Chapter 5
Urban College Students Negotiate Their Identities to Dis/Connect with Notions of Physics

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5.1 Introduction

Pioneers in the field of physics education research (Hestenes 1987; Karplus and Brunschwig 1969; McDermott 1995) sought ways to teach physics such that students build deep conceptual understandings of physics phenomena and develop expert-like views of the epistemology and nature of physics. From interactive engagement in physics learning, such as conducting experiments, engaging in argumentation, and solving problems in groups, students achieve almost twice as much in learning gains as compared to the more traditional lecture-style of instruction (Von Korff et al. 2016). However, gender, race, and ethnic achievement gaps persist even with the use of interactive instruction, though they do not widen (Brewe et al. 2010; Pollock et al. 2007). To explain these continued discrepancies, Kost-Smith, Pollock, and Finkelstein (2010) suggest a "smog of bias…that surrounds us and that we constantly breathe in, though at times we may be unaware that it even exists" (p. 15). Like smog, gender bias is omnipresent and toxic, yet sometimes invisible. However, the harmful impact of smog on public health may be more widely accepted than the impact of gender bias on women's wellbeing. The "smog of bias" referred to by Kost-Smith et al. (2010) suggests an unconscious and pervasive privileging and discrimination in the physics classroom.

Gwyneth Hughes (2001) describes that science is taught as "a body of authoritative, incontestable knowledge which is abstracted from social activity to maintain a high level of difficulty and status" (p. 276). She argues that physics is the most

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positivist and elitist of the sciences. Consequently, few students can connect to this exclusionary perception of the nature of physics. Yet, dis/engagement with the subject depends on more than one's gender. Some females prefer abstract, rational thinking while some males are deterred by it. Rather than essentialize "how females do physics" and "how males do physics," Hughes shows how students negotiate their multiple subjectivities, including gender, race, ethnicity, and class, to align with or disengage from their views of science. Students may see physics as abstract, rational, and elite, which may or may not match views of themselves. This notion of physics as abstract, rational, and elite may contribute to the lack of diversity in participation and achievement in physics where students feel they have to perform a certain way to have an identity in physics.

5.2 Gender Subjectivities and Performance

Judith Butler's (1988) notion of gender performance argues that one expresses their subjectivities in discourse, or the way they communicate themselves to others, including speech, bodily movements, and style. Children learn gender (and race, ethnicity, and class) performance by watching and participating in the social world. They interact with men and women in their lives, watch men and women on TV, and are disciplined by individuals and institutions to be boys or girls. This viewpoint might explain why in a survey of 437 sixth-grade students, boys had more experience with tools, electronics, and simple machines, while girls had more experience knitting, cooking, and gardening (Jones et al. 2000). Women are not biologically determined to be creative, caring, and charming, but they may be disciplined as females to adopt these characteristics. Invoking the category "women" assumes a well-defined group of human beings. It suggests that "women" share commonalities, which are different from "men." Yet, not all women, or human beings, are one way or the other. There may be greater variation within the categories of men and women than between them (Epstein 1988).

Moreover, students negotiate their subjectivities to dis/connect with notions of physics. When negotiating subjectivities, one draws from their subject positions to engage with their environment. For example, Hughes (2001) writes about a female student of color who does not ascribe to traditional femininity. The student rejects the notion of scientific knowledge as coming from authority. Instead, she embraces a constructivist nature of science that aligns with her gender and ethnic subjectivities. She develops a positive science identity. Carlone and Johnson (2007) propose a model for science identity that includes competence, performance, and recognition. While women and people of color may not be recognized by others as "science people," they may see themselves as science people because of their love of science or agency in redefining science (Rosa and Mensah 2016). Thus, populations marginalized in the science classroom may still form positive science identities by connecting with their views of the subject matter.

This study conceptualizes gender as a spectrum of performances associated with femininity and masculinity in the physics classroom. In the U.S. in the twenty-first century, collaborative, emotional, and caring are associated with femininity and competitive, rational, and self-interest are associated with masculinity, to name a few. These associations are socially constructed; they depend on how a society defines what it means to be a woman or man, and therefore depend on time and place. The research question addressed in this study is: how do students negotiate their subjectivities to dis/connect with notions of physics?

