Chapter 4
An Intersectional Physics Identity Framework for Studying Physics Settings

Angela Johnson

4.1 Introduction

Women of color are markedly underrepresented among people who receive bachelor's degrees in physics in the United States. Less than 4% of physics bachelor's degrees awarded between 2004 and 2014 went to Black, Latina, Asian, American Indian and mixed-race women, although they make up 16% of the people who received bachelor's degrees in any subject during that time, and 22% of the US population age 18–24 (National Science Foundation and National Center for Science and Engineering Statistics 2017). Furthermore, there is reason to think that women of color who come to college planning to major in physics are more likely to change majors than male students or White students; women completed STEM majors in 2013 at lower rates than they declared interest in STEM in 2007; this was also true for students from all non-White racial groups (National Science Foundation 2016; see figures 2–13 and 2–14).

Qualitative research suggests that the few women of color who pursue physics majors experience discouraging, alienating conditions. In a study of physics majors that included 10 Black women and Latinas, Ong (2005) found that "regardless of their actual abilities as measured by exam performances, grade point averages, and research mentor evaluations, women of color participating in the study said they perceived nearly consistent messages – with some rare exceptions – that because they lack the standard appearance of a scientist, they also lack the intellectual competence associated with such an appearance" (p. 602). One African American woman told Ong "I've noticed [my peers] in their tone of voice that they take with me … They feel the need to explain things that much more because, well, this Black person won't get it. I see them doing it with Latino students and doing it to Black

A. Johnson (✉)
St. Mary's College of Maryland, St. Mary's City, MD, USA
e-mail: acjohnson@smcm.edu

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students. They go into this extra detail: ‘Do you understand? Do you understand?’ – as though my intellect is gonna be different from someone who’s Asian or White” (p. 602). In another related paper, Ko and colleagues quote Elena, a Latina physicist: “In physics, as a woman of color, you will not find the way paved… You walk into a stranger’s territory, people look at you, you look and perceive yourself to be different, you are walking the narrow path” (Ko et al. 2014, p. 186).

In a longitudinal study involving 17 women physics majors and physicists of color, 13 talked about feeling isolated in physics settings, and 15 reported experiencing microaggressions (defined as “subtle indignities, slights, or insults directed at individuals, consciously or unconsciously, because of their race or gender”; Johnson et al. 2017). Other research has demonstrated the perniciousness of microaggressions. In a study of 21 predominantly White women who were pursuing PhDs in physics and astronomy, 16 reported instances that the researchers categorized as microaggressions, and 5 reported instances of hostile sexism (Barthelemy et al. 2016). The researchers described microaggressions as “subtle forms of discrimination that are often socially engrained and unconscious. An example of a gender microaggression would be not listening to a woman’s idea but then responding to the same idea from a man, or not thinking to initiate a collaborative project with a woman” (p. 4). Tolerating microaggressions and hostile sexism resulted in “a physical and cultural environment that is discouraging of women’s participation in physics and astronomy” and “ignoring these women’s ideas, conveying a message of women as objects, and restricting access to laboratory equipment” (p. 11).

However, I have been carrying out research in a setting where the three women physics majors of color had generally positive things to say about their experiences in physics. A Black third year student, when I asked her how she thought about the dearth of Black women in physics in general, said “physics is what I’ve always been interested in. It doesn’t feel like I’m out of place. It’s the subject I’m interested in. So I don’t really think about it.” When I asked a mixed race fourth year student what it was like to major in physics at this institution, she told me “I mostly love it. It’s been a really great experience majoring in physics here. It’s been really really hard but I love it!” Of course given the small sample size in this study, it’s possible that their experiences were anomalous; however, I spent considerable time immersed in this department, and I think they are making such positive statements because the culture is indeed less toxic for women of color than is the case in most physics departments. White women in the department made similar statements, describing their academic faculty as “friendly” and “helpful” and contrasting their experiences with less-supportive experiences they had had in other physics settings.

4.2 Intersectional Physics Identity

I have written elsewhere, with wonderful co-authors, about the identity of women of color majoring in science at predominantly White institutions (Carlone and Johnson 2007; Johnson et al. 2011). In this study, I conceptualize identity not as an internal individual experience but as *a feature of a social setting*. I consider questions like: What do personal interactions, cultural features and structures in the setting convey about what kinds of people belong here? To clarify: I think a person may have an affinity with physics—may self-identify as a "physics person," someone who enjoys physics and could be good at it. But an individual's affinity with physics doesn't necessarily shed light on the kinds of identity that are supported in a particular physics setting. Affinity to physics might make a person more likely to want to major in physics (although I can imagine cases where a person would major in physics without having an affinity for it) but it's not what I'm interested in here. I'm interested in what happens once people have chosen, with or without an affinity for physics, to try to join a physics setting.

This framing of identity works well with an intersectional analysis. The central idea behind intersectionality theory is that different kinds of people may experience the same setting differently depending on various personal characteristics. Women may experience a physics setting differently from men, but it's not as simple as that; Black women may experience it differently from White women (or from Black men) or women of any other race or ethnicity; affluent women may experience it differently than women who struggle financially; religion may affect experience, too, and sexuality, and any other dimension along which humans can be divided. This is where the term comes from – the idea being that we all exist at particular intersections within social settings, and the intersections we exist at affect how we are perceived and our access to power in those settings (Crenshaw 1989, 1991). The salience of the dimensions that define our particular intersection change depending on the setting; for a Black woman, majoring in physics at a predominantly White university means something different from majoring in ethnic studies at the same university or majoring in physics at Spelman (a historically Black women's college[1]).

But it's not just that one's experiences differ according to setting and social location; these "distinctive social experiences" that result from intersecting systems of power "are fundamentally unjust" (Collins 2015, p. 14). People at different intersections have access to different opportunities; their words and insights are given different levels of attention and credibility; they are welcomed, overlooked or actively dismissed. "At the same time that structures of race, class, and gender create disadvantages for women of color, they provide unacknowledged benefits for those who are at the top of these hierarchies" (Zinn and Dill 1996, p. 327). It's safe to say that in most physics settings, power relations are such that the status quo is maintained; White men find it easier to thrive, have access to more opportunities, receive more attention, find more social support. They find it easier to inhabit an available physics identity. To look at this issue from the perspective of women of color, "the performance of different identities creates higher levels of stress for individuals who belong to more than one group that is underrepresented in physics" (Traxler et al. 2016, p. 9).

[1] Historically Black colleges and universities (HBCUs) are institutions of higher education in the U.S. that were founded before the U.S. Civil Rights Act of 1964. Before this legislation, many U.S. higher education institutions were not open to Black students; HBCUs were founded to provide Black students with access to university educations. Although HBCUs are now technically integrated, they still have the education of Black students as their primary mission.

