Chapter 8
Disability in Physics: Learning from Binary Mistakes

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8.1 Introduction

Physics has its own particular stories that allow for exceptional models of diversity. Many young scientists have been inspired by Marie Curie, or recognized a role model with visible mobility impairments in Stephen Hawking. But these stories tend to be fused with the ideal of brilliance: if your mind is strong and pure and unique enough, you can transcend your limitations (of being a woman, of being in a wheelchair). In truth, all kinds of people deserve the opportunity to become physicists, and physics deserves the contributions of all kinds of people. To build a physics that truly welcomes the talents of diverse individuals, we must learn to tell better stories.

8.2 Disabilities in STEM Higher Education

Work elsewhere has reviewed some of the ways that gender can signal "not-belonging" in physics and STEM (Faulkner 2009; Gonsalves 2014; Hill et al. 2010; Ong et al. 2011), and intersectional studies in this work remind us that gender is never the whole story. In this chapter, we first turn to the disability studies literature for foundational themes and a few STEM-specific points.

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8.2.1 For Students

College and university students in the United States and the United Kingdom are invited to tell their institutions if they have any disabilities for which they need accommodations. Some students avoid this identifier, choosing not to "'accept, disclose, or document' a status of 'disabled student'" (Jacklin 2011, p. 99). Although colleges and universities are only required to provide accommodations for students who disclose disabilities, past experiences with discrimination or fears of future discrimination cause some students to stay quiet. Some also feel that accommodations such as extra testing time—even when essential to their success—give them an unfair advantage (James et al. 2018).

Students who study education may learn little about disabilities. Both academic journals and some academic departments reinforce the segregation of disability by keeping research about special education out of general education journals and spaces, as well as only having one or two courses on special education and disability for general education teacher preparation programs (Connor et al. 2016). This reinforces the "othering" of those with a disability, positioning them as a rare exception rather than an integral part of classrooms.

Undergraduates with disabilities study STEM at the same rate as undergraduates without disabilities: 11% of students with disabilities (Sevo 2012; Sutton 2017) and 12% of those without declare STEM majors (Sutton 2017). There are still differences: students with disabilities are more likely to enroll at a 2-year school than a 4-year school,[1] and they are less likely to pursue graduate study, which is often needed for careers in STEM (Sutton 2017). Note that these figures come from self-reports of current students; institutional census data reports much lower numbers of 1–5% of undergraduates with disabilities (National Science Foundation and National Center for Science and Engineering Statistics 2017, p. Technical Notes), and completion rates are not part of this comparison.

In order to be more welcoming to people with all sorts of disabilities, labs and classrooms need to be more physically accessible. For some STEM disciplines, outdoor spaces and public areas should also be accessible (Carabajal et al. 2017). There could be ramps in hiking areas, automatic doors, and the like. This would be a welcome change from institutional policies and lack of accommodations that keep people out (Marks 2017).

Students have trouble finding mentors with disabilities. They must contend with widespread ignorance, not only about their specific disabilities (whether visible or invisible) but about the Americans with Disabilities Act (Wilkie 2014). Even if someone who is Deaf/hard of hearing does have a sign language interpreter, the interpreter is unlikely to be equipped with STEM jargon (Wilkie 2014). When they

[1] In fact, students with disabilities at 2-year schools are more likely than other students at 2-year schools to pursue STEM (Lee 2014). A recent demographic review by Kanim and Cid (2017) shows that two-year colleges are seriously under-represented in physics education research studies. This bias adds to the invisibility of students with disabilities in physics.

finish their studies, people with disabilities are more likely to pursue STEM careers in the government and less likely than others to go into education. This has implications for visibility, as students are unlikely to know any disabled STEM teachers (Sutton 2017).

Graduate students across fields are at risk of mental health disorders. A 2015 study of graduate students at Berkeley found that nearly half of them had significant indicators of depression (The Graduate Assembly 2015); this was a follow-up to a 2005 study that had found that 10% of graduate students had seriously considered suicide (Berkeley Graduate and Professional Schools Mental Health Task Force 2004). An even more recent study found that PhD students in Belgium were at higher risk of mental health disorders (particularly depression) than other highly educated people (Levecque et al. 2017). A prevailing culture that graduate school is supposed to be stressful can make it more difficult for graduate students with disabilities to ask for or receive accommodations. This situation is likely to be exacerbated in departments with a weed-out culture, which is common in many prestigious physics programs. If campus disability resources are only designed with undergraduates in mind, graduate student accommodations may be handled within the department or according to faculty advisor notions of need, which are idiosyncratic and may not be compliant with the law. Indeed, many college faculty only partially understand how they are required to accommodate disabilities in their teaching and are often unfamiliar with campus resources for these students (Paul 2000).

Perhaps for these reasons, students with disabilities are less likely than their peers to earn graduate degrees in STEM. In 2014, about 6% of STEM doctorates in the United States were earned by students with disabilities (National Science Foundation and National Center for Science and Engineering Statistics 2017). About 6% of those STEM doctorates were in physics or astronomy, comparable between students with and without disabilities. Ultimately, only about 2% (Slaton 2013) to 7% (Sevo 2012) of the STEM workforce is made up of people with disabilities[2].