5.3 Ethnographic Methods

Ethnographic methods (Emerson et al. 2011) were implemented to capture the classroom culture in the physics classroom and to understand within this setting how students negotiate and dis/connect with notions of physics. From the field of anthropology, ethnography is used to develop understandings of different cultures. The physics classroom has a culture, including norms, values, beliefs, rituals, roles, and power structures. This culture is apparent in the way participants engage with each other in activities within the classroom space. Data such as fieldnotes, audio transcripts, and classroom artifacts is collected to form a "thick description" (Geertz 2008) of the classroom culture. This methodology was implemented to see how students enact their subjectivities and how such actions work to construct notions of physics.

The study setting was an urban public college in New York City. The 6-year graduation rate at the college is 42%. The demographic make-up of the college was 40% Latinx, 25% African American, 10% Asian American, and 25% White, which is representative of the typical course enrollment. The physics course for this study was an interactive algebra-based introductory physics course that was taught by the first author. Instead of a traditional lecture hall, students sat at lab tables in groups of four. Each student kept journals and wrote notes and reflections as they related to activities in the course. They designed and conducted experiments to build models of physical phenomena, including acceleration, force, energy, and momentum. After each experiment the student groups presented their findings and engaged in argumentation to reach consensus about tenets of the phenomenon. They then applied the model of the phenomenon to different scenarios and problem solving. Once limitations of the model are reached (e.g. the model for constant velocity cannot be applied to objects that speed up, slow down, or change direction), students engage in a new cycle of model development and deployment.

There were 23 students enrolled in the course, comprising 7 female students and 16 male students. Over half of the class (13 students) will be the first in their family to graduate college. Students self-identified among a range of ethnic and/or racial backgrounds. Most students grew up in the U.S. and 3 students immigrated to the US as teenagers. The students in this course were non-science majors fulfilling a science requirement. Most were freshmen and sophomores, with a few juniors and

seniors. The students ranged in age from 18 through mid-twenties. Upon completion of the course and after grades were submitted, 22/23 students consented to this study. However, for this study, five participants were purposefully selected because their journal entries and actions illustrated three different ways students dis/connect with physics. Three males (Ivan, Louis, and Greg) engage stereotypically; one female (Naira) performs less consistently; and one male (Sameer) excels in problem solving but does not ascribe to the dominant discourse of the physics classroom. (All names are pseudonyms). These five participants engage with each other in a problem presentation that shows the dynamics and outcomes of the enactment of their subjectivities.

5.4 Data Collection and Analysis

In the physics course, there were many artifacts that were collected and served as data for this study. Specifically, the researchers kept field notes of the classroom and interactions between students as ethnographic notes. The students wrote in journals each week about classroom happenings and their reactions, reflections, and feelings. This data source was significant as a personal document where participants shared their thinking about physics and how they dis/connected with physics. The journals from the consenting students were collected, and one large document (i.e., Journal File) was created and used for data analysis.

For data analysis, the Journal File document was analyzed inductively as a process for qualitative data analysis (Merriam and Tisdell 2015). We started with open coding (Emerson et al. 2011) and discourse analysis (Wood and Kroger 2000) to examine the journal entries and field notes. In the process of analyzing the journal entries, we read for moments where students discussed their subjectivities and views of physics. In open coding, many possible ideas were explored in making sense of the data as we coded the content of the journals. Phrases in journal entries were marked with short descriptors such as "experience," "view of science," "gender." We reread the coded journals and wrote notes and memos as the first level of understanding the participants' entries. We saw how the experiences, ideas, and dispositions of Ivan, Louis, and Greg shared commonalities. We pieced together memos from our analysis of their journals to form a narrative. The connection of middle-class white masculinity with conventional physics rang true in each of their stories. They also performed in similar ways in the physics classroom. No other participant wrote or acted like them, except on occasion Naira. The inconsistency of her actions caused us to select her journal data for further analysis and interpretation. Of all students, Sameer sharply contrasted with Ivan, Louis, Greg, and Naira. His journal was also selected for deeper analysis.

In the process of analyzing the field notes, we looked for moments where gender mattered. In other words, we analyzed moments when participants performed in ways associated with a particular gender in how they engaged in physics. For example, we wrote observational field notes when Greg controlled the computer in

his group with two female classmates of color. We noted that as a moment where gender mattered. We were able to connect the fieldnotes to the journal entries because Greg also discussed this moment in his journal. Interpretations of fieldnote excerpts were elaborated in analytical memos.