My interest is in understanding a physics department where women of color feel successful, feel like they belong; in identity terms, I want to understand the physics identity which is available in this setting, and how that identity is accessible to women of color. This commitment is congruent with the origins of intersectionality, which are political, not scholarly. The ideas that we now call intersectionality were developed by women of color and other activists over decades, especially in the 1960s–1980s (see, for example, Anzaldúa 1999; Guy-Sheftall 1995; Moraga and Anzaldúa 1981; Smith 1983). Collins makes it clear that the goal of this work was not a search for "the latest theoretical innovation" (Collins 2015, p. 8). Rather, "Black feminism's immediate concern in the United States was to empower African American women through critical analyses of how mutually constructing systems of oppression of race, class, gender, and sexuality framed the social issues and social inequalities that Black women faced…. Their intersectional framework suggested provocative links that might ground social justice projects" (p. 8–9). It is intersectionality's power as a tool to promote social justice that makes it a valuable framework for this study; intersectional analyses can help us both identify the features of physics settings that make them more challenging for women of color to navigate than other kinds of people (for a particularly strong example of this, see Kachchaf et al. 2015) and, as in this study, identify features of a setting that make it more amenable to women of color. Using intersectionality with the intention to advance social justice is what Collins calls "critical praxis:" "knowledge projects that take a stand; such projects would critique social injustices that characterize complex social inequalities, imagine alternatives, and/or propose viable action strategies for change" (Collins 2015, p. 17). It is my goal in this particular project to help us imagine alternatives: How physics settings could be structured so that women, particularly women of color, would belong more easily in those settings. What would a physics setting be like where valued identities in that setting could be assumed as easily by women of color as by White men?

Collins (Collins 2009; Collins and Bilge 2016) provides another analytic tool in addition to intersectionality to help with this quest. She argues that if we are interested in understanding how power is organized in a setting (which is to say, who belongs in the setting, who has access to the opportunities in the setting), we need to consider four domains: the interpersonal, the cultural, the disciplinary and the structural; she calls this the Domains-of-Power Framework (Collins 2009).

In the *interpersonal domain*, power is expressed between individuals; a person may be included or excluded, praised or criticized, honored or overlooked. It is the "domain of one-on-one encounters and the area of personal choice" (p. 53–54). In my prior research on the experiences of women of color majoring in STEM, one pattern of interaction which made it more difficult for women of color to be recognized as good science students was the choosing of lab partners. A number of women told me about how White students would immediately partner up and leave them either partnerless or working with the few other students of color in class (Johnson 2007). An example of how personal choice can determine who is valued in a setting comes from a study in which male and female biology, chemistry and physics faculty, at all career stages, were asked to evaluate the application materials of a hypothetical applicant for a lab job (Moss-Racusin et al. 2012). Each participant received the same application materials; the only difference is that some had a male name and some had a female name. Participants rated the male applicant significantly higher and indicated that he should be paid more; this was true after controlling for age, gender and discipline – so women scientists were doing it too. In the study I am presenting in this chapter, given the small, bounded setting (one physics department, consisting of a handful of academic faculty and 30 declared majors), I focused on how students interacted with one another, how faculty interacted with students, and how faculty interacted with one another. I gathered data both from my own direct observations and from what members of the setting told me.

The *cultural domain* is where a group's values are conveyed (or contested); "when it comes to the organization of power, ideas matter in providing explanations for social inequality and fair play" (Collins and Bilge 2016, p. 10). The cultural domain is very powerful in physics settings; US culture is saturated with what it means to be a physicist. Physicists are eccentric geniuses, experiencing flashes of insight, laboring in solitude. Researchers analyzing case studies of laboratory practices in three physics settings found that "a static and nonperformative idea of masculinity may be associated with many of the valued attributes also associated [with] being a physicist" (Gonsalves et al. 2016, p. 4). In an analysis of interviews from 21 women pursuing graduate work in physics and astronomy, researchers documented "a physical and cultural environment that is discouraging of women's participation in physics and astronomy….[which] resulted in ignoring these women's ideas, conveying a message of women as objects, and restricting access to laboratory equipment" (Barthelemy et al. 2016, p. 11). Put more simply, physics students, as a friend of mine told me decades ago, "don't shower much." They are Sheldon Cooper, solitary, living his life according to bizarre systems; Newton, developing the theory of universal gravitation in one glorious moment after being hit on the head by an apple; Einstein of the crazy hair and endearing accent. Of course the cultural domain also influenced the outcomes of the lab applicant study; academic faculty were exercising personal choice when evaluating the fictitious application, but that choice was influenced by cultural ideas about who is good at science.

The *structural domain* has to do with how power is allocated via large social structures. When writing about colorblind racism, Collins talks about "how racial practices are organized through social institutions such as banks, insurance companies, police departments, the real estate industry, schools, stores, restaurants, hospitals and governmental agencies" (Collins 2009, p. 53). An example of how the structural domain plays out in STEM is the pipeline issue in the US: many poor students and students of color can never even enter the pipeline, because they attend schools where there is no access to high-level math and science classes. "A quarter of [US] high schools with the highest percentage of black and Latino students do not offer Algebra II; a third of these schools do not offer chemistry" (Office for Civil Rights 2014, p. 1). In this study I am looking at structures on a smaller scale; the structure of the major itself – how physics classes are officially organized. When analyzing the 2014 FIFA World Cup, Collins and Bilge used the structural domain in this way; they specified that the structural domain in that study referred to "how FIFA itself is organized or structured" (Collins and Bilge 2016, pp. 11–12).

The *disciplining domain* focuses on how rules and regulations get enforced, and for whom; whether, as Collins said when writing about colorblind racism, "people use the rules and regulations of everyday life to uphold the racial hierarchy or to challenge it" (Collins 2009, p. 53). Although Collins called this the disciplinary domain, for the purposes of this study I am calling it the disciplining domain, to avoid the confusion between disciplinary as referring to the discipline of physics and disciplinary as referring to the disciplining (regulating, punishing) of members of a physics setting. An example of how power gets allocated in the disciplining domain of STEM comes from the finding that when grant applications were not blinded, Black applicants were 10% less likely to receive NIH grants than White applicants, after controlling for factors like educational background, previous research awards, and publication record (Ginther et al. 2011). The rules for awarding grants were apparently used differently when evaluating Black scientists. Again in this example we can see the interpersonal and cultural domains at work as well; the way grant reviewers used the rules for awarding grants was influenced by their cultural understanding about who is good in science and resulted in them making personal choices about how to score each grant. The power of the disciplining domain is illustrated by the experiences of the five women who reported hostile sexism to Barthelemy et al. (2016). "In the cases of all of these women, four attempted to find resolution by reporting their experiences to superiors. However, with only one exception (Melissa), these reports were met with deaf ears" (p. 11).

At this point it is useful to pause and think about the prototypical physics department; the physics department that exists in our shared imagination. In this department, women are isolated; women of color even more so (National Science Foundation and National Center for Science and Engineering Statistics 2017). They may experience microaggressions on top of that isolation (Barthelemy et al. 2016; Johnson et al. 2017). The department culture is marked by competition and the belief that physics is a meritocracy, students with the most natural ability will deservedly succeed, and difficulties are an indication that a student isn't cut out for physics. Physics classes consist of faculty lecturing up at the front of the room; high levels of student failure are expected. In the disciplinary domain, it's the Wild West, the boy's club; faculty don't intervene in how students interact with one another (Table 4.1).

