

Spatialized Injustice in the Contemporary City

Protesting as Public Pedagogy

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Educational Borderlands

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Intentions Crossing Borders into a
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Introduction

A great deal has been written about the ways in which school culture marginalizes some students based on social categories such as race, social class, and gender (Allen, 2013; Briscoe, 2014; Miller, 2018; Schroeter & James, 2015; Vass, 2018). The further a student's home culture is from that of the school or the further the individual student is from the school culture's conception of the ideal student, the more difficult their school experience may be. The way we, as educators, deal with the divergence of home and school culture is often dependent on how we conceptualize this problem.

Cultural border-crossing is a metaphor for transitioning between different cultural spaces. This metaphor can be used to facilitate the development of teachers' understanding of students' experiences transitioning from home to school and back. We can enhance this understanding further by considering the conceptual spaces in which these borders are drawn – the borderlands (see, for example, Clarke, 2013). Educational borderlands are defined as “the physical and/or conceptual landscapes where one must negotiate notions of cultural difference as she or he lives and learns—landscapes that envelop an array of pedagogical and cultural spaces, yet are typically guarded by exclusionary tactics” (Wilson, Ek, & Douglas, 2014, p. 1). This chapter will focus on high school physics, a high-status subject (Becher & Trowler, 2001) with exclusionary tactics that amount to symbolic violence (Connolly & Healy, 2004). Symbolic violence is Bourdieu's (1988) term for the process whereby subordinate social groups accept the dominant group's conception of who or what is worthy of admiration. Unlike Gramsci's (1971) conception of hegemony, which is an involuntary imposition by a dominant group on all others, Bourdieu posits a negotiated process of internalization of dominant norms (Connolly & Healy, 2004). In this study, high school physics provides a concrete example of how this symbolic violence can occur.

I begin with a description of the context in which the study that is the basis of this chapter occurred, followed by a description of physics practice and high school physics in particular, including its characteristics and

relative status within high schools. This will be followed by the specific experiences of the participants in the study. I conclude with a discussion of the wider implications of these findings.

Diversity, Schooling, and Border-Crossings

This study was conducted in Ontario, a culturally diverse jurisdiction. In Toronto, its largest city and the destination of seven out of ten of Ontario's new arrivals, almost half of the population is an immigrant. Further, more than half of those living in the Greater Toronto Area are visible minorities – South Asian, Black, Latin American, Arab, East Asian, West Asian, First Nations, Metis, Inuit (“2011 National Household Survey - Backgrounder,” 2011). Toronto is also culturally diverse with no ethnic group forming a majority (the highest percentage being Chinese at 12.7%) (Statistics Canada, 2017). All of this means that students are much more likely to be crossing multiple cultural borders (with friends, with teachers, within and between neighborhoods) as they attend school and go about their lives (Sparapani, Seo, & Smith, 2011).

Border-crossing implies both an existing structure and an intentional agent. Thus, the metaphor gives rise to a conceptual tension between structure and agency. On the one hand, we can discuss structural issues such as the nature of the border, the cultural spaces that it separates, and the relative statuses of those cultural spaces. On the other, we can use the agent as the object of inquiry – examining intentions and actions toward both the individuals in the cultural space the agent is trying to enter and their interactions with people in the culture to which they already belong. A critical approach attempts to address both structure and agency in its analysis because, as Hanson (2007, p. 155) states, “the critical approach argues that structure *and* agency are important in understanding sources of inequality” (emphasis added).

In many ways, educational borderlands are also normative spaces. They are differentially shaped by the agents' beliefs about what *should* be done. Indeed, the characteristics of educational borderlands are constructed not of events or rules but of perceptions of events or rules. They are conceptual spaces, built by the individual in response to his or her cultural milieu. Thus, the borders are fluid because the landscape is fluid but constant revisiting has artificially reified them in the agent's eye.

Teachers use their understanding of borders to inform their interactions with students but this understanding is based on fundamental beliefs about difference (Wade & Raba, 2003). Some teachers view difference as deficit (Waddell, 2011), as is poignantly described in Daniel's chapter in this volume. Some teachers, based on their own experiences, are ambivalent about the significance of the identities they bring to their teaching practice (Brand & Glasson, 2004). Novice teachers' beliefs about border-crossing are

important to examine because they are in the midst of making the transition from student to teacher, therefore, border-crossing is integral to their early development. Further, initial teacher education and the first years of teaching are crucial times where (student) teachers make decisions about the kind of teacher they wish to be and test the efficacy of their aspirations.