Field note memos were integrated with journal narratives to deepen, elaborate, and develop arguments toward the development of themes that were coming from the analysis process. For example, the problem presentation was a classroom occurrence where gender mattered, and we tied together the narratives of the five selected participants in a meaningful way. As we worked with the data, we assigned pseudonyms and recorded the date of each entry to show when the entry was written (at the beginning, middle, or end of semester). This showed the persistence or changes of ideas over time. We maintained the participants' exact words, and punctuation and spelling edits were made only when necessary to make the excerpt more reader-friendly. The terms "masculinity" & "femininity," "white," and "middle-class" were used as concise labels for role behaviors that are commonly associated with either men or women, race or class designations, respectively. These categorizations do not represent innate or biologically determined categories of behavior, but they are culturally associated with particular gender, race, and class.

As researchers, we shared the process of analysis by reading excerpts from the journal entries and shaping them into stories that could be told. We served as peer reviewers for each other (Guba and Lincoln 1989) during the process to ensure both rigor and negation of meaning. We sought to highlight variation in how the participants negotiate their subjectivities to dis/connect with notions of physics. In this process, our goal is to bring forth a more comprehensive explanatory mechanisms for dis/engagement with physics, specifically in participants presenting the solution to a physics problem. We highlight below three themes as they relate to negotiating and disconnecting with notions of physics as middle-class white masculinity aligns with conventional notions of physics; as subjectivities are not essential; and as subjectivities are dynamic and gendered performances confer status.

5.5 Negotiating Subjectivities to Dis/Connect with Notions of Physics

This study focuses on one activity common to both traditional and active physics classrooms: solving a textbook physics problem. Findings show that subjectivities are intersectional, nonessential, and dynamic, and they reveal variations within the categories of gender, race, and class for the five participants. The participants draw from these subjectivities to connect with or turn away from their views of the discipline. The performances of subjectivities in the classroom activity of doing physics problems construct a general notion of physics as elite, authoritative, and rational. In this construct, *middle-class white masculinity* is privileged, and

underrepresented voices are silenced, thereby reproducing hierarchies and discrepancies in physics education.

5.5.1 Middle-Class White Masculinity Aligns with Conventional Notions of Physics

Ivan, Louis, and Greg embrace the interests, performances, and discourses associated with middle-class white masculinity. These three participants appear as white males; Ivan is from Eastern Europe, Louis is Spanish (from Spain, as he indicated) and Caucasian, and Greg is white (he did not indicate ethnic background). They participate often in class and dominate whole-class discussions and small-group work. They speak with confidence and enjoy competition. These performances of dominance and entitlement align with conventional notions of physics as authoritative, elite, and masculine. The subjectivities of Ivan, Louis, and Greg overlap with a conventional notion of physics and they have positive physics identities. For example, Ivan describes his extensive experience and positive view of physics. He writes:

> In the past I have studied physics and I find it pretty interesting. It's one of my favorite subjects. I finished my high school in my country and there, physics was a subject that we had everyday. I have studied physics for 6 years, four in high school and two in college. (Ivan, 1/30)

Ivan's Eastern European background allowed him much experience in physics. In New York City public schools, physics is not a required course and only 20% of students take physics (Kelly and Sheppard 2009). In the following excerpt, Ivan explains his early like and understanding of physics:

> When I was in high school the first three years I never liked physics. Actually, I hated it. I rarely studied it. But on my senior year occasionally I used to read the book. At times I could understand it and to me it would make sense. I think from that year I really started to like it. I really like physics now. The reason for taking this course was that I somehow, I had missed that excitement when you get something right. (Ivan, 3/13)

Ivan constructs physics as authoritative. Physics knowledge comes from the textbook and success is defined by right answers and good grades. When Ivan is able to master physics content as dictated by the textbook and physics problems, he develops a positive physics identity. He describes a paradox that "you cannot learn science if you don't understand it," which highlights the exclusivity of the discipline and absence of entry points. Ivan's interest in physics stems from his feeling of success as determined by traditional indicators and not by curiosity about the physical world, testing ideas, or collaboratively building knowledge based on data.