It's hard to know just how common this prototypical physics department is, but we all immediately recognize it (it's the reason that I attended a women's college decades ago). It's easy to understand why there would be so few women of color (or women at all) in a prototypical physics department, because power relations are structured at each level so that women face obstacles to being recognized as belonging in the setting – obstacles that White men don't face. The interpersonal domain would be so discouraging; who wants to endure years of isolation and subtle digs at one's dignity and personhood? The emphases in the cultural domain on competition and natural genius work against women, too. As Seymour and Hewitt pointed out decades ago (Seymour and Hewitt 1997), women and men interpret the competitive, alienating environment of most STEM classes differently. Whereas men are socialized to be self-sufficient and stoic, women are socialized to "perform for the

Table 4.1 The Domains-of-Power Framework in prototypical physics departments

	Typical physics departments
Interpersonal domain	Women of color experience isolation and experience microaggressions.
Cultural domain	Physics is a competition; good physicists are natural geniuses who work in isolation.
Structural domain	Classes consist of faculty lecturing; high levels of student misconception and failure are expected.
Disciplining domain	Faculty do not intervene in student-student interactions

approval of others" (p. 266). Thus, "in treating male and female students alike [by subjecting both to the competitive environment in STEM], faculty are, in effect, treating women in ways that are understood by the men, but not by the women" (p. 262). The structural domain, with its emphasis on delivery of information rather than on student learning, does nothing to offset the unpleasant conditions in physics; nor does the hands-off approach that prototypical physics faculty take to conditions in physics settings. This prototypical physics department serves as a useful foil for analyzing the components of physics identity in real departments.

4.3 Methods

I used Collins' Domains-of-Power Framework to develop both a set of guidelines for gathering data about physics identity, and also a set of questions to help me analyze that data intersectionally – to consider how that identity aligns with and how it contests wider patterns in physics and in society; see Table 4.2.

These questions allowed me to develop a sketch of who belongs in the physics department I was studying – the ways members of the department interact with one another, the cultural beliefs of the setting, the values and goals embedded in the setting's structures, and what kinds of actions and speech, on all these levels, were considered important enough that people who violated them were reprimanded. This theoretical framing lent itself beautifully to the traditional interests of anthropology: What people say, what they do, and the material objects they use, and most especially the meanings they share about these. The traditional ethnographic methods – participant observation and open-ended interviews – can be used to gather the kind of nuanced information this framework demands (Spradley 1979, 1980).

Thus, I immersed myself in the life of the physics department under study. I attended at least one class session of every physics class and lab being taught during the semester I began the study, with the exception of the one class that was being offered only for non-physics majors. I made sure to attend the 100-level class as well as an Emerging Scholars-type seminar (Fullilove and Treisman 1990; Treisman 1992) several times during the first 2 weeks of the semester, so that I could observe what happened as new students attempted to negotiate the setting for the first time.

Table 4.2 Questions to support an intersectional analysis of physics identity

Domain	To look for	To consider
Interpersonal	How do students interact with one another?	Are there patterns along race and gender lines? Do they conform to or contest common patterns in physics? In society?
	How do students interact with faculty?	
	How do faculty interact with students?	
	How do faculty interact with one another?	
Cultural	What do the words and actions of faculty convey about what's valued in the domain?	How do the things that are valued align with larger cultural beliefs about race and gender? Conform to or contest common patterns within physics settings? In society?
	What do students' words and actions convey about what's valued in the setting?	
	What does the setting itself – the objects which make it up – convey about what's valued in the setting?	
Structural	What are the policies in classrooms, labs and other physics spaces?	Do the policies in place serve to perpetuate or challenge under-representation in physics?
Disciplining	What kinds of student behaviors do faculty correct?	How do the student actions that faculty condemn or correct align with or challenge under-representation in physics?
	What kinds of student behaviors do students believe faculty would correct?	

When I attended classes, the academic faculty welcomed me and made use of my presence; as students worked on problems during class, I circulated and did my best to help them. At the invitation of faculty, I also spoke about the pleasure and challenge of being a high school physics teacher, and how to become a teacher.

Besides attending classes and labs, I interviewed 6 out of the 8 women majoring in physics, including all three women of color; during interviews, I started by asking them "tell me your life story in physics." For some students, their answers were so wide-ranging that this question was enough; for others, I also asked them "what is your life in physics like?" Typically I also showed them NSF data about the under-representation of women in physics, as well as the somewhat better numbers at their own institution, and asked them what they thought of these patterns. Each interview was highly idiosyncratic as I followed each participant's interests. Interviews typically lasted about an hour. At the end of the interviews, the focus often shifted to the students asking me for guidance about their future choices. At the institution where I carried out this research, faculty advise students intensively, so this was a normal shift in this context. First and second year students tended to talk about pursuing research opportunities; third and fourth years were more focused on graduate school options and careers.

I interviewed four of the five physics faculty members; those interviews typically lasted more than an hour (questions are in Table 4.3, below). In addition to the formal interviews, I spoke repeatedly with the faculty members. I am a faculty member in a teacher education program and a former high school physics teacher; I taught AP physics C (the more rigorous AP physics sequence) for many years and the members of the department I studied often talk with me about educational research design (as a department, they avidly study their own teaching) and about inclusion and diversity issues. For example, one faculty member asked me for feedback about how to encourage more students to participate during class; another one consulted with me about a struggling student.

Finally, I attended a physics class in which most of the third and fourth year students were enrolled, and used it as a focus group. Again see Table 4.3 for the questions I asked. I told the students that the goal was to hear from as many voices as possible, not to reach consensus. For popular responses, I noted how many people agreed. Although the women physics majors in the department where I carried out this study were by-and-large positive about their experiences, 75% of the physics majors were still men, and this focus group led to the curious situation of a group of male students explaining to me what it was like to be a woman majoring in physics, while their female classmates sat quietly and their male faculty member grew increasingly annoyed at them – but the data I gathered from the focus group was nonetheless useful (and the women in class laughed good-naturedly afterwards, for which I commend them).

I coded the data by searching for common patterns, and then using those common patterns to answer the questions in column 2 of Table 4.2. Once I had tentative answers to those questions, I looked through the data both for discrepant examples

Table 4.3 Interview questions

Students during individual interviews	Tell me your life story in physics.
	What is your life in physics like?
Faculty	What does it mean for someone to be a good physics student?
	What do you do as an individual to support and teach students?
	What does your department do?
	Why do you think this institution has these good numbers for retaining women, and what could be done to make them even better?
	For women: What was it like for you to study this field? What has it been like for you to be faculty at this institution?
Students during focus group	Why did you decide to major in physics?
	What was your route to this particular institution?
	Is majoring in physics like you thought it would be?
	What is it like to major in physics here?
	What do you like about physics classes?
	What could be even better?
	Why do you think this institution has more women in physics than average?
	What ideas do you have for attracting even more women?

and for examples where participants contrasted this setting with other physics settings where they had spent time. I carried out the coding using NVIVO. Once I was confident that the answers to my questions were supported by my data, I considered the implications of those answers using the questions in column 3 of Table 4.2.

I shaped this study around Patricia Hill Collins' four precepts of Black feminist epistemology (Collins 2000). Collins argues that "many Black women have had access to [an] epistemology that encompasses standards for assessing truth that are widely accepted among African-American women" (p. 256). These standards are:

- Truth is grounded in experience (so that "those individuals who have lived through the experiences about which they claim to be experts are more believable and credible than those who have merely read or thought about such experiences," p. 257).
- Truth is arrived at through dialogue ("new knowledge claims…are usually developed through dialogues with other members of a community," p. 260).
- Truth demands caring ("personal expressiveness, emotions, and empathy are central to the knowledge validation process," p. 263).
- Truth demands accountability ("Knowledge claims made by individuals respected for their moral and ethical connections to their ideas will carry more weight than those offered by less respected figures," p. 265).