Symbolic Violence and Border-Crossings into High School Physics

Some research has been done on how racialized students navigate entry into school science. Costa (1995) studied the historic underachievement of Latino students in science and found that they struggled with the idea that if they wished to be good at school science, they would have to give up who they were. She noted that school science was not just asking them to learn content but be a certain type of person that they identified as White, male, and European, and students felt that they had to reconcile themselves with the idea that they could only be successful in science by letting go of their own culture and identity and embracing the dominant one. This personification and positioning of science is similar to the symbolic violence described by Bourdieu (Connolly & Healy, 2004). Similarly, Aikenhead (2001) demonstrated that Indigenous students were faced with the same identity dilemma as described by Costa (1995) when it came to school science. Since then, much has been written about the ways in which the alignment of science with the dominant culture makes border-crossing especially hazardous for some students (Aikenhead & Jegede, 1999; Barton & Yang, 2000; Lyons, 2006; Medina-Jerez, 2008; Teo, 2015). The danger is highlighted by the methods of border-crossing available to students. We can categorize the experiences and methods of students' border-crossings to/from school as described in Table 9.1. Type I represents a student who is already a member of the dominant culture. Type III (assimilation) is a method which amounts to succumbing to the symbolic violence of the transition. Type II (acculturation) is a method that requires a high level of skill and self-awareness. Arguably, this would be the ideal approach for a member of a marginalized community.

Costa (1995) and Aikenhead (2001) focused on archetypal identities and their connection to the experience of border-crossing. However, in this chapter, I will not categorize the participants. Rather, I will explore the act of border-crossing itself, into the Territory of Physics Practice, through its educational borderlands. Further, I am treating the educational borderlands as its own territory. Specifically, the Territory of Physics Practice is the cultural space where graduate students, post-docs, professors, and industry scientists engage in cooperative open-ended inquiry done via experiments, mathematics, and/or theory development on topics deemed relevant to physics. They are all physicists, thus citizens of the Territory of Physics

Practice. The educational borderlands surrounding that territory are populated by undergraduate programs and high school physics courses that must be navigated successfully in order to become a physicist.

The academic discipline of physics enjoys a particularly high status among the range of science disciplines within schools (Becher & Trowler, 2001) and it is used as an ideal of how science in general should be (Carlone, 2004). Further, because of the high status of the discipline, physics students are assumed to be smarter than the average student (Holmegaard, Madsen, & Ulriksen, 2014). Through stories about particular famous physicists (almost all of whom are White, European, and male), students in these courses learn who and how they are expected to be if they choose to go on to be a physicist. Like most school science, high school physics is mainly concerned with what physicists have done rather than giving students the experience of doing what physicists do. That is, school physics is highly individualized and focuses on reproducing and reinforcing known physical phenomena and famous experiments. There is virtually none of the open inquiry characteristic of physics practice (Carlone, 2004). In spite of and because of all of this, many students feel no affinity for the discipline (Holmegaard Madsen, & Ulriksen, 2014). This alienation from the subject is especially acute among women and racialized students, who are underrepresented both in physics courses and in the ranks of physicists and more so than in any other science discipline (Danielsson, 2012; Due, 2014; Hyater-Adams, Fracchiolla, Finkelstein, & Hinko, 2018). The findings to be presented in this chapter will shed some light on the experiences of four teachers who successfully entered the education borderlands of high school and undergraduate physics and how their experience of border-crossing relates to how they escort their students into that space and beyond.

Methodology

This chapter is based on and offers parts of the findings of a larger study that examined the beliefs of 12 preservice and new teachers. The four teachers

Table 9.1 Methods of Cultural Border-Crossing (adapted from Alston, 2004, p. 82)

	<i>Type I</i>	<i>Type II</i>	<i>Type III</i>	<i>Type IV</i>
Experience	Congruent worlds Smooth transition	Different worlds Border-crossings managed	Different worlds Border-crossings difficult	Different worlds Borders impenetrable
Method	Enculturation	Acculturation	Assimilation	n/a

featured here – Bill, Paul, Renate, and Franco (pseudonyms) – serve as exemplars of each of three of the four different experiences and approaches to cultural border-crossing described by Alston (2004) and summarized in Table 9.1. Type IV represents the choice of not crossing at all; therefore, it is outside of the scope of this chapter.

All four participants were recruited from a physics teaching methods course (see Table 9.2) and, for their first degrees, had majored in physics. Bill and Renate had recently immigrated from Alberta and British Columbia, respectively (two provinces in Western Canada).

Each teacher was interviewed at least three times over the course of their teacher education program and first year of teaching. The semi-open-ended interviews (which had preset questions but involved follow-up questions as needed) occurred during their one year in a teacher education program and one year later after they began their teaching careers.