Ivan describes the problem presentations as his favorite part of class because he can use his voice, compete, and exercise power:

> For today my favorite part was the homework. It looked pretty interesting and funny to me because Louis and our group would have convinced the whole class that our method was

> right if you professor had not intervened. I like this part of the class maybe because there is room for discussion and also for competition. (Ivan, 2/27)

He describes his strategies when presenting problems:

> I think that I'm really confident on my skills. I always make the others listen to me. So, confidence and determination … Also belief I think played a part. Believing in something that you think you are right, it gives you confidence and force to fight for it. (Ivan, 3/6)

Ivan invokes his middle-class white masculine subjectivity in his desire for competition, power and confidence. He likes that he was almost able to convince the whole class of his group's way of thinking and describes his discursive strategies to convince the class of his answers. He is confident and self-assured. He writes, "I always make others listen to me." For Ivan, physics is a prideful "fight" for "right answers", as opposed to a collaborative effort to deepen his and others' understanding of the physical world. He identifies with and perpetuates the elitism of physics as his positive physics identity.

Louis also engages in such discourse. However, his enthusiasm for physics stems from his experience in sports. Louis writes:

> As an enthusiast of physics, I have been quite happy over these past two classes. I enjoy physics very much, because I find it to be a very practical science. That if you try to look physics is everywhere and it's fun. As a Mixed Martial Artist I notice the transfer of energy a lot. But I have a question. When I punch someone the energy transfers through their body. Though where does it go after that? Does it transfer through the floor or elsewhere? Just some things that's been on my mind. (Louis, 1/30)

Louis views physics as practical and sees physics in his life as a mixed martial artist. He says that "physics is everywhere." However, not all students feel this way. Martial arts is a male-dominated sport, and male-dominated activities are used often in physics instruction. For example, Louis wonders about the energy transfer in throwing a punch. Even though physics is relevant in activities deemed feminine, such as cheerleading, dance, and music, the conventional curriculum may not relate these activities to physics. Masculine topics in physics align with Louis's masculine interests, allowing him to take-up a positive physics identity.

Greg also sees physics in his gendered, raced, and classed activities, including downhill ski racing, rock climbing, and lacrosse. Wealthy white males are the primary participants in these sports. So, like Louis, these activities connect to his interest in physics. He writes in two examples the connection of physics to his extracurricular activities:

> Physics is something in high school I had a blast in. Growing up as a downhill ski racer and a lacrosse goalie I learned what movements were needed to throw the ball to a teammate which I always felt helped me become better in sports. Especially with skiing and learning how to control my speed while going through gates to get the fastest time on the course. Having this information allowed me to make quick estimations on the sensations I would be feeling going through the race course. (Greg, 1/30)

> A story of using physics I can think of is when I was rock climbing I was able to experiment with different grips by distributing my weight differently by moving my body in unusual positions. By doing this I'd be able to make more traction with the wall. And I found it really cool on how calculated the movements are even though no numbers were involved. (Greg, 2/6)

For Greg, there is a clear overlap between his pastimes and physics. Physics knowledge helped him as a lacrosse goalie in knowing where to throw the ball; as a skier in knowing how to control his speed; and as a rock climber knowing how to distribute his weight. Greg sees physics as related to these predominantly upper-class white masculine sports, allowing him to construct a positive physics identity.

Like Ivan and Louis, Greg's discourse of privilege, dominance, and entitlement reflect his middle-class white male subjectivity. He describes as a child being able "to take charge in a bit of a leadership position" which allowed him to become the goalie on his lacrosse team. He says he "plays to win" and "by being able to control and motivate [his] teammates by making big saves they would perform better for [him]" (Greg, 3/11). Greg's disposition suggests that he views himself as superior to his teammates. He engages with his teammates for his own benefit, so that "they would perform better" for him. His elitism, dominance, and self-centered goals reflect his subjectivity as a middle-class white male.

Greg's self-centered and dominant dispositions translate to performances in the physics classroom. Greg's description of working with two female classmates of color on a video analysis lab is similar to how he describes controlling his lacrosse teammates. He writes:

> I found I was able to make the program work the best and kept asking my team questions about what was going on to make sure that they understood what was happening as I explained the process of what I was doing. I wasn't sure if they understood or if they figured I knew what I was doing and just let me do my thing. (Greg, 2/13)

Greg dominates the group lab because he believes he makes the video analysis program work best. Though none of the students had prior experience with the software being used, Greg assumes his technological know-how is superior to his female peers of color. He positions himself as the source of knowledge and assumes they do not understand the assignment. This scenario is one illustration of how performances of subjectivities have implications for students' learning.