Thus, as the researcher, I saw my role as getting to know people in the setting better and better, rather than seeking objectivity. I am an avowed advocate for women in physics; I want to better understand both the obstacles they face and the characteristics of settings where they thrive, because I want physics to become more inclusive. I see it as my job to behave in ways that my participants can trust and respect, not just in order to gain greater access to the setting but because I would be morally compromised were I to do anything else. In carrying out this study, my interviews with faculty and students were shaped as ongoing conversations, where I checked with them to ensure that I understood what they were saying, and continued (and continue to this day) to talk with them about their thoughts that arise from this project. My research emphasis – and indeed the emphasis of all ethnography – was on experience, and I centered the experiences of the women of color in the setting, always sitting near them while doing participant observation in classes, for example. I expect myself to be accountable to all members of the setting, but first and foremost to the women of color. When I use students' words in public, I first check with them to be sure they are comfortable, particularly the women of color, whose identities it is difficult to obscure. This is on top of the standard consent procedures I made use of; I double-check, and I send out the language I will use in publications, so participants can see for themselves exactly what they are agreeing to. So, for instance, before this chapter went to press, I sent it to all six students I interviewed as well as all four faculty members, indicating to each person where I was using her or his words and asking for (and receiving) clarifications and for permission to use those words. I have continued to advise students about their career choices even past graduation, and I actively put them forward for physics opportunities – for example, connecting a student to the National Society of Black Physicists.

4.4 Physics Identity in This Setting

In all four power domains, the physics identity that I found expressed in this setting was strikingly different from the prototypical physics student identity. Two related forms of physics identity emerged, one for students, the other for academic faculty. To be a good physics student involves doing group work (whether students like it or not), working on physics homework together, and helping other physics students. Good physics students are curious, interested and engaged; they think critically about concepts and abstractions; but they don't have to be on track to pursue a PhD – many career paths are valued. To be a good physics faculty member (in the eyes of a student) involves being accessible to students, seeking shared goals through discussion, using research-based, interactive teaching practices, letting assessment guide teaching practices, emphasizing the importance of hard work (rather than natural ability) in physics; and, for male faculty, understanding the challenges faced by women in physics and addressing those challenges. These components of physics identity were conveyed in all four domains of power, as I discuss.

4.5 Interpersonal Domain

4.5.1 How do students interact with one another?

At the time I carried out this study, there were eight women majoring in physics; I interviewed six of them, including all three of the women of color and mixed race women. Five out of the six women I interviewed spontaneously told me about how the physics majors *work together* and *help one another* – which is especially appreciated because the work is difficult. One woman summed it up like this: "Physics has the past couple years been more difficult, more time-consuming classes. But that was OK because I enjoyed it more anyway. Misery loves company, and there's always company within the physics department!" They used the following words to describe physics majors: "friends," "everybody is so friendly," "super nice!", and "I definitely socialize with all of them." This quote from a second year student pulls all these themes together: "Sometimes I'll be in [the physics building]. So I can just like ask a question. Maybe not my class, but it could be an older physics student that could help me. They're super nice! [Q: just women? or women and men?] Either one. Whoever's there. I think I could ask any of them. We're kind of all in it together, why wouldn't they help me? They know what I'm going through – they've done it themselves!"

Several women told me that when they first started out as physics majors, they found the male-dominated environment intimidating, but this culture of *working together* helped them get over their initial intimidation. A fourth year student told me "now I've made friends with everybody and know everybody, I'm fine with it. But at first it's intimidating…. [Now] it's not just a bunch of men – they're people you know, who you become friends with. So it's not like intimidating anymore." A second year student described it this way: "At first, when I went through the introductory classes, I kind of thought like I didn't have much of a natural ability for physics, but that just wasn't true. As I've gone through it I've kind of noticed how even the guys struggle as much as I do, but I might not have known it before. There's more of a feeling, like, we're sort of all in it together. I don't feel like they know more than me because they're guys or something, or they get it more."

This common practice of working together is a central element of what it means to be a physics student in this setting, and it draws on strengths that are associated with the feminine; it creates a space where women can flourish. And it's not just the women who talk about the physics department this way. These themes came up during the focus group I held with third and fourth year students majoring in physics ("You get to know everyone in the major, and you get to know all the professors;"[2] "You learn what everyone's good at; if you get stuck on something, you know who you can to go ask. Sophomore and junior year are really tough – going through the hardship with everyone – it's nice.") During the focus group, several men talked about how they dislike this aspect of the major (one man said that when he began majoring in physics, "I just didn't really want talk to people. Wanted to sit around in a corner by myself doing cool things"), but recognize its value: "I know it's good for me but I still kind of dislike group work, and the amount of it I have to do, because I'm a pretty antisocial person. I recognize how good it is for my learning, but there are times I just want to copy what's on the board." As soon as he said this, a woman responded "I feel the opposite. I find it more satisfying if I do it with other people."

4.5.2 How do academic faculty interact with students?

Below, in the section where I analyze this setting in the structural domain, I discuss how faculty interact with students formally, in their classrooms. Here I want to report that the students' focus on working together is replicated in how the academic faculty work with the students. Four of the six women physics majors I interviewed spontaneously told me that the *faculty are accessible*, using words like "nice" and "helpful." One told me that her research advisor "is like the nicest professor I've ever met in my life. She's…if you do something wrong, she doesn't even frown at you. She's so helpful, she's just…everyone loves her. Especially – I've heard the general physics kids really like her, and they're the ones who are forced into taking physics and don't actually want to! It seems like she's found a way to really explain things well and get people to be productive without being mean or making you feel bad." Another one told me that *both male and female faculty are accessible*. After we looked together at some statistics indicating that more women

[2]Note that professor is the standard term for any US academic faculty member; thus it is used throughout the quotes in this chapter to denote anyone with an advanced degree teaching a physics class.

study physics at this institution than the national norm, a woman told me "I would love to say it's because we have more female professors than male professors, but that's not true. I feel more comfortable talking to any of those professors. I've never felt intimidated by the male professors more than the female professors." This accessibility is not a coincidence; the faculty make a deliberate choice. One told me "I try and make myself really open to if they have questions – just trying to be around the department, so they can find me and ask me if they have questions." Another said "I try to mentor people, and develop relationships with students and help them to grow and figure out what to do with themselves, and understand that success is what they define it to be and not what someone tells them to be."

Finally, the newest physics faculty member told me that her colleagues offer her the same support: "They've been very good about checking in with me as far as – how are you feeling? how are things going? are there any resources you need from the department? Do we have access to the journals you need for your research? … everyone being completely open to me hopping into their classroom, saying 'here's something I don't know what to do about' [responding with] 'come in, shut the door, I'll tell you my viewpoint and what I think the viewpoint of other people will be, and you can go and ask them.' Being super-generous with their time."

4.5.3 How do academic faculty interact with one another?

When faculty spontaneously told me how they interact with one another, two themes emerged strongly. First, the department *seeks shared goals through discussion*. One told me "I don't want all of us to be thinking the same way about all the problems. What I do want are shared aspirations. I want everyone to have the same goals for the department that I do, but everyone should have their own ideas about what the best ways to achieve them are. I think that's been a great strength of the department. The faculty are pretty markedly different, but I think that all of us share the same aspirations." Another echoed this: "We're going to be as a whole talking about reaching consensus on what students should be learning, and assessing and seeing what changes we need to make in order to better meet the learning outcomes."