The interviews, each of which ranged between 45 and 90 minutes, focused on the origins of the participants' normative beliefs about how and what they wished to teach their students. This was done through our discussion of their reactions to what I will call *critical incidents* (Nespor, 1987) – experiences which have stayed with them because of the ways in which they have challenged their agency and identity. Critical incidents are crisis points that involve choices that change the person experiencing them and, upon reflection, they are easy for him or her to identify. These incidents become permanent features of the educational borderlands that participants revisit again and again, as a justification for future actions and current beliefs.

All interviews were audio recorded and fully transcribed. Transcripts were sent to participants after each interview so that they could offer clarification or correction in the subsequent interview. Transcripts were also open-coded and then analyzed for themes through a process of de-contextualization and recontextualization (Tesch, 1990). These themes were verified with participants through a member checking interview which followed soon after their final interviews. Although they made factual corrections throughout the process, participants agreed with my overall analysis.

Table 9.2 Participants

<i>Pseudonym</i>	<i>Age</i>	<i>Race</i>	<i>Ethnicity</i>
Bill	Mid-twenties	White	Anglo Saxon
Franco	Early twenties	White	Portuguese
Paul	Early fifties	White	Anglo Saxon
Renate (pronounced "Renata")	Early twenties	White	German

I am a Black woman who immigrated to Canada at a young age and became interested in science late in high school. I majored in chemistry and taught high school science for a decade before moving into postsecondary education. In my experience as a student, the educational borderlands of high school and then undergraduate chemistry were hazardous. Indeed, having never gained a sense of being a science insider, I opted to stay within the educational borderlands of high school science and not move on to a career as a chemist. I recount all of this to provide the reader with a sense of my personal stance as I analyzed the data.

Findings and Discussion

The following analytical narrative begins with the participants' descriptions of the cultures of high school and undergraduate physics. This section is followed by a recounting of the critical incidents in their experiences of border-crossing as students. I then discuss participants' intentions for their students with respect to navigating the borderlands and end with a discussion of the implications of these findings.

School Physics Culture Is...

All four participants seemed to conflate the Territory of Physics Practice with the educational borderlands of high school and undergraduate physics. Beyond this, each participant had different perspectives on the matter. For example, Paul seemed to view school physics as a flawed meritocracy:

Physicists think highly of themselves. And they think highly of their field. And there are some reasons for that. Physics is a very rigorous science to be done at least in the style that it's done in a conventional university department. It's actually a sore point for me. I think that the way physics is taught and the way physicists think about teaching physics is very much based on their perceptions which are a self-fulfilling promise. If you have a system that extracts a very tiny fraction of the population then that refined group of people [is] going to think that what works for them works for everyone else. But the evidence is very clear that it doesn't.

Here, Paul acknowledges that the culture of school physics is perpetuated by the lack of diversity (however he defines it) of those who are physicists. He argues that recruitment of physicists could be opened up without negatively affecting the merit of those who are admitted to the field. Paul tended to view merit solely in terms of the ability to do physics – to understand concepts and their implications for further study. Indeed, all of the participants agreed that high intellectual ability was a key marker of those admitted

into the high school and undergraduate physics communities. For example, Franco commented:

There seems to be this idea out there that in order to do physics, you have to be mentally strong to get through it all because a lot of people find it very confusing and anything that comes out of physics is...really confusing for those who don't know anything.

However, Paul's concern with the state of school physics as a meritocracy did not acknowledge the modes of being expected from physics students. As has been highlighted by other researchers (see, for example, Brown, 2004), doing physics or any science is much more than lab skills and conceptual exercises and that "more" has a profound effect on who chooses to study physics (Taconis & Kessels, 2009). According to two participants, physics also seems to demand a pervasive materialist worldview. For example, Bill contended that physics knowledge naturally led to a secular worldview, using the experiences of his classmates in university as illustration:

I have had a conversation with at least one friend who felt like he was being left outside the loop because he was in a Christian family and had a bit of that upbringing. And eventually he was just led to abandon that. Another one...in his first year of university, he was Jewish and he pretty well made it clear to everyone towards the end of undergrad, he was shying away from that. I think, again, he felt that he was being left out because of that. On the other hand, that may have just been his personality doing that.

In this quote, Bill seems to attribute his two classmates' abandonment or concealment of their respective faiths to individual decisions and personality while glossing over the culture that seemed to make them uncomfortable. Yet, he does use phrases such as "led to abandon" and "being left out" which seems to indicate that these decisions were influenced from without. In other interviews, he mentioned the times when he and his other classmates would discuss their disapproval of religion in front of their religious colleagues (once while attending a dinner party at a Christian colleague's house). Although some authors have suggested that there is generally no conflict (Glennan, 2009), there was no indication that Bill thought that there was any space for religion in physics practice. Paul agreed, referring often to the Intelligent Design vs. Evolution debate. Still, both Bill and Paul were adamant about not simply separating religion and science but using the latter to defeat the former.