Ivan, Louis, and Greg demonstrate their middle-class white male subjectivities and positive physics identities. They make personal connections to the notion of physics from sports and other activities where they see strong physics connections. The three men take-up middle- class white male subjectivities in the physics classroom that also match their class status, race, and gender.

5.5.2 Subjectivities Are Not Essential: A Woman Who Likes Physics and a Man Who Does Not

Not all middle-class white males are dominant, confident, and self-interested, and not all females and minorities are collaborative, open minded, and selfless. Naira's performances do not match stereotypical notions of femininity. She takes control of her group, does not listen to her peers, and defends her thinking assertively. Unlike Ivan, Louis, and Greg, Naira's performances do not match her appearance. She is

from Pakistan and has brown skin and long dark hair worn in a braid. Naira's performances show that females also engage in exclusionary practices, which may work to give them access to power that is traditionally reserved for men. Assimilating females into the culture of physics does not necessarily challenge the gender order but may engage them in an elitist discourse that sustains it. Naira, like Ivan, Louis, and Greg, enjoys physics. She writes:

> On Tuesday 1/28 I was afraid of physics, but today I feel as if physics can become one of my favorite subjects. I love how we can use technology to enhance our learning and with no doubt technology has succeeded in helping our understanding. Physics is fun, and I love how it involves physical techniques like using a meter rule, using a stopwatch, etc. I personally enjoy physics and wish to learn Physics102 as well, which includes electricity, power, gates, etc. What makes physics more fun is that it is very conceptual. (Naira, 1/30)

Naira is interested in topics associated with masculinity, including technology, physical techniques, and electricity. This contradicts an essentialized view of gender, where girls like animals and boys like machines, for example. Ivan enjoys the stereotypical cultural nature of physics, including competition, dominance, and elitism. Whereas, Naira enjoys the conceptual nature of physics, including using hands-on methods to study physical phenomenon. Naira's view of physics is more aligned with the practices of science (Etkina et al. 2006).

In addition, Naira sees physics as relevant to her life through nontraditional connections, including her lower-class work as a cashier. She writes:

> Doing physics can take any form when we walk, or work or even use our everyday routine we are "doing physics." An example can be found every minute of our life. Walking on a road as compared to walking on slippery ice is a form of physics. The concept involved in this example is friction. When we are at work, for example a cashier, he/she takes the money, puts it in and pushes the register to close it. In this example, pushing brings the concept of force while also involving power, energy and work as concepts. Using technology is a form of physics. Physics can be anything from switching on lights (concept of electricity) to even pulling a slinky (concepts of waves, motion, etc.). Physics is a part of our daily life and we don't even know it. (Naira, 2/6)

While Louis and Greg related physics to their pastimes, Naira sees physics in her workplace. Naira works part time as a cashier at a fast-food restaurant and describes the physics of operating the cashier machine. She describes physics as relevant to daily life that many do not notice.

Similar to Ivan, Naira's physics education began abroad and was defined by exams. She grew up in Pakistan. She writes:

> About my past experiences, I took physics, but it was much tougher. The physics course I took was called O'Levels from Cambridge University in England. The exam was 3 parts, it had 40 multiple choice questions, about 20 long and short questions, and an "Alternative to Practical" part, which was like 5 different labs done on the question paper and we had to analyze and answer questions. It was an extremely long exam, but I did well especially because I read the whole textbook and did 10 years of past exams as a practice. So, I think practice is highly important for any subject to prosper. (Naira, 4/10)

Naira discusses the rigor of her past physics course and the difficulty of the standardized exam. Such high stakes testing may promote fear, as Naira wrote on 1/28,

"I was afraid of physics." Naira attributes her success to practice, unlike Greg who assumes natural superiority and leadership in controlling his group's work. Successful male students may be viewed as having raw talent while successful female students are seen as quiet and hardworking (Carlone 2004). Students may embody this belief about themselves as well.

Naira, like Ivan, Louis, and Greg, performs characteristics associated with masculinity, including confidence and independence. In the following fieldnote excerpts, Naira prepares to present a homework problem with Sameer and two other female students. Their group was assigned part (A) of the following problem (Knight et al. 2009, p. 63):

> A light-rail train going from one station to the next on a straight section of track accelerates from rest at 1.1 m/s^2 for 20 s. It then proceeds at a constant speed for 1100 m before slowing down at 2.2 m/s^2 until it stops at the station. A) What is the distance between the stations? B) How much time does it take the train to go between the stations?