An even stronger theme came through what both of the women faculty told me: that their *male colleagues take responsibility for gender issues*. One told me "It's almost as if because someone else is thinking about this, I don't have to waste my brain thinking about it. In other environments, I would ignore that I was the only other woman in the room – no-one else was acknowledging it – I would have to flip that part of my brain on and run it in the background. Here, because someone else has got this, I can just do physics. … We're all handling this together, nobody has to handle this themselves." Notice how she talks about how in other settings she had to run her awareness of her gender "in the background" – a constant drain on her cognitive resources. Her colleague talks about the emotional weight that is lifted because their male colleagues take responsibility for thinking about gender issues:

"[the men] really are very proactive about understanding the issues of being a woman in physics, so I don't have to educate them, which is a huge relief." I saw this in action when one of their male colleagues told me about how another department encourages students to call faculty by their first names. He told me that one of his female colleagues "has raised the point that there are ways that can be somewhat problematic" by playing into the tendency some students already have to disregard the expertise of female faculty. Because of this, he told me, both he and his male colleague refer to the women in their department as "professor" in front of students because of "both the fact that they're women, and also that they're younger."

I would like to end this section with a story about how a student interacted with me. In one class where I was conducting participant observation, the faculty member gave me a few minutes to talk about my project, and when I told the students that the number of women majoring in physics, math and computer science at their college is significantly higher than at other liberal arts colleges, a student cheered. This is a place where you can publicly express your support for women in physics.

4.5.4 Are there patterns along race and gender lines? Do they conform to or contest common patterns in physics? In society?

This is a setting with a high degree of social support and interaction, where the ability to work together, be helpful and be friendly is highly valued for members of the setting, to the point that even people who don't enjoy high levels of interaction see it as something they must engage in to be in the setting. For women of color, especially, this high level of social inclusion is in stark contrast to their typical experience of isolation in physics settings (Johnson et al. 2017). It's a setting where people with more power take responsibility for the success of those with less power (faculty helping students and more junior faculty; more advanced students helping first and second year students). Interactions in the interpersonal domain of power in this setting indicate that a person who belongs here is: helpful, friendly, nice, responsible for others, able to work together on challenging work. For male faculty, there is an additional element of physics identity: They are aware of the challenges that women face in physics, and they see it as their responsibility to take those challenges seriously and take action on them. Interpersonal interactions in this setting are, in short, saturated with caring: Older, more experienced physicists (faculty; third and fourth year students) care for younger people (less experienced faculty; students; first and second year students). This care is sophisticated; it includes a willingness to take seriously the social location of others (men's acknowledgement that their experiences in physics are different from those of women's). Care is strongly associated with the feminine; thus, this caring environment is more welcoming to women students than the prototypical physics environment, where the dominant cultural theme is likely to be competition.[3]

4.6 Cultural Domain

To get at the cultural domain and what it can tell us about acceptable physics identity in this setting – acceptable ways of being a physics major – I directly asked both students and faculty what they think it means to be a good physics student. I also looked at the cultural implications of the physical spaces in physics – what messages the setting itself conveyed about who belongs in physics. Finally, I asked faculty what they think their department is doing to be a good place for women in physics, and some of their answers also helped me understand the cultural domain.

4.6.1 What do academic faculty members' words and actions convey about what's valued in this setting?

I asked all the physics faculty what they think it means to be a good physics student. Three of their responses were detailed and rich (more on the fourth in a moment). All three of them brought out these themes: Good physics students are *curious, interested and engaged*; they *think critically about concepts and abstractions*; and they should be prepared, through their physics major, to live *productive, happy, good lives,* but they *don't have to pursue a PhD*. One faculty member told me that to be a good physics student means "to be curious and work hard. Curious in that you ask questions – you have to have enough confidence to ask questions, and realize – it does take some confidence to realize you can ask questions and it's not a bad reflection of you." Another said she's also "looking for enjoyment – they say 'this is cool' at one point during the semester. Otherwise it seems like you're setting yourself up for four years of pain!" A third told me "We want everyone to be good physics students, but they don't have to all be great physics students. They have to be successful at acquiring various useful skills. They're not all going to be physicists, and we want them to be productive and happy." Two faculty members also said that good physics students can *work together* and one said they should be able to *work hard*. One told me that he would judge someone to be a good physics student "if the

[3] A student who had transferred from a large research intensive university talked explicitly about the non-competitive atmosphere in this physics setting: "The relationship you have with teachers here is worth noting. They want physics majors, and the teachers want you to learn and understand the stuff. At [my previous institution] you're competing against other students for the curve – you do really well and you hope other people don't understand it as well as you so the curve is in your favor. Teachers there, they know a third of you are going to fail no matter what. Here they really want you to understand it."

student is turning in work, and participating in the group work, and working at it, and willing to make multiple attempts."

The fourth faculty member gave me an answer in which he didn't discuss the elements of physics identity he is looking for in his current setting; he did, however, explicitly reject an older form of physics identity. "What does it mean for someone to be a good physics student? I don't know! I would have given you a very different answer when I started my career. The answer back then was 'someone who's a lot like me' – does really well in this or her physics classes, goes on to get a PhD in grad school, and then can't get a job when they get out because there are no jobs for PhD physicists now. Right now I'm not sure I know the answer to that question very well. This may sound weird, but I'm not sure I really want to have in my mind a vision of what I would consider to be a good physics student, because any concrete model that I have in my mind, a person I consider to be a good physics student, is going to be exclusionary."

4.6.2 What do students' words and actions convey about what's valued in the setting?

These cultural themes were echoed in other data sources. The idea that good physics students are *curious* and *enjoy abstractions* came out in the focus group I held with third and fourth year physics students, during which I asked students why they chose to major in physics. One person answered that they "like knowing how things work," and 12 other people (virtually the entire group) indicated that this was one of their primary motivations as well. During an interview, a fourth year student told me that "My parents, physics people here – just make fun of me because all I talk about is [deep significant voice] space. But at least people appreciate it! That is part of why I made friends with physics majors." The students in the focus group also emphasized that majoring in physics entails *long, hard work* in the physics building:

> Me: "What characterizes majoring in physics?"
> Students: "The physics building."
> "We live here."
> "If I wasn't a commuter I'd be there 24-7."
> "Spending more hours in the physics building outside class than you do sleeping."
> [Someone suggests a 3rd story of the physics building so people could sleep there.]
> "We could save so much money we pay for residence if we could just live here."
> "I slept on a table."
> "[Another student] waking me up at 2 in the morning on a professor's couch, asking if he could have a turn."
> "Waking up just before dawn, being relieved at least the sun wasn't up yet."
> "The sign in the lounge asking people to be out before the cleaning staff was there."
> "Is there life beyond this building? That's the question."