8.2.2 For Faculty

For faculty living with chronic illnesses and disabilities, the procedures are less clear than they are for students. Usually the office which provides accommodations works only with students, so faculty must work with multiple offices at their schools (if they can determine which office or offices to work with). A survey of faculty

[2] Even at this level of summary statistics, numbers are elusive because how (or if) the data is collected varies widely. The figures for PhDs come from the Survey of Earned Doctorates, which in 2005 reported less than 2% of STEM doctorates going to students with disabilities (Committee on Equal Opportunities in Science and Engineering 2009). In 2012, the question from which these numbers derive was changed from "Are you a person with a disability?" to ask about functional limitations in several areas, so numbers before and after 2012 are not directly comparable.

reported that fewer than half were familiar with accommodations that they may have been entitled to, and fewer than 15% had asked for accommodations (Price et al. 2017). Many faculty choose not to disclose their disabilities, particularly mental disabilities. Instead, they handle their accommodation needs informally or privately, if at all. This is particularly disturbing given a recent UK study that found that the percentage of academics with mental illness is over 50% (Wilcox 2014). For faculty who did not seek accommodations, fear of stigma was a recurring theme (Price et al. 2017). Specific concerns included workplace gossip, loss of credibility, or harming chances of promotion, tenure, and contract renewal. For faculty in untenured or short-term positions, or still on the job market, requesting accommodations is inherently risky (Adjunct 2008).

In the survey by Price and collaborators, the most common reason for not disclosing was "Feeling that it's not other peoples' business" (62% of non-disclosing respondents). For faculty as well as students, "the disabled person who is 'invisible' is responsible for making himself visible, or discernible. When we make this assumption, responsibility for alleviating injustice is placed upon the person suffering the injustice in the first place. Oppressed persons should not bear the burden of educating and reforming their oppressors, and yet, that is what the visible/invisible metaphor asks of disabled people" (Price et al. 2017). What makes this even more disturbing is that faculty who choose to remain invisible are unlikely to appear as role models and mentors for their students, although the need for both non-disabled and disabled people to see disability in STEM fields is crucial, both to the field they are in and society as whole (Marks 2017).

Compared to gender, or to race and ethnicity, students with disabilities are more equally represented by number in seeking undergraduate degrees. Without intersectional data, it is unclear whether these numbers are even across demographic groups (and it is likely they are not; see Lee 2014). At the graduate level, the situation is somewhat worse. For many STEM careers, an undergraduate degree is necessary but not sufficient, and the references above document some of the ways that students with disabilities are filtered away from some scientific careers.

8.3 Critical Frameworks of Disability

The next theoretical task we set for ourselves was challenging: to combine elements of several frameworks that are mostly used outside of science education, discuss them in a physics context, and distill themes to guide study of disability in physics. Below we introduce key elements of disability identity, critical race theory, DisCrit, and crip theory. We include these perspectives because one major lesson from our past work was how deeply embedded and implicit are the frameworks that all of us, as researchers and as humans, have about gender (Traxler et al. 2016). We have called it the binary deficit model: the idea that there are only two kinds of people, that the most important (useful, scientific) kind of study is to compare them on some quantitative measure, and that from this ranking one can plan how to fix the more

deficient group. This may sound like a harsh exaggeration, and we do not claim that it is the conscious paradigm of any particular researcher. But it emerges in aggregate, from the overwhelming prevalence of binary, sex-coded, quantitative comparisons that use men's scores or performance as the standard to aspire to and that suggest remediations for women[3].

Sexism is not the same as racism; ableism is not the same as transphobia. We do not want to simplify the nuances of different struggles against oppression. However, it is possible to learn things from the study of one area that help us anticipate and recognize bias and discrimination when they occur for similar reasons in another place. So in trying to fuse a more inclusive understanding of how disability plays out in physics, we begin by listening to what researchers have said about other facets of identity. We start with key themes from the disability studies literature, focusing on what seems most relevant to science in higher education. Next we introduce some elements of critical race theory, a framework made for the purposes of deconstructing the far-reaching, bitterly entrenched implications of racism. In a field as improbably White as physics, it would be irresponsible not to draw on this expertise. The next piece discusses DisCrit, or dis/ability critical race theory, a recent synthesis of those two frameworks. We will touch on this in parallel with crip theory, which studies the intersection of disability with LGBT identities. This work has primarily appeared in literature or film criticism, with some extension in the medical field (Egner 2016; McRuer 2006b). The climate for LGBT physicists is often unfriendly or unsafe (Atherton et al. 2016), and we hope to learn from this area of scholarship as well.

This work is not expected to synthesize all the answers. Rather, we hope that by drawing in different threads of identity study, we can be more aware of the places where multiple identities can complicate or intensify issues faced by physicists with disabilities. We also aim to outline concepts and collect useful references for physics or science education researchers hoping to learn more.

8.3.1 Disability Identity

The question of what is defined as a disability is ongoing. A crucial first distinction to make is between medical and social models of disability. In the medical model, disability is "an individual condition and a problem needing medical solutions" (Linton 1998). It arises from biology and is primarily treatable by doctors' interventions, with the goal of fixing deficiencies in the disabled person (Egner 2016; Shakespeare 1996). The social model argues that people have impairments, but that a person is disabled by the societal conditions that surround them. A person who uses a wheelchair may not be disabled in surroundings with curb cuts, ramps,

[3] Work that tests interventions can make a real difference for women or other marginalized students (Brahmia 2008; Hill et al. 2010). But there is an often-neglected flip side: as Brickhouse and Potter (2001) put it, "what needed transformation was the schools, not the girls."

and elevators, but is disabled by a building that requires the use of staircases (Connor et al. 2016; Linton 1998).