Naira stands at her seat leaning over the whiteboard, looking from her paper to the whiteboard as she copies down her work. Without looking up, she describes her approach out loud, "So we know velocity, the v is zero and we know vf … It's kind of complicated but I think it's correct." She writes and talks quickly without looking up. A female peer chimes in occasionally saying "yeah" to show her approval of Naira's work, but Sameer disagrees. He suggests, "But isn't it area?" Naira and Sameer exchange in a back and forth. Naira says, "But we don't know …" and Sameer says, "Isn't it?" Eventually, Naira shuts-down Sameer's suggestion and closes the discussion by saying, "We don't know. That's for this part. We already know the speed is the same." A female peer says, "Yeah." Naira continues writing. She continues to announce her thinking as she writes on the board: "And then 'a' is …" The second female peer remains quiet, watching as Naira writes. Sameer proposes a second time: "For some reason I get a different answer." Without changing her stance, leaning over the whiteboard with an Expo marker in hand, Naira looks up and affirms, "I actually got help from my sister." This interaction feels tense, and the first female peer tries to alleviate the discomfort of the confrontation by saying, "We will see when we go over it." A moment later, Sameer interrupts a third time: "But isn't it supposed to be the area under the curve?" The second female peer says, "I got confused" and the first female peer turns to explain to her. Meanwhile, Naira looks to Sameer and says: "You did it that way. Let me see." She looks over his work but continues to record her own ideas instead.

In this exchange, Naira takes charge of her group's presentation and attempts to work independently on their whiteboard. She announces her ideas as objective facts; her statements are not prefaced with "I think" or "I did it this way," nor does she ask her group members for suggestions or approval. Her dominant, confident, and assertive discourse is similar to that of Ivan, Louis, and Greg, and aligns with the notion of physics as authoritative and elite. Naira's confidence, assertion, and quick speed may suggest to Sameer and the two other female peers that physics is only understandable to a select few like Naira, and they are not included. Though Naira is female, her discourse of entitlement, confidence, and independence works to exclude others while promoting herself.

Sameer's discourse, on the other hand, is associated with traditional conceptions of femininity. Sameer is a male student from the Middle East. He interrupts Naira three times before she gives him her attention. He lightly nudges, "But isn't it area?" "For some reason I get a different answer." "But isn't it supposed to be the area under the curve?" He does not speak with the same conviction as Naira, and he is passive rather than assertive in his suggestions. He writes:

> Something that stuck out to me today is working with my group on the homework problem. I was listening to them say there are three parts to the problem, and in my mind I was saying excellent work. However, when it got to the point where we had to choose the formula, I stopped them and told them we cannot use the distance formula. The three insisted on using it anyway. I asked what answer they got and they told me 1730 m. Something is wrong… My group members said we are positive and I said I won't go against the three. I thought they could be right and I am wrong… After the professor stopped us when we were presenting, I knew I was right. But I learned one thing, that I must stick with my group members no matter because if I don't it will make me look like a stranger. It will even impact the teamwork and the enthusiasm of the group. (Sameer, 2/27)

Sameer mostly stayed silent while he observed Naira working on the whiteboard. According to his journal entry, he listened carefully to his group and kept his thoughts to himself, except when he thought they (i.e., Naira) made an error. Yet, his group mates' confidence (all three are females) and their majority opinion caused Sameer to doubt himself, when in fact they were wrong, and Sameer was correct. Sameer did not argue his way of thinking for what he considered to be for the benefit of the group dynamics. For Sameer, selfless collaboration was more important than the self-centered presentation of his thoughts. This viewpoint contrasts greatly with the words and actions of Naira, Ivan, Louis, and Greg, who each take control, argue, and believe they should be heard. His concern for others, complacency, and silence contrasts with a conventional culture of physics as independent, self-interested, and elite. In this moment, Naira's discourse associated with middle-class white masculinity dominated Sameer's modes of engagement, traditionally associated with femininity. In the end, Naira's ideas were presented on the whiteboard, and no one benefitted from Sameer's counter argument. Sameer writes about his decision to keep quiet:

> I agree that one must stand up for their point and disagree to a certain point; however, this never works in teamwork. When doing teamwork, there must be a consideration to everyone's answer and thoughts; however, at the end there must be an agreement, otherwise it won't be considered teamwork… I had this experience before in high school in physics class. I stood up in front of the class and said I got a different answer from my group members. Fortunately, I was correct, but I created hate from the group. They basically ignored me, but I apologized, and we became friends… Group work is sacrifice and agreement. [Even] if you are wrong, you at least created a team and an agreement and happiness to the group members. (Sameer, 3/6)

