Chapter 10
Conclusions Part I: Responding to Frameworks and Methodologies that Attend to Gender in Physics Education: Practical Implications for Higher Education

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10.1 Introduction and Positionality

In their chapter, Diane Crenshaw Jammula and Felicia Moore Mensah (Chap. 5) demonstrate that physics students' subjectivities are dynamic and gendered, but not essential characteristics of their sex. Further, they argue that "physics teacher educators are tasked to broaden the ways that physics teachers think about physics and their students' multiple subjectivities" (p. 95). In her chapter, Angela Johnson (Chap. 4) describes a physics department in which the women students of color feel supported. In that department, "male physics faculty members take gender issues seriously, rather than leaving equity issues to their female colleagues". Accordingly, as a physics teacher educator and a male physics faculty member, I open my discussion by describing some of my own subjectivities, professional practices, and conceptions of physics. In doing so, I aim to provide context for, and thus facilitate criticisms of, my interpretations of the ideas in this book.

I am a white cisgender man, and my gender expression is typically interpreted as masculine. I am a former experimental atomic physicist and a current education researcher who studies teaching and learning in physics laboratory courses. I have been educated and trained in physics departments that are predominantly white and male, and I currently work in such a department. Similarly, I was raised in a predominantly white middle-class community, and I currently live in one. Thus, middle-class white masculinity has been a major socializing force in my professional and personal lives. This type of masculinity aligns with dominant conceptions of physics (Jammula and Mensah, Chap. 5), and it can cultivate a sense of entitlement or righteousness that facilitates injustice in the academy (Shahvisi 2015). To resist

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my socialization into white masculinity, I recently entered into an accountability partnership with Regan Byrd and Simone Hyater-Adams, two Black women who have expertise in issues of race and gender. Our partnership draws on models for self-accountability that have been developed in antiviolence movements (Fujikawa et al. 2018). It provides structure, boundaries, and compensation for Byrd and Hyater-Adams to support me in processing feedback about my own racism and sexism in professional contexts and to set attainable and appropriate antiracist and antisexist professional goals for myself (Dounas-Frazer et al. 2018).

I am openly gay and queer. Queerness informs my knowledge of the world. For example, I am skeptical of dichotomies, including technical-social dualism. "Technical-social dualism" refers to the pervasive and oppressive belief that technical things are different from, and better than, social ones (Cech and Waidzunas 2011; Faulkner 2000). Taken to an extreme, this dualism can manifest as messaging that physics is more important than everything else. Indeed, some of the physics lecture jokes analyzed in this book convey precisely that message (Johansson and Berge, Chap. 6). Consistent with my aversion to binary thinking, my queerness implores me to view physics as both a powerful cis/heteronormative socializing force and a powerful metaphor for queerness and genderqueerness. As a physics student, some of my peers invoked physics models and apparatus (technical) to position my sexuality (social) as unnatural: opposite electric charges attract, identical charges repel, and prongs plug into sockets. As a more mature physicist, I now see myself and other gender/queer people reflected in the laws of the universe: quantum entanglement as metaphor for nonbinary and dynamic genders and quark confinement as metaphor for gender/queer solidarity. I am not alone in this queered conception of physics. For instance, Amrou Al-Kadhi, a queer nonbinary artist, has previously described how quantum physics helps them understand their own queer identity (Al-Kadhi 2018). The collective weight of these gendered subjectivities, experiences, and notions of physics informs which ideas and findings in this collection resonate with me most strongly and how those ideas could impact physics teaching practice in higher education.