The medical model underpins many legal and official documents. The Americans with Disabilities Act (ADA) defines a disability as "(i) A physical or mental impairment that substantially limits one or more of the major life activities of such individual; (ii) A record of such an impairment; or (iii) Being regarded as having such an impairment" (Americans with Disabilities Act Title II Regulations n.d.). Significantly, the individual involved may not be the one who defines themself as disabled; if there is a record, or others regard them as having an impairment, then they are disabled.

The ADA does not define a set of qualifying impairments, and there is no universal list. Table 8.1 shows two sample lists of disabilities. The first is from the Wright State University Office of Disability Services, the list that students see when they register themselves for accommodations (Wright State University Office of Disability Services 2018). The second is from the United States Department of Labor's "Voluntary Self-Identification of Disability Form," which collects data when people apply for jobs at which they may require accommodations (United States Department of Labor n.d.). These lists overlap, but they are not identical.

A person with impairments included under broader criteria might find themselves declared non-disabled by a more restrictive list. In either case, the authority to decide rests with the institution, often in communication with a doctor. This brings us back to the heart of the medical/social model contrast: the underlying structure of power and responsibility. The medical model casts disability as the problem of the individual, who must ask for accommodations and rely on the

Table 8.1 Two different lists of disabilities

Wright State University Office of Disability Services (WSU ODS 2018)	US Department of Labor "Voluntary Self-Identification of Disability Form" (US DOL n.d.)
ADD/ADHD	Blindness
Aspergers/Autism Spectrum Disorder	Deafness
Hearing Impairments	Cancer
Learning Disability	Diabetes
Other Health Impaired	Epilepsy
Other (multiple disability, deaf/blind)	Autism
Physical Disability	Cerebral palsy
Psychological/Mental Health	HIV/AIDS
Speech/Language Impairment	Schizophrenia
Traumatic Brain Injury	Muscular dystrophy
Visual Impairments/Blindness	Bipolar disorder
	Major depression
	Multiple sclerosis (MS)
	Missing limbs or partially missing limbs
	Post-traumatic stress disorder (PTSD)
	Obsessive compulsive disorder
	Impairments requiring the use of a wheelchair
	Intellectual disability (previously called mental retardation)

kindness of authority figures to provide them. The social model contends that disability is a social problem, which must be solved at that level by a fundamental shift in priorities to make institutions accessible to all (Burgstahler 2015).

"What is a disability" shifts depending on who is doing the defining and what the stakes are. Gee (2000) distinguishes several senses of "identity" that help to unpack this idea. The four ways he proposes of viewing identity are: natural (something you "are"), institutional (an assigned position), discourse (a way you are recognized by others), or affinity (a shared set of focused practices). The medical model might be said to rest on natural and institutional views of identity—a person "is disabled," with the implication of a static individual state, or "receives accommodations" because of a medical diagnosis filtered through university policies. The social model brings in discourse and affinity identities. How (or if) to acknowledge a disability to peers or mentors, and how they may react, lives in the realm of discourse identities. Groups such as the International Association for Geoscience Diversity (https://theiagd.org/) harness the power of affinity identities for collective action. All of the above senses are folded into the term "disability identity." To distinguish between them in a given situation or research study, we must keep these questions in our pockets: Who has the authority here? Who gets to decide?

8.3.2 Notes from Critical Race Theory

Critical race theory (CRT), which came out of the study of law, takes the position that racism is normal in American society, so ingrained that it now seems natural to White people. The law might be able to help with the most blatant and extreme racism, like explicit policies of discrimination against non-Whites, but the law cannot help with everyday microaggressions and more "acceptable" forms of racism (Delgado 1995; Delgado and Stefancic 2012; Essed 1990).

Embracing CRT means realizing that even the mainstream civil rights discourse still believes in the idea of a meritocracy, assuming that it will be possible to level the playing field and that people of all races will then have an equal chance to compete for what they need and want. Fully embracing CRT means realizing that this is not so; we need first to question why "jobs, wealth, education, and power are distributed as they are" (Crenshaw et al. 1995, p. xv). It may no longer be possible to use the courts to correct the injustices of racism without examining the role that the courts and the law itself has played in sanctioning racism. Law schools themselves are embedded in our racist culture, so lawyers who have succeeded there are likely to have racist attitudes themselves, albeit unconscious ones (Crenshaw et al. 1995).

An important facet of CRT is the rejection of the idea that research and scholarship can be objective or neutral; since everything we do is embedded in society, everything is political. Our education system positions affluent White voices as the "standard" knowledge (Ladson-Billings 1998), and physics is steeped in this tradition as well. Racism is ingrained in society, so research about race is either entrenched in its own racism or actively fighting against it (Crenshaw et al. 1995).

CRT urges us to fight this ingrained racism with counter-storytelling, rewriting narratives about people of different races. It is hoped that the actual stories of individual people of color will both show how and why they push for change and, eventually, change the norms of society (Delgado 1995; Delgado and Stefancic 2012; Rosa and Mensah 2016).

The idea of rejecting objectivity and neutrality pulls at one of the central tensions in physics education research. Physics has thrived as a science of reductionism, with the objective search for truth as a core value (Whitten 1996, 2012). Appeals to objectivity have historically distinguished science from non-science (Gieryn 1983; Harding 1986), so stepping away from this ideal can threaten a researcher's place in a physics department.[4] This element of CRT aligns with critiques of objectivity in feminist science studies (Harding 1986) and with calls for emancipatory research to break down traditional divides between researchers and subjects (Liasidou 2014; M. Oliver 1992; Whitten 2012). It also calls for pushing against decades—arguably centuries—of disciplinary norms, so it is no surprise that PER has not seen a wild proliferation of critical (in the CRT sense) perspectives.