Sameer expresses his value of relationships and emotion and holds his independent thinking in order to create a team effort. In contrast to the views and performances of Ivan, Greg, Louis, and Naira, Sameer values the happiness of his group members over his pride in getting the right answer. Sameer's discourse and values do not align with his view of physics as authoritative and abusive. He writes:

> I HATE science so much! I really do. Back in my country I had the worst teacher ever. He used to beat up all the kids if they didn't know anything. He used a heavy stick made out of wood and beat students' hands. He hated me because he was conservative and since my family had American citizenship, he hated that fact. He used to call on me before he even teaches and asks me questions that I don't know. He made my life terrible. I hated science classes because of him. I had him as my science teacher for three years. (Sameer, 1/30)

Sameer's formative experience in science growing up in a Middle Eastern country involved judgment, discrimination, and abuse. He was expected to come to class already knowing, rather than come to class to learn. Corporeal punishment is unlawful in U.S. schools. Nonetheless, teachers may inflict harm by expecting students to know before even teaching them. Students with novice ideas may be viewed as lazy, stupid, or incompetent as opposed to ready to learn. Sameer's view of science as authoritative, unfair, and abusive does not align with his subjectivities as caring, collaborative, and selfless. Unlike Ivan, Greg, Louis and Naira, Sameer hates science, though his aversion may have nothing to do with the subject matter.

5.5.3 Subjectivities Are Dynamic and Gendered Performances Confer Status

Though Naira was domineering and assertive when working on her group's homework problem, she does not always perform roles associated with masculinity. During the last 4 weeks of the course, Greg and Naira were assigned to the same group with Sameer and another student. Greg described this group as "quiet," "intimidated," and "not as vocal," compared to his previous group with Ivan and Louis. Yet, these words do not describe Naira's performance when working on the homework problem presentation with her previous group. At times, Naira performs roles associated with masculinity, but other times she performs roles associated with femininity. The following fieldnote excerpt describes Naira's presentation of Part A of the light rail problem, and Ivan, Louis, and Greg's presentation of Part B. As a reminder, this is the problem:

> A light-rail train going from one station to the next on a straight section of track accelerates from rest at 1.1 m/s^2 for 20 s. It then proceeds at a constant speed for 1100 m before slowing down at 2.2 m/s^2 until it stops at the station. A) What is the distance between the stations? B) How much time does it take the train to go between the stations?

During problem presentations, the group presenting stands with their whiteboard in the front of the classroom and the rest of the class listens and can ask questions or make comments afterward. Sameer and his group members read the problem out loud, and Naira explains her thinking: "First I drew a graph … It accelerates at 2.2 and then slows down at 1.1." She explains that she worked on the problem in three pieces: speeding up, constant velocity, and slowing down. She found a distance for each segment and then added them to see how far the train went from one station to the next. She then states her final answer.

However, not everyone agrees. Louis, sitting in the back corner of the classroom, raises his hand and says, "I might nit-pick it because I did it my way. I used the equation $\Delta x = 1/2$ vf t." Naira calls back, "But we don't need the area," referring to the area under the velocity vs. time graph. A student in the middle of the room, calls out, "*B U R N* …," drawn out and exaggerated, as if to say *she got you*! The class laughs. Ivan and Greg chime in. Naira responds, "No, I'm not finding the area under it." Tension builds in the class as students call back and forth.

Though her answer was incorrect, Naira's performance of confidence, independence, and self-assuredness may convince others that she is good at physics. Such discourse allows her to take-on Ivan, Louis, and Greg. During the semester, only one other female argues against these three male students. Had Naira shown humility and uncertainty, Ivan, Louis, and Greg may have taken the opportunity to express her ideas for her. Instead, she holds her ground to the surprise of the class (as indicated by a student's comment). Naira gains practice and skill in this discourse of independence and confidence. By the end of the semester, she writes, "I loved everything [in this course] but one thing would be homework presentation" (5/15). For Naira, homework presentations elevated her social status by giving her access to the power that Ivan, Louis, and Greg display. Her masculine performance allows her to defend herself from their critique, while positioning her as someone good at physics. This positioning had little to do with her understanding of physics, but depended on her discourse and performance as independent, assertive, and elite.