10.2 Resonant Ideas and Findings

In their ethnographic description of students' identities and corresponding connection or disconnection to physics, Jammula and Mensah (Chap. 5) show that students' subjectivities are not essential: Naira, a Pakistani woman, sometimes enacted masculinity to defend her ideas; Sameer, a man from the Middle East, valued relationships and emotion, which are typically associated with femininity. That is, behaviors that are typically associated with whiteness or masculinity are not inextricably coupled to one's race or gender. As a white cisgender man who is attempting to resist the white masculine socializing forces of physics culture (e.g., elitism and hyperindividualism), this finding resonates with me because it gives me hope. It reinforces that other cisgender men and I are not biologically prohibited from enacting and modeling for our students behaviors that are typically coded as feminine (e.g., diligence and empathy). However, Jammula and Mensah also show that physics is aligned with middle-class white masculinity, and that gendered performances confer status in the classroom. Their work contains a message of caution: physicists of all genders who embrace (or aspire to embrace) feminine behaviors and values may experience a harsh disconnect with the dominant physics culture.

Due to my various professional identities, I am particularly interested in the performance and construction of gender in physics laboratory courses. For some students, laboratory courses can be formative experiences that position them as more central in a community of physics practice (Irving and Sayre 2014). Work in this book by Marianne Løken and Margareta Serder (Chap. 7) and Adrienne Traxler and Jennifer Blue (Chap. 8) suggests that laboratory courses may also be doing another kind of positioning. Løken and Serder (Chap. 7) employ a sociomaterial approach to illustrate that people's educational interests, aspirations, and choices are shaped in part by the "things that surround us, the experiences we have with them, and our bodily situation in the world". They describe how Mia and Violet, two women studying physics at a Norwegian institution, came to be interested in physics through formative childhood intra-actions with material experience: construction games for Mia and a rocket launch for Violet. This sociomaterial analysis is immediately applicable to laboratory courses, environments whose importance stems from the opportunity they afford students to use sophisticated physics apparatus (Caballero et al. 2018). Moreover, providing students with opportunities to design, build, and troubleshoot their own experiments can foster their sense of project ownership and their interest in corresponding physics topics (Dounas-Frazer et al. 2017b). Recent work by Allison Gonsalves, Anna Danielsson, and Helena Pettersson (2016) shows that "performances of masculinity in physics are constructed through tinkering with instruments designed for larger (male) bodies." (p. 020120–13). Therefore, analyses that consider the agency of equipment and software could provide crucial insight into students' negotiations of both their gender and their connection to physics through intra-actions with physics apparatus. That is, sociomaterial approaches like the one presented by Løken and Serder could help physics educators better understand our students' gendered material experiences in laboratory courses.

The social model of disability described by Traxler and Blue (Chap. 8) further complexifies the performance and construction of identity in laboratory courses. In their recent call to invest in the improvement of physics laboratory courses, Caballero et al. (2018) note that "labs may give rise to a unique combination of stereotypes, discriminatory behaviors, and mobility or sensory barriers that unfairly prevent full participation for some learners." Reinterpreting this call through the social model of disability, "barriers that unfairly prevent full participation" could be viewed as disabling structural features of the classroom. How might the type and use of equipment and software cause some learners to be disabled, regardless of whether they self-identify as having a disability? That is, how might the material and social conditions of laboratory courses contribute to a harsh disconnect with physics for students with certain types of body?

10.3 Practical Implications for Higher Education

In Chap. 2, Louise Archer, Emily MacLeod and Julie Moote suggest that redressing inequality in physics requires a disciplinary shift:

> [W]e suggest that the challenge (and potential) will lie in getting the field of physics (and the myriad of powerful actors within this field) to understand the ways in which social reproduction functions in this space – and to then accept a reduction in their previously-enjoyed privilege in order to genuinely redress the effects of inequality and to open up the field to a more diverse demographic of participants.

This broad call can feel overwhelming for individuals who want to take action in support of gender-, race-, class-, and ability-based equity and to eliminate the disconnect between physics and femininity. However, there are several concrete actions that men can take to disrupt inequities in physics. Focusing on higher education, I will draw on my own experiences as a white queer cisgender man who is involved in physics at four grain sizes: (i) professional society, (ii) university department, (iii) post-secondary classroom, and (iv) individual person.