8.3.3 DisCrit and Crip Theory

"DisCrit" is a crossover field, grown from combining disability studies and critical race studies. Guiding tenets include (1) recognizing that while categories such as race and disability are socially constructed, they do have material and psychological consequences, (2) valuing multidimensional identities, and (3) amplifying voices and stories of people from marginalized groups (Annamma et al. 2016).

Both racism and ableism are deeply ingrained in our society. Both are considered normal to the dominant culture, and science (or pseudoscience) has been used as a tool to reinforce both of them (Dolmage 2017; Gould 1996). Racism and disability are both social constructs, and therefore both can change. People of color and disabled people suffer economic disadvantages as a result of discrimination, which prevents people in both groups from being able to fully participate in society (Connor et al. 2016).

Disabled people should not be treated like children; they can usually live independent lives without a guardian, they can advocate for themselves, and they can tell their own stories. These counternarratives are vital. Of course, intersectionality is important. Some traditional ways of activism (marches and other forms of physical civil disobediences) are often rooted in ableism, though this is not necessarily on purpose. People need to recognize the importance and need for diverse forms of resistance, which does not have to be physical in order to be worthy (Connor et al. 2016).

[4] Objectivity is a concept with its own complicated history (Daston 1992) and plethora of meanings (Barad 2007; Harding 1986), but we take as given here that it is held as a core value of modern physics.

DisCrit and crip theory both lay open how disability intersects with other facets of identity, in Crenshaw's sense of "intersection"—that people caught at these borders may be uniquely underserved by efforts made on behalf of a single identity "group." Efforts made to help women, for example, carry the organizers' ideas of what "women" are and what support they need. "Women in science" alliances do not typically drive efforts to establish safe and accessible bathroom use on campus. These efforts tend to be seen as an LGBT rights issue or possibly the domain of an office of disability services, even though they are a more pressing concern for many women than workshops on future salary negotiation.

No one advocacy group can do everything, of course—the point here is that as researchers, if we want to do something useful for our participants, we have to be aware of how people's identities are separated, sorted, and categorized by the social and institutional power structures that we are all embedded in. Earlier work has reviewed male/female binaries and how those have consciously or unconsciously shaped what research questions are asked in physics education, the methods used to probe them, and how results are framed (Danielsson 2010; Traxler et al. 2016). DisCrit and crip theory both bring out ways that disability intersects with other facets of identity, further complexifying this binary model.

Not all facets of identity have the same substance, which Gee (2000) explores in the context of education. Gee uses "being ADHD"[5] as an example to tease apart natural, institutional, discourse, and affinity views of identity—ways of being a certain kind of person. Many identity statements could start with "I am..." but "I am an identical twin" indicates a fairly straightforward natural identity, a fact of birth. "I am a physicist" includes elements of training, a job, recognition by peers—a blend of institutional, discourse, and affiliation identities. The more one differs from the expected presentation, the more elusive recognition can be.

DisCrit focuses much of its criticism on the first two of these categories, natural and institutional. Some DisCrit studies analyze how powerful racist stereotypes collide with officially diagnosed impairments—beliefs about natural and institutional identities—to produce overrepresentation by race in certain official categories of disability (Artiles et al. 2010; Connor et al. 2016). Crip theory has its origins in literary criticism, with a focus on discourse (Egner 2016; McRuer 2006b). In Gee's terminology, crip theory might be said to focus on institutional and discourse identities. A crip theory perspective might consider how a student is categorized by their university (as "needing accommodations," and what kind) and how this plays out in their daily life as they are recognized by peers and faculty. Though not explicitly crip theory, Slaton (2013) raises parallel issues of what bodies are regarded as "normal" in STEM laboratory courses. These assumptions about bodily normalcy[6] combine with other images of engineers' identity (White, straight, etc.) but also

[5] Attention-deficit/hyperactivity disorder, also previously known as attention deficit disorder.

[6] Defining and enforcing "normal" has become a society-wide endeavor linking prisons, factories, and schools (Foucault 1979). At universities, power is handed down by credentialed authority figures in elaborate ceremonies. This credentialization process becomes its own justification for maintaining authority (P. Oliver 2010)—in the emotional moment of a prestigious graduation, it becomes easy not to ask why none of the professors or the new PhDs use a wheelchair or a sign language interpreter.

come saddled with ableist stereotypes. STEM students who call attention to their diverse needs risk disrupting their under-construction discourse identities as precise, up-to-standard professionals (Slaton 2013).

The DisCrit and crip theory literature shows how applying the term "identity" to gender, race, disability, and scientific field often involves shifting among Gee's four connotations in terms of where the identity derives from and how it is acted out. In our study of disability in physics, we are especially drawn to the institutional and discourse senses. Specifically,

1. How have people's experiences as students or physicists with disabilities played out in the context of university or workplace power structures?
2. Have they interacted with a formal "accommodations" structure, and if so, what were the results?
3. How have their relationships with other people (peers, mentors, advisees, staff, etc.) been a part of their trajectory?

These two literatures explore issues of power and recognition, who defines "normal" and what that boundary can mean for those who fall variously outside it.

