculty member who identifies as a white, gay woman shared the complex ways gender, sexuality, tenure status, and institutional culture intertwined to shape her experiences:

> At present, I am fortunate to work at a very gay-friendly university with many out gay administrators and faculty. My sexuality is no big deal here. In my previous place of employment, I was closeted for several reasons. It's nice to be a grown-up and have tenure now. Accusations of being lesbian (or slurs about it) are one way men impose power over junior women. A woman with opinions may be called a dyke, as an insult.

> That sends so many bad signals--not just the anti-gay aspect, as though being gay is worthy of insult, but of challenging straight women's sexuality, too.

Others offered up stories about how challenging it is to know when to share an aspect of who you are when it is something that is not immediately visible, or colleagues make assumptions. For example, a queer woman in the physical sciences shared, “people are generally accepting/friendly once they know my sexual orientation. Sometimes it’s difficult to know when is appropriate to tell them and how to navigate awkward situations (like someone asking about my boyfriend/husband).”

AWIS members with disabilities or chronic illnesses expressed a great deal of discomfort in being open about that part of themselves at work. Women of color, particularly if they identified as LGBTQ, reported the highest levels of discomfort in sharing their disabilities in their STEM workplaces (Figure 7). They were also overrepresented among the 10% of our respondents who expressed discomfort in discussing or disclosing their racial identities.

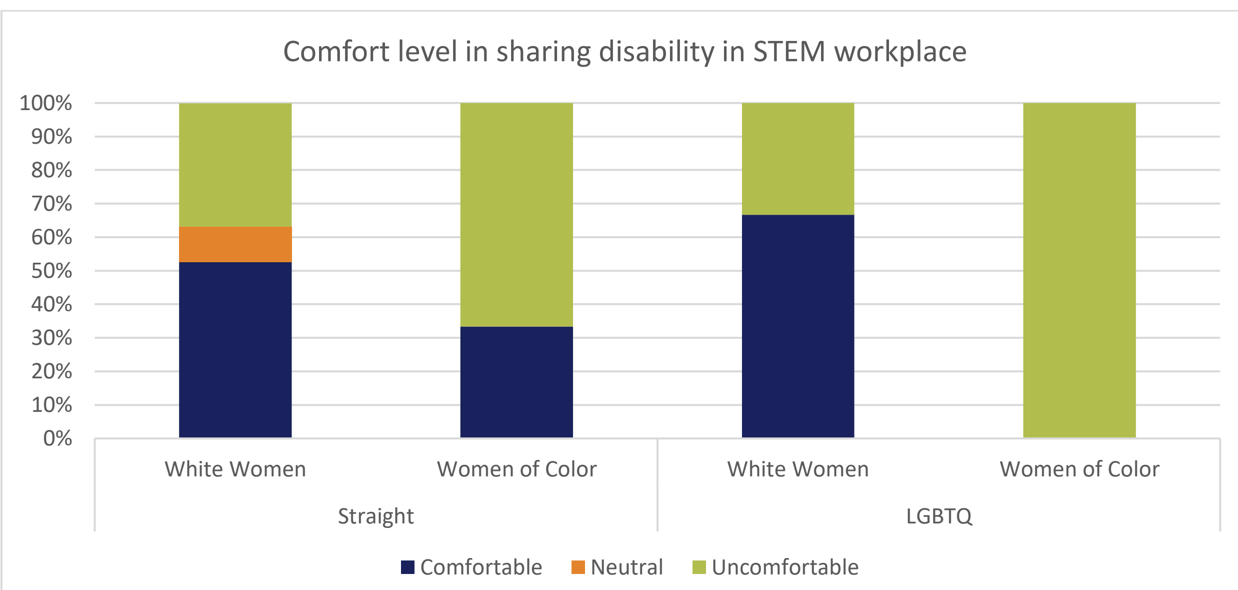

Figure 7: Comfort level sharing disability in STEM workplace

While they did not share any experiences with explicit disability-related harassment in their open-ended responses, they did offer rich context for understanding challenges in navigating STEM culture, exclusion, bias, and stigma. One participant, a straight, white woman in the neurosciences said, “I do privately identify as a person with a disability; family members and close friends know this about me; however, I do not publicly (nor at my workplace) identify as a person with a disability.” Others gave more detail about the negative sentiments and biases surrounding their disabilities at work. A straight, Filipino American woman in the biosciences wrote, “I feel like my disability comes with stigma and it is hard to come out and ask for support at work.” A white, pansexual woman in the biosciences shared, “[My disability] has been a serious challenge, and most PIs did not want me to work in their lab. It’s also an ‘invisible disability’ so it doesn’t always get taken seriously.”

Others offered details on positive experiences they’ve had in supportive STEM workplaces as well. For example, a straight, black, and Puerto Rican woman in physiology explained:

> During my years as a graduate student, my thesis advisor was extremely supportive [of my disability] and showed a level of empathy that still surprises me to this day. I am confident that I would not be where I am today without his support.

Through an intersectionality framework and a critical-mixed methodological approach, we were able to expand our understanding of well-known cultural biases and barriers in STEM workplaces, like gender bias, and sexual harassment. Incorporating other forms of identity-based exclusionary behavior in our data collection efforts also allows us to work toward more holistic change, advocating for cultural shifts that aim to improve belonging. This approach also provided us with the capacity to see shifting contexts, like the added protection tenure provides LGBTQ+ faculty, and circumstances in which scientists and engineers receive profound moments of inclusion and support.

Creating inclusion through survey design.