4.6.3 What does the space itself convey about what's valued in the setting?

Physical and virtual spaces in physics underscore the messages that in this department, physics is about *working together* and that physics majors *don't have to pursue a PhD*; many career routes are celebrated. The building where physics classes and labs meet and where the physicists have their offices has several open spaces where the physics majors are encouraged to work together, including a lounge (formerly a very small seminar room) for the physics students. There are posters on the wall promoting high school teaching as a career and indicating that physics majors score high on the LSAT and MCAT. The department website lists careers that physics grads have gone on to pursue, including, as one faculty member put it, "med school, geology, earthquake, undersea things" (and I must say that a career in undersea things sounds pretty great). The latter message is also underscored by an annual event: A career panel of physics alums. A faculty member told me that their intent with this panel is to convey "you don't have to go to grad school to be a physics major. There are many other things you can do, and we're excited about them, they're cool jobs, they're a good way to spend your time, to spend your career. It isn't 'you have to look exactly like us to be a physicist.' There are many options."

One faculty member told me about a concern he has about a poster of Einstein displayed outside his office. "I sometimes feel guilty having this poster here, because it's perpetuating the myth of the lone genius, and this epiphany takes place and changes the world. That's not really how it's done. It's incremental, it's social and interactive, and I actually find that empowering. I'm not Einstein and I can still do physics!"

4.6.4 How do the things that are valued align with larger cultural beliefs about race and gender? Conform to or contest common patterns within physics settings? In society?

The cultural domain, like the interpersonal domain, indicates that assuming a physics identity in this department involves being collaborative and working hard; the physics identity is expanded in the cultural domain to indicate that desirable physics students are curious and engaged, and enjoy thinking abstractly. However, good physics students are not expected to go on to become research scientists; there is support in the cultural domain for students to pursue a wide range of careers. Again this promotes a physics identity which is more comfortable for women – especially women of color – to step into, because it emphasizes that success in physics is about interest (which all the women in this study had in abundance) and hard work. This contradicts the idea, common both in physics settings and in US society, that success in physics comes from natural ability; that successful physicists are (White, male) geniuses who work in isolation.

4.7 Structural Domain

4.7.1 What are the policies in classrooms, labs and other physics spaces?

This environment – in which students support one another and faculty support students – is created and maintained at the structural level. Several years before I carried out this study, the academic faculty in the department began adopting the Student Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) protocols (Beichner 2008). They also strive to use the best practices outlined in the 2003 report from the American Association of Physics Teachers (commonly called the Spin-Up report) on the characteristics that differentiated thriving physics departments from those that were declining in size or not graduating many students (Hilborn et al. 2003). These characteristics include:

- "A widespread attitude among the faculty that the department has the primary responsibility for maintaining or improving the undergraduate program. That is, rather than complain about the lack of students, money, space, and administrative support, the department initiated reform efforts in areas that it identified as most in need of change.
- "A challenging, but supportive and encouraging undergraduate program that includes a well-developed curriculum, advising and mentoring, an undergraduate research participation program, and many opportunities for informal student-faculty interactions, enhanced by a strong sense of community among the students and faculty.
- "Strong and sustained leadership within the department and a clear sense of the mission of its undergraduate program.
- "A strong disposition toward continuous evaluation of and experimentation with the undergraduate program" (Hilborn et al. 2003, p. vi).

These features permeate the physics department; both faculty and students allude to these practices, and I saw them enacted during my participant observation in physics settings. As one faculty member told me, "we now teach the introductory course using SCALE-UP methods. … *Group work* and lab work – or lab exercises which take the place of lab – are part of the course work. Group work is built in, lectures are very strongly de-emphasized in favor of a lot of group work, a lot of *interaction between faculty and students*, fairly short lab exercises which are pertinent to the material being taught rather than having separate lab sessions which could be a week behind or a week ahead of the class material at the time." Students report the same thing; one woman told me "I like that the classes aren't lectures.

Most of the teachers will lecture for a half hour, 45 minutes, and then at some point in there ends up being some partner work or someone goes up to the board and works through a problem. So it's very interactive, instead of just being talked at. It's more a conversation with everybody in the class and the professor than information being thrown at you, because that's not helpful. I think that's a big thing to me as to why I enjoy it and I have learned so much from it."

The Spin-Up protocols aren't the only use the faculty make of research; they *use research to guide all their practices* (and this is in fact how I initially gained their trust to be allowed such free access to their classes and students – for years before I carried out this study, the physics faculty had used me as a sounding-board as they explored educational research, trusting my expertise in education coupled with my previous career as a high school physics teacher). Another member of the physics faculty told me "We try to pay attention to the things studies show is useful, instead of what we feel is useful. The style of teaching that we do – the interactive style" was adopted because of its research grounding. The physics faculty not only make use of physics education research, they actively contribute to it, including publications in *The Physics Teacher* and involvement in the local and national branches of the American Association of Physics Teachers. One of the principal manifestations of this commitment to research is through the *constant department-wide use of both formative and summative assessment*; the faculty constantly check to see what students are learning during each class session and they also make use of the Force Concept Inventory[4] (FCI; Savinainen and Scott 2002) and its sister assessments to compare their students' conceptual growth across the semester both to students from other institutions and to their own students during other semesters. A faculty member told me that "our data match national statistics – faculty who use interactive methods, and strongly use interactive methods, and group work in class, and feedback between students and faculty members have higher FCI gains than faculty who don't." Another faculty member told me that "we're pretty well-off with our evaluation stuff, our assessment things, so we try to stay on top of that, we try to stay in front of it because a) we're going to have to do it anyway, b) it's better to choose an assessment that actually assesses things you want to know. Then we can do things that actually make a difference, as opposed to just guessing."

Two of the faculty members use clickers to monitor student understanding during class (they project a conceptual question with several possible answers on a

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[4] The Force Concept Inventory is a multiple choice test that assesses a student's conceptual understanding of force and Newton's Laws. When the FCI was first introduced, physics teachers and professors across the US (and I count myself in this number) were horrified to discover that some of their students could solve physics problems proficiently while still holding utterly wrong beliefs about how the world works – they had learned to solve problems but hadn't actually learned physics. This physics department uses the FCI not to assess students but to measure their own effectiveness – they administer it at the beginning of the introductory course and again at the end to see whether their teaching approaches were effective in helping students identify and correct their misconceptions about force. Since the development of the FCI, a number of similar tests have come into use; see for instance https://www2.ph.ed.ac.uk/AardvarkDeployments/Public/60100/views/files/ConceptualTests/Deployments/ConceptualTests/deploymentframeset.html

screen; students use hand-held devices to "click" the answer they think is correct; faculty monitor the answers on their laptops and modify their instruction accordingly). A third uses the old-school method of having students simply hold up cards to indicate which answer they prefer. A student describes this process: "We have these cards for answering the multiple choice questions in our groups, and it's for him to see where everyone is. We'll like answer the question, and maybe everyone's cards will have a different letter, so we discuss why we chose which one."

Faculty members expect students to work in groups, but they don't leave this process to students. They *teach students how to work effectively in groups*, and grade them on their success. "We talk about – instead of just modeling it – we talk about 'here are the things you need to do to work in a group, here it's important to be explaining what you're doing.' We provide feedback as well – things like group work, where we're trying this CATME system [a set of electronic tools that support group work], stuff like that – frequent feedback, even on the more concrete physics skills – trying to provide frequent feedback starting out in low-stakes situations, then eventually there has to be something at stake to incentivize it." Faculty also intervene when students are failing to work collaboratively in their groups; I will talk more about this in the disciplining section, below.