8.3.4 Disability Identity Reprise—Weaving Together the Threads

We began this section by marking a split between medical and social models of disability. Like all stark binaries, this idea unfolds into complexity. Shakespeare (1996) unpacks five variants of the social model, noting that the unified, unequivocal positions needed for political activism are often explored in more nuance by those on the "inside." He draws some parallels between the disability rights movement and the struggles for women's and racial civil rights (Linton 1998). However, Shakespeare's chapter also notes divergence: compared to gender or racial identity, an identity as a person with a disability may cause isolation in families. Someone with a disability may face ongoing decisions about whether to "come out" about their disability in various social settings. These experiences may be more parallel to those of scientists in the LGBT community, and indeed a "coming out" metaphor recurs in disability studies.

One final question which we argue that education researchers should return to is: What is the goal of this work? Some accessibility efforts are underpinned by the hope that in the future, no such accommodations will be needed. If medical science can someday "fix" all impairments, would this not be ideal? This thought, usually unexpressed but often present, goes back to the notions of a compulsory standard of "normal" raised in crip theory (McRuer 2006a). We raise it here to disagree explicitly: the goal is not a future where neurodiversity and diversity of bodies has

been somehow smoothed away[7]. As readers of older science fiction or futurism can testify, the future is always different—weirder, more varied, and in many ways more wonderful—than we can predict from the current point in time. Physics is capable of adapting to a more equitable and diverse body—and bodies—of students and practitioners. If we believe it is a truly fundamental science, then finding and welcoming a wide range of talented individuals must be a perennial priority.

The culture of STEM today is one that strives for the standardization of reasoning and behavior (Nespor 1994; Slaton 2013). There is little acceptance of, or interest in, differences.[8] It is also true that people in STEM are seen as White, male, cis, heterosexual, and able-bodied. These perceptions can exclude anyone who might be different: Why go into a field where you are the only one of your identity? Those who do push for change are labelled as outsiders and often ostracized by others in their field (Slaton 2013).

Ability, like race, is a social construct. The experts are those in power, and their knowledge about not only STEM but about who is able to do STEM comes from them—so they remain in power. Any suggestion that the culture of STEM is not already fair is taken as a threat to American values of meritocracy and democracy (Slaton 2013).

People in STEM have traditionally published papers in the passive voice, not referring to themselves at all; therefore all identifiers of race, ability, gender, and sexuality are left out. This contributes to the lack of visibility in the field and upholds systems of oppression. Although many would argue that these identities do not influence the field and are therefore irrelevant, at the same time feminist theory, critical race theory, and DisCrit inform us that most people believe that women, people of color, and people with a disability are less capable in STEM. The medical and binary models of both gender and disability keep these systems in place (Slaton 2013).

8.4 Identity and Intersectionality

One of the challenges of categorizing identity is that imposing categories invites us to look at identity or oppression as a linear problem. If we can understand the state of "gender," and the state of "race," then the superposition of these two states tells us what is going on or how to fix the injustice. There's a high risk of doing this when only one category is considered. The phrase "gender in physics" implies a world where "gender" is a thing with a universal essence, experienced in more or less similar ways by all varieties of people. Even when considering gender and race at the same time, the linear superposition model is easy to apply, often without even

[7] For essays and fiction exploring this point, see Uncanny Magazine's *Disabled People Destroy Science Fiction!* issue (Sjunneson-Henry et al. 2018).

[8] At least, difference between researchers—even when the goal is a relentless search for differences among research subjects (C. N. Jacklin 1981).

noticing. Exploring the nonlinear interactions of lived experiences takes an explicitly different way of thinking about identity categories. This problem has been explored in various ways by feminist scholars using frameworks of intersectionality (McCall 2005). In this section, we want to focus on that intersectionality, which has already occurred by example in some of the frameworks discussed above. We begin with work in physics, then discuss how intersectionality is used in DisCrit and crip theory. Gender is a theme in some of these research areas, but not all, and we return to this point in Sect. 8.5.

8.4.1 Beginnings and the Double Bind

Studying intersectionality has a number of roots, one of them in scholarship about the blend of racism and sexism experienced by women of color (Crenshaw 1991). Crenshaw's work discusses how social programs designed to help women (with the implication of "all women") are often structured so that they are most useful to White women because of assumptions made by the (usually White and affluent) benefactors about language access, family childcare resources, and other factors. In STEM fields and in physics, Ong et al. (2011) and Ko et al. (2013) explore the idea of the "double bind," the simultaneous experience of racism and sexism that is more than simply an additive sum. Ko et al. (2013) examine themes of activism and work-life balance among women of color in physics and astrophysics. Resonating with Crenshaw's points, they note that work-life balance supports designed for White women in STEM may be less useful if women of color have different family roles or social pressures. In their narrative analysis, several women discussed taking less-prestigious career paths to be more available to mentor students, a choice they are more likely to face than White women academics (Prescod-Weinstein 2015).

Heidi Carlone and Angela Johnson studied fifteen women of color for several years, starting when they were undergraduates. All of these women majored in science, though none in physics. Although nearly all of them thought of themselves as scientists, most of them had interactions with other people in which they felt invisible, or worse, singled out in a negative way. Sometimes the students associated these negative experiences with their gender, sometimes with their race or ethnicity, and sometimes they said that many students had similar experiences (Carlone and Johnson 2007). Unfortunately, many of the themes that emerge from the studies in this section are about barriers, even when successful women are the focus of the research. In male-dominated fields, challenges to the "belonging-ness" of women are common. As gender combines with other facets of identity, these challenges often intensify for those positioned farther away from the "norm."