Our critical mixed-methods approach pushed us to more deeply contemplate the response options offered to our participants. While many surveys offer up a limited set of categories for gender (e.g. male/female), race, and ethnicity and few ask questions about sexuality or disability, we chose to incorporate a series of options that better represent participants' identities in our 2016 survey of AWIS members. We worked to balance the need to collect data that can be compared to national-level surveys while also broadening the options to best represent the many social identities of our respondents. To do so, before launching our survey broadly across our membership, we piloted it with the traditional categories, plus those shown in the research and practice as most comprehensive, and open-ended response options for pilot participants to add any options that might be missing. In the pilot and the full survey, we also had space for participants to comment directly on the response options available. Once we completed the pilot, we revised the survey response options and distributed the survey to our members.

This resulted in a wealth of selection options for our participants that also allowed us to finely disaggregate and intentional group data in the analytic process. In addition, by incorporating options that more accurately represented participants' identities, we found that respondents who rarely see themselves reflected in typical questionnaires expressed a sense of gratitude and relief at finally being included. Through the survey design process itself, we were able to build a sense of belonging and inclusion among our participants.

The reaction that we received to the new options was overwhelming. To be fair, a very small set of participants questioned some of the options or expressed offense or hostility, especially to the new options for gender and sexuality. For example, on the question that shifted gender from the common options of male/female to incorporate agender, genderqueer, gender-nonconforming, man, pangender, and woman, one participant said, "I don't see how it's AWIS' business to ask these types of questions." Another said, "Sexual identity is NOT relevant to the workplace!" A third explained that "there are only two genders" even though more of our respondents identified as gender minorities than men and 19% of respondents identified as LGBTQ+.

Despite a minimal set of negative reactions, the majority who offered commentary shared a great deal of gratitude for our survey and their membership in AWIS and went on to offer detailed descriptions of their experiences throughout the survey. Common responses that we received from these members include:

> "Wow, thank you for allowing so many answer possibilities!!"
>
> "I am very pleased with the fact that "asexual" is an option, as it typically is not in many surveys. Good job!"
>
> "Thank you for offering such a wide spectrum of answer options."
>
> "Thank you for distinguishing middle eastern from white".
>
> "I appreciate the value of being able to parse information about individual experiences with respect to gender and ethnic identity!"

Others specifically called out the ability to select multiple options rather than being forced into a single choice:

"Congrats! This is the most comprehensive race/ethnicity questionnaire I ever encountered because I was able to check all the ones that apply to me unlike others that are limited to one option."

"THANK YOU FOR LETTING ME PICK ALL RELEVANT BOXES!"

While adding additional response possibilities, multiple-selection, and open-ended questions to surveys can make the design, testing, and analysis complex, addressing this complexity not only best represents the identities and experiences of STEM workers and provides additional context, it also empowers us as inclusion researchers to incorporate inclusion directly into our data collection methods.

Recommendations

Whether using existing or gathering new data, there are many ways to adopt intersectionality frameworks and critical methodological approaches to the study of STEM participation. While this approach can present new challenges, facing these challenges is not only worth it, but necessary to advance our scientific work and its impact on policy and practice. Here we offer a few final recommendations to guide researchers in applying this approach to their work.

Be inclusive in response options and language.

Gather data on social categories and options often neglected or dropped from studies and pay attention to how the language your data collection instruments use affects your respondents' answers and experiences in your studies. Choose language that best represents how your participants would describe themselves and their experiences. Doing this incorporates inclusion intentionally into your research design and can have a large impact on participants' sense of belonging and desire to share their experiences with you.

Analyze data from an intersectional approach, even when the n is small.

Whenever possible, be sure to analyze your data from an intersectional approach, even if it means the sample size is small. These are often the most underrepresented groups in STEM. Without understanding their experiences, there is no way to inform efforts to broaden participation that incorporate their perspectives. For far too long in our quantitative work, researchers have prioritized statistical significance over meaning.

Remember the systemic and contextual focus.

Remember that this approach is about systems. Be sure to weave a systemic and contextual view into all aspects of your research, not just the disaggregation and aggregation of data. This includes the kinds of research questions you ask, the prompts and response options you offer your participants, the assumptions you and the surrounding policies and programs make about who is included or impacted and why, whose voices are missing, how your respondents' experiences connect to larger systemic issues, and more.

Incorporate qualitative elements.

Incorporating qualitative components in your work provides additional context. Whether it is conducting interviews, adding open-ended questions to surveys, or analyzing text in policy or historical documents, the depth offered helps you situate your research, guides you in interpreting your findings, allows you to see limitations in your research, and offers insights on how your participants are responding to the questions posed.

Pay attention to power dynamics.

Lastly, as a researcher, it is important to pay attention not only to the power dynamics involved in the research settings you study, but also those at play in your own role. It can be far too easy to dismiss the experiences of our participants as outliers, especially when they are different than our own experiences. Paying attention to your own biases, holding yourself accountable, and validating the experiences of people who share them with you are necessary parts of the critical research process.

Conclusion

The approaches to research on broadening participation in STEM suggested in this paper allow us to deepen our understanding of long-standing recruitment, retention, advancement, and participation issues. They generate a richer pool of resources for achieving, rather than undermining, our equity and inclusion goals. They also help us see the subjective choices made in the construction and analysis of data sets, large and small while providing context and connection to the systemic roots of the patterns we find in our data. They also strengthen our work by showing us limitations and sustainability issues we might not see otherwise. By calling into question our own and others' underlying assumptions, methods, models, and measures, broadening our thinking, and richly contextualizing our work, we step outside our comfort zones to open up the possibility of seeing our institutions and our worlds differently and changing them.

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