Finally, the academic faculty in the department systematically convey that physics is learned through *hard work and practice, not natural ability* (Dweck 2006). A faculty member told me how they do this: "We explicitly mention [theories of growth mindset], we're emphasizing the discussion and exploring, making it safe to make mistakes – doing conceptual questions with clickers and having students have to talk about it – a low-stakes environment, they see that there are lots of other people who don't fully grasp it, and through working at it they collectively develop their understanding." Another faculty member pulled together all these themes: "Active learning – it gets everybody involved, lets you know if there are problems and it kind of makes everybody act on the knowledge—'maybe I don't know this.' The message is '*you can be wrong and still be a physicist*.'" I witnessed this in class; for instance, in a 400-level class where students were busily working on the board, a student put up an answer, returned to his seat, then announced" I think I need to change it." The physicist teaching the class responded "you're allowed to modify!" and he got up and changed his answer. Then after a few minutes, as he listened to students discuss other problems, he jumped up and changed it yet again; clearly there was no penalty in this setting for taking some time to understand a challenging physics concept.

During the focus group I conducted with third and fourth year physics majors, a student who transferred to this institution after 2 years at a large research university contrasted the experiences: "There's a lot of interaction in class that you won't get at a place like [previous institution]. At [that university] you can show up and scribble stuff down and you leave. Here's an example. [My current professor] – she's like painting a picture, and she wants you to fill in the trees, make a metaphor. She was doing these differential equations, and like 'what are the boundary conditions?' And we all know it, but we might be wrong, so we wait like ten seconds, then we say 'x=0 and x=L' and she's like 'that's right!' … You don't even have to show up to class at [previous institution]. 300 person lectures. It was really easy – no accountability until test time rolled around. Here you feel awkward if you aren't in class."

4.7.2 Do the policies in place serve to perpetuate or challenge under-representation in physics?

One faculty member told me that teaching in the department is organized around these themes – especially around the idea that physics is done in collaboration and involves hard work and practice, not natural genius – explicitly because they want a more diverse student body. When I asked why he thought that the women physics majors were reporting such good experiences, he told me "you can talk about some of the things we don't do from the traditional methods that were problematic – 'weed them out, produce someone that looks like me, another physicist' approach is problematic if you're already starting with a bunch of white males as the professors. Also the whole idea of – 'you've got to come in with some innate talent' – 'the lone genius' – 'let's revere Einstein and Feynman' – that leads to people selecting people who look like them. There was a study in *Science*, I've referred to it like 3 times this week – where they looked at a bunch of different disciplines – not just in the sciences; economics, philosophy, psychology, English. One of the things that correlated with underrepresentation of women was disciplines in which more people subscribed to the genius model – fixed intelligence vs a growth mindset kind of thing."[5]

So teaching practices in the structural domain are crucial for creating a physics identity that women of color can step into without much difficulty. But it's the practices of the academic faculty in the disciplining domain that make it clear that this doesn't just happen by itself; it requires constant maintenance.

4.8 Disciplining Domain

4.8.1 What kinds of student behaviors do academic faculty correct?

I collected a number of instances of physics faculty members correcting students' behavior. The same theme emerged in this domain as the interpersonal, cultural, and structural: The importance of collaborative group work. In the disciplining domain,

[5] He is referring to the study by Leslie, Cimpian, Meyer and Freeland (Leslie et al. 2015) that showed that the under-representation not only of women but also of African Americans was tightly correlated to the perception by people in a particular field of the importance of natural ability to success in that field.

however, I was able to see that faculty mean what they say and take responsibility for making it happen. I saw several instances of faculty *reprimanding students who failed to work equitably in groups*, and faculty told me about other instances. For example, during the first day of an introductory class, a member of the physics faculty was explicitly telling students about how to work in groups to solve problems at the whiteboard. He offered a tip on how to make this happen: On different problems, have different people hold the marker. Despite this suggestion, one student continued to maintain control of the marker, and said that it would be more efficient if he and his group members just divided up the problems. In response, the faculty member said that *the goal of group work is not efficiency but that everyone learns*. In a similar example, a faculty member told me about working with a student who was dominating group work during a lab. He was controlling all the materials, so she told him he had to let other people have a chance, at which point he backed up and stood far away from his group. She told him he didn't have to stand so far away and that he was either dominating the group or not participating. According to this faculty member, she said "You can't only participate when you're building, that's not OK. It can't be 'I'm either in charge or I'm out of here, guys.'"

Note that in these examples, faculty were reacting to students who were trying to assert the prototypical physics student identity I laid out in Table 4.1: that good physics students are the ones who can get the answers on their own; that physics is about individuals getting the right answer (ideally faster than others), not about working collaboratively or ensuring that everyone learns. This prototypical identity is aligned with masculine norms and domains – competition, individuality, winning. For male students, adopting the physics identity which is required in this setting involves a loss; it involves giving up a sense of their own superiority which they have likely used in the past to bolster their egos, and it involves developing some skills that are looked on as feminine (concern for others; the ability to work collaboratively). One faculty member told me about dealing explicitly with issues of *gender and group work* when giving students feedback. She was dealing with a situation in which two male students were in a lab group with a woman, and they almost entirely excluded her from participation (I was present in this lab and witnessed this). After the lab ended, the faculty member talked with all three of them about it. The excluded student said she was OK with what happened, but the faculty member told me "it wasn't OK to me. It didn't really matter what [the woman student] thought. She can have her own subjective opinion on it. My opinion on it matters more." She suggested to all three group members that "they pay attention to the way they interacted" – men with women, women with men – "to see if women would ever say no. Because it really surprised when I started to pay attention. I was surprised how often I would not say no, but instead come up with a better idea, and argue about it. I didn't realize you could say no."

4.8.2 What kinds of student behaviors do students believe academic faculty correct?

The women physics majors believe that *their faculty would protect them from sexism*. While I was carrying out this study, I was invited to present at a Conference for Undergraduate Women in Physics.[6] I invited all the women physics majors and both women physicists to a session where I practiced my presentation. Almost all the students and both faculty members attended. The presentation included some experiences women of color have had in physics (experiences collected by me and also by Mia Ong and Apriel Hodari). One of the stories I presented had actually happened to one of the women in the room while she was doing summer research at another institution (called a research experience for undergraduates, an "REU"), and she had given me permission to include it (without revealing that it was her story). I presented the story on a slide, and everyone read it silently:

> I was both the only girl and the only undergrad in the entire lab. I didn't actually work with the man who hired me, I worked with a graduate student. I was working with this one volatile chemical to try and density match things, and another person walked into the lab and bumped me while I was pipetting the liquid, and it spilled onto the lab table. I moved one of the hoods over it and someone else walked into the lab, commented on the fact that it smelled, and my mentor laughed and said 'can you guess who spilled it?' and they all looked at me, and they all started laughing, and I was the only girl in the lab at that point, and they all continued to laugh, and I just kind of stood there awkwardly, and the grad student said "how does it feel to have the boys club laughing at you?"

This prompted some discussion, with one student saying she wouldn't know what to say, she would just be silent if this happened to her. Then I posted a slide about what happened next:

> I just packed my things up and left that day. [For the rest of the summer] I didn't speak except when spoken to. I was too afraid to reinforce their idea that I was incapable and didn't belong there. I was afraid of making the necessary mistakes to succeed. I spent basically an entire month being silent in a lab and trying to just work 8 to 6 like I was supposed to, and just leave.