8.4.2 *Gender and Race in Physics: Coping Methods, Shaping Methodologies*

Several strands of work in physics have highlighted the intersection between gender and race. Maria Ong (2005) gives a longitudinal view of ten women of color in physics and the conflicts they encountered in reconciling field of study, gender, and race or ethnicity. Ong describes two broad strategies of fragmentation or multiplicity. In fragmentation, the women suppressed one or more facets of identity to "pass" as normal in a given context, such as buying pants on the way to lab to avoid comments from labmates, or adopting (though not necessarily endorsing) the kind of "zero uncertainty" language that is more associated with masculine forms of communication in the United States. In multiplicity, the women carved out ways to foreground their identities without suppressing them, such as a student who consciously adopted the role of "loud black girl" to claim space in meetings. Both of these strategies come with a price. Fragmentation means denying a part of yourself, which is a harsh cost to pay to practice science, while multiplicity tactics can provoke backlash from peers (as in the case of a woman who felt empowered to be more feminine at work, and promptly received pushback from her labmates despite her excellent work). There are echoes of this choice in talks given by disabled physicists at the 2016 American Association of Physics Teachers summer meeting[9] as well as in non-STEM specific research on disabled students (Jacklin 2011). Students who assert themselves to get accommodations for disabilities, regardless of on-paper legal protections, risk being stigmatized as "making excuses" or even being barred from programs. On the other hand, pursuing a fragmentation strategy of hiding impairments means that the student is at a hidden disadvantage when completing the same class and research tasks as their peers.

The work above uses intersectionality to focus the area of inquiry, with the goal of learning more about an understudied group of people. Other work embeds intersectionality even more deeply in the research methods. Rosa and Mensah (2016) use critical race theory (CRT) to study the pathways of Black women physicists. Their work highlights three themes from CRT: racism as a permanent feature in America, the importance of counter-storytelling against the dominant narrative, and interest convergence. The persistence of racism emerged in stories of their participants, who talked about exclusion from the graduate study groups formed by their White or Asian peers. This exclusion, a more pervasive theme than in studies focused only on gender, meant that it was sometimes easier to form a study group with other people of color or with international students outside of physics entirely. Counter-storytelling highlights these barriers but also the strategies that the women pursued to overcome them, and to counter dominant expectations ("[she] probably won't amount to anything," in the words of one teacher (p. 6)). Disabled scientists face their own range of dominant narratives about their ability to do their work, and Rosa and Mensah's work shows how researchers can choose

[9] Session BJ, http://www.aapt.org/Conferences/sm2016/session.cfm.

methods that elevate the stories of their participants over an oppressive system. Finally, interest convergence is the idea that civil rights advances for Black Americans only occur when they serve the interests of White Americans as well, as in the case of school desegregation (championed for years by African Americans) only happening in the face of Cold War labor and public image demands. There are echoes of this theme in the Universal Design framework, which argues that making classes more accessible for disabled students will benefit everyone in the long run (Burgstahler 2015; James et al. 2018). For example, posting lecture notes may help students with executive function issues to stay engaged in class, but also help other students who can use the example of a well-structured outline. While true and important, this argument must be made by Universal Design advocates because a justice-based argument is historically not enough.

Other work by Simone Hyater-Adams and collaborators (Hyater-Adams et al. 2018) fuses prior work on gender and physics identity with constructs of racialized identity to tease out complexities in students' accounts of their experiences. These authors give extensive detail about building their framework, providing an example of what this process can look like in physics. Problematizing research methods is one of the hardest ways to do feminist physics, and we are profoundly grateful to the authors in this section who are leading the way.

8.4.3 Race and Disability: Institutional Intersectionality

The emerging field of DisCrit uses the interplay between critical race theory and disability studies to examine how diagnoses and experiences of disability play out in racialized ways. In school, people of color are overrepresented in special education classes (Artiles et al. 2010; Tomlinson 2016). Connor et al. (2016) argue that this is due to White supremacy. People of color are often labelled as having a learning/intellectual disability or mental health/behavioral issues based on the subjective views of their mostly White teachers, who have been socialized to see non-White people, even their students, as violent and/or intellectually lacking. It is worth noting that people of color are less likely to be overrepresented in physical or sensory disabilities, suggesting racism is a key player in labelling disability (Connor et al. 2016). DisCrit does not only focus on an institutional view, but this perspective is important to add to the above work in physics. Intersectional work in PER has tended to focus on the experiences of individual students and their interactions with other students or faculty members. The university as an edifice may or may not enter into these stories, but is likely to come up for any person who has to navigate an official accommodations process. Disability has a long history as an object of research, where universities built for the elite used people with disabilities as fuel for scientific output while excluding them from membership (Dolmage 2017). Much DisCrit work to date focuses on primary or secondary education, but Dolmage's work on the history of academic ableism warns us that these themes continue through college.