Archer, MacLeod, and Moote call for increased understanding of mechanisms for social reproduction within the field. In higher education, one way that physics educators advance our collective understanding is through conferences. Conference sessions, panel discussions, and plenary presentations represent existing mechanisms that can continue to be leveraged to infuse new ideas and language about gender into the physics education community. Moreover, it is possible to leverage these mechanisms in ways that challenge the reproduction of middle-class white masculinity in physics. Invite experts from beyond the physics education community, and ensure that groups of experts are diverse with respect to gender, race, class, ability, and other dimensions of identity. Secure funds to defray speakers' travel costs or pay them honorariums. Advertise the event to ensure high attendance, and organize appropriate networking events for speakers and relevant community members. My experience is that women, especially women of color, are overrepresented among organizers of sessions, panels, and plenaries focused on doing gender in physics education. Thus, there is a need for men to take on the labor of organizing such events.

At the departmental level, Johnson described a department in which faculty use research-based teaching strategies, foster student collaboration, and view success in physics as the result of hard work. Importantly, male faculty members in that department "take gender issues seriously." If one is not already embedded in such a department, what can be done? Cultural change in physics and other science or engineering departments is an emerging area of focus in physics education. Corbo et al. (2016, 2018) have been employing a Departmental Action Team (DAT) model that involves teams of students, staff, researchers, professors, and trained facilitators working together toward enacting a shared vision for their department. Others have also used the strategy of assembling a team of students, educators, and facilitators external to the department. For example, in order to accommodate the specific needs of a blind physics major, one physics department assembled a team consisting of the student, a blind physics bachelor's degree recipient from a different institution, a consultant on accessible science education who is also blind, and multiple sighted faculty, staff, and students (Holt et al. 2019). Further, there is also a role for departmental investment in student groups dedicated to collective self-education about issues of equity in physics (Dounas-Frazer et al. 2017a). Physics faculty members, including and perhaps especially men, could familiarize themselves with this literature and advocate within their institution for resources to support cultural change through hiring of external facilitators or consultants; forming heterogeneous teams of faculty, students, and staff; and investing in student-led diversity organizations.

Whereas a single actor cannot easily change the department, the classroom is a space that can benefit from both collective and individual action. Classrooms are impacted by departmental commitments (or lack thereof) to using research-based teaching strategies and instructors' implementation of those strategies. Similarly, the notion that physics is elite can be reinforced or challenged in the classroom through structural gatekeeping practices (cf. Archer, MacLeod, and Moote, Chap. 2) and instructors' use of humor (Johansson and Berge, Chap. 6). After reading the other chapters in this book, I adjusted my large-lecture teaching practices to incorporate more explicit framing about the conditions for success in physics while also pushing back on technical-social dualism. I told my students that physics requires social, emotional, and communicative skills in addition to mathematical ones; that it is a collaborative human endeavor rooted in sociopolitical contexts; and that it is learned through practice and dialogue. Although these messages were constrained to the first day of class, there was a strong response. Two students told me they appreciated the messaging. Three others explicitly questioned my competence as an educator. I had never before received such criticism from even a single student, but my colleagues who are women found the criticism familiar. I wonder whether my sexuality and my teaching practices—in this case, the framing of just one lecture—worked together to construct me as sufficiently feminine that some students perceived me as misaligned with physics culture and therefore as having low status in the classroom (cf. Jammula and Mensah, Chap. 5). I further wonder about which social supports I can rely on as I continue to experiment with teaching framings or strategies that misalign with the dominant physics culture.

At the individual level, my accountability partners are an invaluable source of social support when it comes to challenging myself to take action in support of gender- and race-based equity in physics (Dounas-Frazer et al. 2018). This partnership is both proactive and reactive: my accountability partners help me set and reflect upon inclusive and attainable teaching goals and they help me anticipate and process my gendered and racialized experiences in physics and academia more generally. Archer, MacLeod, and Moote have called not just for changing physics itself, but also for a shift in how "powerful actors within this field" understand gendered socializing forces. Although the partnership I co-developed with Byrd and Hyater-Adams is new and experimental, I believe that this or similar mechanisms have the potential to facilitate a positive disciplinary shift through individual self-accountability.

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