At this point, one of the faculty members, appalled, said "wait, this happened in an REU?" Throughout the rest of the workshop, the faculty member kept coming back to this story and talking about what a jerk the graduate student had been. When I asked the women in the room what could have been done to make this incident better, one of them said "having our professors!" – and, indeed, when I had asked the same question of the woman who originally told me the story, she told me she wasn't sure what would have happened had the same incident occurred at her undergraduate institution; she said "I would hope that someone would speak up and be

[6] The first Conference for Undergraduate Women in Physics took place at the University of Southern California in 2006. Since then the number of conference locations has grown annually; in 2018 there were 9 conferences held simultaneously at different locations throughout the US and, for the first time, one in Canada as well.

like ‘that’s wrong, you shouldn’t say that to another person,’ but I think probably generally there would be laughter that followed it.” Although she wasn’t sure how her peers would react, she was confident that at least one of the members of the physics faculty would have intervened: “I’m sure if I said something to [physicist], he would pull that person aside and have a conversation with them, because he is kind of like the dad of the physics department.”

4.8.3 How do the student actions that academic faculty condemn or correct align with or challenge under-representation in physics?

These faculty members don’t just talk about valuing diversity; they are willing to step in and insist on student behaviors that create a more welcoming environment. Women students believe that the members of the physics faculty will protect them from the most egregious behaviors of male students.

4.9 Discussion

In Table 4.4, below, I have summarized the components of physics identity that I was able to pinpoint by gathering data in the interpersonal, cultural, structural and disciplining domains of power. The component of student identity which emerged in every domain is that physics students work collaboratively together. The cultural domain added more components to what it means to be a physics student in this setting: Physics students are curious and engaged, and can think critically, but don’t need to be on track to become research scientists; physics majors can aspire toward a variety of satisfying careers. The most important components of physics faculty identity emerged in the structural domain (and were reinforced in the disciplining domain): Physics faculty members use research-based teaching strategies including high levels of faculty-student interaction, collaborative group work, and extensive assessment of student learning. There are two more components of physics faculty identity that I think are particularly crucial for this setting: Physics faculty believe that success in physics is a result of hard work rather than natural ability, and male physics faculty take gender issues in physics seriously, rather than leaving equity issues to their female colleagues.

Table 4.4 Components of physics identity in this setting

Domain	Student identity	Academic faculty identity
Interpersonal	Physics students work together	Physics faculty are acessible to students ("nice", "helpful")
	Physics students help one another	Physics faculty are accessible to their colleagues ("super-generous")
		Physics faculty seek shared agreement with one another through discussion
		Male faculty take responsibility for gender issues
Cultural	Physics students are curious, interested and engaged	Physics faculty are proud of the range of jobs their alums work in
	Physics students think critically about concepts and abstractions	
	Physics students should be able to use their major to pursue productive, happy lives	
	Physics students don't need to be on the physics PhD track	
	Physics students work hard and spend a lot of time in the physics building	
	Physics students work together	
Structural	Physics students do group work in class	Physics faculty interact extensively with physics students in class
		Physics faculty use research to guide their practices
		Physics faculty use assessment to guide their teaching
		Physics faculty teach students how to work effectively in groups
		Physics faculty believe hard work, not natural ability, leads to success in physics
Disciplinary	Physics students should be able to work smoothly in groups, ensuring that all group members participate	Physics faculty take responsibility for making sure group work goes smoothly, by having difficult conversations with students who are not effective group members
	Physics students should be committed to the learning of all group members	Physics faculty protect students from racist, sexist microaggressions

In Table 4.5, below, I return to the description of prototypical physics departments that I included in Table 4.1, and compare prototypical departments to this department. This comparison makes it clear just how different the interpersonal, cultural, structural and disciplinary domains of power are in this setting than in many other physics departments.

Table 4.5 Comparing characteristics of domains of power in a prototypical physics department and the department under study

	Prototypical physics departments	This physics department
Interpersonal domain	Women, especially women of color, are isolated and experience microaggressions	Students are friendly and helpful; they work on problems together (even if they don't really like group work) and socialize together
Cultural domain	Physics is a competition; good physicists are natural geniuses who work in isolation	Physics is collaborative; success in physics results from hard work and practice; physicists can be wrong
Structural domain	Classes consist of faculty lecturing; high levels of student failure are tolerated	Faculty and students are highly interactive; students work collaboratively during class to learn physics and solve problems
Disciplinary domain	Faculty do not intervene in student-student interactions	When students contest this collaborative culture and attempt to assert a prototypical physics identity, faculty intervene

I analyzed this setting using an intersectional physics identity framework; however, my findings have for the most part been relevant to why this setting is comfortable for all women; my insights have not been particularly intersectional. The setting is marked by an emphasis on collaboration, caring and hard work, skills that I would argue are stereotyped as neutral-to-feminine – in sharp contrast with more prototypical physics settings, where the more stereotypically masculine skills of competition and natural ability are venerated. Thus, women in this setting are not under the stereotype threat that they can experience in other physics settings; they are not, by virtue of their gender alone, disadvantaged by having to disprove stereotypes about people-like-them. On the contrary, male students may be under stereotype threat, particularly in regards to caring. (One imagines, however, that the tremendous stereotype lift that men get by being in physics more than offsets this disadvantage).

The ways I have identified in which women of color would particularly benefit from this setting are a question of quantity more than quality. All women are isolated in most physics settings; women of color are isolated even more. All women are under stereotype threat in physics; Black women and Latinas are doubly stigmatized as not smart enough, based on not just gender but racial stereotypes as well.

Because there are so very few women of color majoring in physics in the United States, it is difficult to study how, for instance, Black women's experiences might differ from those of Latinas or White women or Asian women.[7] I'm not sure that the questions I proposed in my intersectional identity framework are sufficient, either. The framework was powerful in helping pinpoint how this particular setting differs from prototypical physics departments, and those differences made it very clear why the physics student identity and the physics faculty identity are both manageable for women to assume in this setting. These identities downplay the more

[7] Of the 6283 people who received bachelor's degrees in physics in 2014 across the entire United States, for instance, 81 were Latinas, 52 were African American women and 5 were America Indian women (National Science Foundation and National Center for Science and Engineering Statistics 2017).

masculine characteristics that prototypical physics settings emphasize; instead they rely on neutral-to-feminine skills and characteristics, like curiosity, collaboration, hard work, caring, and (for faculty) embracing best teaching practices.

I want to end this chapter with another event from my practice presentation. After I had finished going through all my slides, one of the faculty members said that they stirred up a lot of feelings for her. I asked her what she'd done when her belonging in physics had been questioned, and she said she'd reminded herself that she has a PhD, she knows what she's talking about, she has plenty of objective evidence that she is competent in physics. Then the other faculty member said that what she has done is "out-compete them." When she was in the middle of her physics major (near the end of her second year) her physics instructor leaked everyone's grades, and it turned out that she was a whole letter grade ahead of everyone else. From that point on, she said, no-one would work with her and she had no friends in her major for the rest of her time as an undergraduate. After she told this story, there was a silence that went on and on; it seemed to me that the other women in the room were feeling for her, imagining what her isolation had been like, realizing the cost she had paid so that she could create a very different place for them to do physics.

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