8.4.4 Disability and Sexuality: The Enforcement of "Normal"

Disability status interacts with other identities in interesting ways as well. McRuer (2006b) talks about the intersectionality of queerness and disability in his book *Crip Theory.* Examples he highlights include gay men living with HIV and the Sharon Kowalski case, where the courts had to intervene to allow Kowalski to recuperate with her same-sex partner after she was severely injured in a car accident. In a more recent book, Hirsch (2018) talks about the intersectionality of gender and disability. She talks about how many women, especially young women, do not "come out" and disclose their illnesses or disabilities—and even when they do, they minimize them. She also discusses further intersectionality with queerness, as she notes that female partners are less likely to leave disabled women than male partners are, and with being a woman of color, which makes navigating life as a person with a serious illness or disability harder. Justine Egner (2016) reviews crip theory from the perspective of medical sociology, perhaps the closest current reference to how disability and sexuality intersect with issues in science. There, she defines crip theory as "a disability focused queer approach that is concerned with the relationship between the physical body, embodiment, and the self" (p. 161). This perspective contrasts sharply with the prevailing "culture of no culture" in physics (Traweek 1988), where bringing up bodily needs and realities is taboo and seen as a distraction from pure science. Enger ends with a review of empirical research on disability that applies queer or crip perspectives (2016, pp. 186–187) and suggestions for future research directions. These include two that seem especially salient to studying disability in physics: How do individuals who identify as both LGBT and disabled negotiate these (at times) socially contradicting identities? How does the importance placed on progressive and curative discourses shape and affect disabled people's personal narratives and experiences?

8.4.5 Approaches to Intersectionality

McCall (2005) distinguishes three broad approaches to the complexity of categories in intersectional feminist work. The first, anticategorical, draws from poststructuralism (such as work by Foucault referenced earlier) and attacks the very usefulness of researchers imposing a set of categories. The intercategorical approach seeks to understand relationships of inequality along multiple axes at the same time (e.g. gender, race or ethnicity, and education level), combining women's studies insights with quantitative methods. Between these two approaches is what McCall calls intracategorical complexity, which understands that identity categories are provisional and somewhat reductionist, but nonetheless have social reality. Studies in this framework often focus on a particular social group or position that has been previously under-studied, with the goal of elevating those voices. This reading of intersectionality resonates with our goals in exploring disability in physics.

8.5 Beyond the Binary View of Gender and Disability

8.5.1 Reflecting on Frameworks

In her book *Reflections on Gender and Science*, Evelyn Fox Keller (1985), discusses the association that science has with the "impersonal, rational, and general" (p. 7). This has allied well, to the benefit of many, with the association of men with "objectivity, reason, and mind"—and not very well, to the detriment of many, with the association of women with "subjectivity, feeling, and nature" (p. 7). In physics education research, we have been on the margins between scientific research and social science research. There have, historically, been few distinctions between these research paradigms; both take as a given that there is a clear division between researchers and their subjects and that the researcher knows things that their subjects do not. When the subjects of research are people, however, these distinctions should be questioned (M. Oliver 1992; Whitten 2012). At one extreme, traditional social science research has been called "the rape model of research" (Reinharz 1979). In her *Feminist Methods in Social Research*, Reinharz (1992) argues for the amplification of less-heard voices and attention to the intersection of identities. Whitten argues that research in physics, not just in physics education, should embrace categories of projects to make physics more inclusive and to set physics research in social/political context (Whitten 2012).

The theoretical frameworks discussed above each bring tools for thinking critically about disability in physics. Social models of disability focus on structural inequities rather than interrogating students for "what is wrong with you?" (Table II, below). However, physics has aligned itself strongly with the "objectivity, reason, and mind" half of the binary discussed by Keller. That stance is friendly to the medicalization of disability discussed in crip theory (Egner 2016), because it neatly partitions disability as a phenomenon to be studied in isolation from the surroundings using familiar reductionist approaches. In fighting this cultural inertia, we may draw on some of the same arguments in favor of diversity in science that have already been made for gender and race. These arguments include the idea that science is underserved if large sections of its talent pool are excluded (Tilghman 2003). This is true, but it is logic that critical race theory might recognize as interest convergence—that things must improve for Black students, or students with disabilities, because that will better serve a White, able-bodied majority. In using these rhetorical framings for scientist peers or funding agencies, we must not lose sight of justice-based goals, even if we voice them less to those audiences.

DisCrit and crip theory can teach us about the intersections of disability with other facets of identity. These may be institutional (in terms of how people are categorized or "accommodated"), or play out in how people are recognized or treated by peers. The lessons from this work are bittersweet: it teaches us to see new kinds of injustice, but also to celebrate the complexity of human lives that cannot be contained (Star 1991).

8.5.2 *Reflecting on Methods*

One thing that often happens in quantitative research, even (or especially) by those with good intentions, is that some subject identities disappear. In many quantitative studies in science and engineering, there are often so few students who are not White men that researchers avoid disaggregating their data—they do not want to compromise the anonymity of their subjects. This means that, even if results for women are reported separately, or results for non-White people are reported separately, it is incredibly unlikely that, for example, results for women of color will be reported separately from those of White women (Slaton and Pawley 2015). "If quantitative human sciences research (whether deploying large or small numbers of subjects) relies on the use of categories (delineating white, black, or brown subjects; healthy or ill subjects; subjects of particular genders; students of various achievement levels, etc.) as the basics of its systematic inquiry, then recent Queer Theory prompts us to question the social origins and functions of category making" (Slaton and Pawley 2015, p. 26.1564.6). The "queering" of anything, including research categories, involves embracing contradictions.

There is already at least one good example, though being published in the journal *Disability and Society*, it has been hard for physicists to find. Gibson (2012) interviewed university students with disabilities, producing narrative accounts that illustrate the students' experiences of exclusion and of barriers to learning. This work aligns with the various calls above to prioritize the voices of students and others on the margins (Annamma et al. 2016; Reinharz and Davidman 1992; Rosa and Mensah 2016). Further, Oliver (1992) calls for us to be careful in how we ask questions of our subjects. Table 8.2 contrasts questions actually asked by the British government in a disability survey with possible alternatives.