Naira does not enact the same competition, confidence and entitlement that Louis, Ivan, and Greg have when presenting their work on part (B) of the same problem. Greg explains their board and states their answer to the question. Naira disagrees with Greg, but only quietly mumbles: "I got 80 seconds." A couple other students mumble they got 80 seconds too, but no one calls out to "nitpick" their work. After a moment, a male student raises his hand and says, "You said you …" He tries to repeat back how Greg solved the problem in an effort to find where he and Greg disagree. Naira's assertiveness followed by her silence suggests that she enacts masculinity to defend herself, but she does not use it as an offensive tool. Naira is outspoken when her own position is on the line. However, when Greg, Louis, and Ivan present their work, she keeps to herself. In fact, Naira is often quiet in problem presentations, except when she is presenting her own work. For Naira, the performance of masculinity is a tool she uses to her advantage at opportune moments, where patriarchal culture is rewarded with air-time, praise, and power.

5.6 Broaden Notions of Physics to Reach a Wider Range of Students

Three themes are presented in this study. First, middle-class white masculinity aligns with conventional notions of physics; second, subjectivities are not essential: a woman who likes physics and a man who does not; and third, subjectivities are

dynamic and gendered performances confer status. These three themes offer several points for discussion about physics education and subjectivities. The findings of this study support Hughes' (2001) work in that students whose subjectivities align with the presentation of physics are more likely to take-up positive physics identities. A conventional notion of physics as elite, authoritative, and rational resonated with Ivan, Louis, and Greg. These elitist characteristics are stereotypical of middle-class white men. The alignment of white middle-class masculine subjectivities with conventional physics gave Ivan, Louis, and Greg the confidence to dominate whole-class discussions and thereby define physics in an interactive classroom.

However, not all middle-class white males engage in this way, and some females and minorities engage similarly and differently. For instance, Naira and Sameer show how students perform gender differently. Naira acts assertive, dominant, and self-interested when preparing her group's whiteboard for a problem presentation. Naira shares her interest in "physical techniques … electricity and power," which are stereotypically masculine science topics for study. Naira's narrative brings into question, must a woman "act like a man" to connect with conventional physics? In other words, does a student have to take-on interests, dispositions, and discourses associated with normative masculinity in order to be successful in conventional physics education? Because individuals take on femininities and masculinities independent from sex, some women delight in conventional physics and some men do not.

As a male physics student, Sameer did not embrace traditional masculinity. He considered the group dynamic over his individual achievement. His selflessness, insecurity, and care are associated with normative femininity. The mismatch of his identity and conventional physics may have contributed to his dislike of physics though he was talented at solving physics problems. Could physics have been constructed differently to be more collaborative, friendly, and kind? Would Sameer have connected with this notion of physics?

5.7 Implications and Conclusion

Even in an active classroom, physics may still be constructed as elite, authoritative, and simplistic. As students engage with each other, particular subjectivities are privileged in discussions and group activities. Three male participants and one female privilege competition and knowing how to do physics. In addition, the role of curriculum and instruction is paramount. Traditional textbook problems reinforce the notion of physics as abstract, irrelevant, and simplistic. In a student-centered and constructivist classroom, the instructor designs the intended curriculum and plays the role of facilitator or coach rather than source of knowledge (Driver et al. 1994). The ways the instructor's actions (or lack thereof) reinforce or push against conventional notions of physics is ideal for a future study.

In conventional physics education, a dichotomous notion of physics is created, where physics is elite (not accessible); independent (not collaborative); and

competitive (not caring), to name a few. These terms are associated with middle-class white masculinity, while the words in parentheses are associated with femininity and are delegitimized in conventional physics education. This is problematic because it constructs a singular notion of what it means to do physics and who can do physics. This notion privileges middle-class white masculinity and leaves no room for students to negotiate their subjectivities to dis/connect with other notions of physics. It also discounts the importance of inclusion, collaboration, and care in the scientific endeavor. Therefore, physics teacher educators are tasked to broaden the ways that physics teachers think about physics and their students' multiple subjectivities. To support this desired outcome, teachers must be educated to critically examine constructions of physics and constructions of students' identities and to recognize the multiple and sometimes conflicting ways students negotiate their subjectivities in physics. Broadening and negotiating ways of doing physics that allows for multiple and differing subjectivities may encourage females and males to connect more in physics.

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