These alternative questions, centering on the validity of the experiences of the people with disabilities, seem more likely to not only treat them with respect and dignity but describe those experiences so that others have a chance to understand

Table 8.2 Taken from Tables I and II in Oliver 1992

Sample of questions from a 1986 survey of disabled adults by the British government	Sample of alternative questions written by Oliver (1992)
1. Can you tell me what is wrong with you?	1. Can you tell me what is wrong with society?
2. Are your difficulties in understanding people mainly due to a hearing problem?	2. Are your difficulties in understanding people mainly due to their inabilities to communicate with you?
3. Have you attended a special school because of a long-term health problem or disability?	3. Have you attended a special school because of your education authority's policy of sending people with your health problem or disability to such places?
4. Does your health problem / disability affect your work in any way at present?	4. Do you have problems at work because of the physical environment or the attitudes of others?

them. We know from standpoint theory that there are some things people with privilege may never truly be able to understand (Hartsock 2003). Hartsock argues that the nature of women's work (reproduction and beyond) gives them a standpoint from which they can see things that men never could. The argument could certainly extend to other people who have traditionally been discriminated against: people of color, LGBTQ people, and people with disabilities. People who have not experienced discrimination do not, and perhaps cannot, perceive the same world. That being said, we hold out hope that qualitative research that respects those who have been excluded from physics can shine light on their experiences so that others have a chance to see (or hear, or feel).

Finally, though it may be pushing uphill, research questions can be framed to interrogate the system rather than the students. Scanlon and collaborators examine four research-based introductory physics curricula for alignment with the guidelines of Universal Design for Learning (Scanlon et al. 2018). They find that some checkpoints are well satisfied, but others (such as providing multiple means of engagement) are not. They give detailed suggestions for thinking about accessibility and Universal Design in curriculum development, both critiquing the physics education community and providing ways forward. Though there is much to be angry or discouraged about, we (the authors of this chapter) have trouble imagining this conversation happening 10 or 20 years ago. Change is necessary, but it is also possible.

8.5.3 Returning to Gender

In the literature discussed above, gender occurs in several places, most often in work on women of color. But gender has not been a central theme of our review, in part because searching for literature on "women in _____" tends to yield results that focus on the experiences of white, straight, cisgender women. Our goal was to explore scholarship surrounding an understudied-in-science identity, that of disability. When photographing the corona of the Sun, you need a filter (or an interposed moon) to block out the overwhelming brightness at the center. Here, to align different theoretical slants on disability and identity, we have first looked to the side of gender.

In the realm of lived experience, gender infuses and connects these other facets. Literature on feminist disability studies (Garland-Thomson 2005) explores these connections and emphasizes elevating unheard voices, challenging social constructions of disability and "normal," and drawing analogies between ableism and systems of racial or gender oppression. Much of this work lies in women's studies, literary criticism, or other scholarship that may not be read by physics education researchers. Some of the lessons translate bluntly: "Women with disabilities, even more intensely than women in general, have been cast in the collective cultural imagination as inferior, lacking, excessive, incapable, unfit, and useless" (Garland-Thomson 2005, p. 1567). For a career in science, you must make

an identity—in the minds of others and yourself—that is the opposite of these qualities. Echoing Ong's finding of fragmentation as a self-preservation strategy, it is no surprise that many women in the sciences must hide, minimize, or deny disability as a piece of their identity. The effect of gender is not limited to women; disability is often seen as weakening men and making them less masculine. For agender or nonbinary scientists, disability can become another axis of their existence that must be translated and negotiated to deal with teachers or colleagues. The specifics vary from person to person; the only relative constant is that gender shapes how society reacts to disability. Though we have prioritized other writings in this chapter, gender is always there behind the filter.

8.5.4 Final Thoughts

It is hard to be anything but White, male, cisgender, straight, and able-bodied and be recognized as a physicist, and that is a shame. We already know that it is hard to embrace duel identities of women and physicist, and above we have tried to chart some of the space of disability identity. Students have to worry about whether to disclose their disabilities, the inaccessibility of laboratory and other work spaces, and the very slim chance that they will find a mentor who is "out" about being disabled. To think about how scientists at all career stages grapple with these issues, we have drawn together elements of disability studies, critical race theory, DisCrit, and crip theory. A depressingly common thread in these studies is that people across these identity groups are viewed as less capable in science. Though the categories of identity are socially constructed, they have real consequences for the people sorted into them (Lewontin et al. 1993; Mostert 2002). To break free of these old patterns, we must wield several key ideas:

8.5.4.1 The Interlinking of Disability and Other Facets of Identity

In classification, recognition, accommodation, or decisions not to disclose, gender and race and LGBT identity inevitably affect the institutions and people around you and how they react.

8.5.4.2 The Question of Who Gets to Belong and Who is "Normal"

Physics tends to enshrine certain kinds of genius—White, male, socially awkward—and not to look far outside this mold for talent. Challenging these ideas can provoke a backlash from physicists who came up through this tradition and now see attacks on their own identities as scientists.

8.5.4.3 The Importance of Voice

If everyone is different and even the concept of "normal" is weighed down with baggage, where should a researcher begin? The importance of being recognized, of telling your own story about yourself, comes up over and over. If we were to frame a narrative study of disability in physics at the size of a cross stitch sampler, it might be: "What is your story? Tell us about you and physics."

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