It is not my intention, here, to debate the merits of the materialist worldview and/or the benefits or pitfalls of religion in science practice. This has

been and continues to be discussed elsewhere (see, for example, Ceglie, 2013; Reiss, 2009). Nor am I implying that physics practice is necessarily anti-religious (as opposed to non-religious). Rather, I am pointing out that Bill and Paul both perceived school physics as justifiably anti-religious and saw this as a significant enough topic to raise continually during the interviews. Interestingly, Renate, a Mennonite, never mentioned a conflict between her religion and her studies, which suggests that such conflicts are not necessarily as simple as they appear (Donnelly, Kazempour, & Amirshokoochi, 2009). Her religious beliefs were an important factor in her experience as a physics student but, as will be discussed later, in ways that were different than one might expect based on Bill's comments.

In spite of gains in the other science disciplines, we know that women continue to be the minority in physics courses designed for physics majors (Hazari, Sadler, & Tai, 2008). Yet, Renate was the only participant out of the four to mention it as a concern. Even so, when Renate discussed the ways in which a classmate was left out, the critical incident that she used to illustrate her ideas about the educational borderlands of physics related to a male university classmate during the final year of her program. The program was based on a nuclear physics component and this classmate had objected to the exposure to radiation.

Some sort of mocked him because they felt that he was just trying to make trouble. And they didn't really take his concerns legitimately. He wasn't that well received before this. And so I don't know if that influenced their treatment of him on this issue— sort of ignoring the issue and continuing to dislike him, argue with him....He was a brilliant theoretician. But, yes, he was being rejected by the community. But I don't think it was because he didn't fit in the stereotypical physics. I think it was because of his opinionated aggressiveness....There isn't necessarily the room for emotion in physics...It's true.

It is important to note here that her classmate, a male, was not the first to make this complaint about working with the radioactive material. Another female classmate who was pregnant had raised similar objections and had been accommodated. Considering Renate's reaction to the incident, first, she mentioned the female colleague's experience as a matter of fact and then concluded with the above statement. Apparently ignoring the questions that such a discrepancy raises (e.g. double standards), she, like Bill, focused on her classmate's character and dispositions as the reasons for the department's reactions to his protests. Renate's characterization of her classmate illustrates the expectations of the physics department for how a physics person should behave and the ways in which the community encourages desired behavior. Renate reduces the clash between dominant expectations

and individual behavior to blaming the individual who is not fitting in. Still, Renate does acknowledge at the end that “there isn’t necessarily room for emotion in physics.”

The incident Renate describes and her response to it, leads to the question, what does this say about the ideal physicist, from a physics student’s perspective? Throughout school, the ideal physicist is tacitly conveyed to students through stories about the heroes of physics (Becher & Trowler, 2001). As Franco put it:

I used to hear about all these heroes like Albert Einstein and all the others— Bohr and the rest. And they were made out to be like superheroes of intellect....And then you hear about their personal lives and they often led very strange [lives]. [They were] kind of strange people as a whole apart from their work.....And I don’t know what induces [it]. Is it just the physics that attracts kind of strange people or is it because when learning physics you also become kind of strange?

Renate had similar concerns:

Many physicists that we looked at....their personal lives are sort of chaos because of their passion for physics; because of their drive to do calculations.

Apparently, then, Renate believes that physicists are allowed to be passionate about their calculations but nothing else. Both Franco and Renate seemed concerned by the apparent imbalance between greatness in physics and a balanced life. Franco described the personhood that he feared in detail:

Very mathematical. They have poor social skills. The kind of nerdy type of person. They’re really into computers, into technology....I don’t want to say lacking personality but they seemed just sort of one tracked.

What Franco describes above is a stereotype, but that stereotype represents good science students who will someday become good scientists (often equated with physicists) and this is precisely the image that causes students to reject science careers or school science altogether (Aschbacher, Li, & Roth, 2010). Indeed, that was certainly one of the participants’ concerns. However, I want to focus on how the participants, who were quite successful in science, viewed these stereotypic images.

We tend to assume that if students who rejected these stereotypic images in turn rejected science, then those who embraced science must have either identified with these stereotypes or known better than to see them as true or ideal.

The comments of these four teachers do not support that assumption. Bill, Paul, Franco, and Renate were students who were successful in the educational borderlands of physics and continue in careers related to it. Yet, they describe physicists in more or less stereotypical ways – unemotional, non-religious, wedded to abstraction, intent on conformity with heroes who seem to illustrate unbalanced lives. The four participants all seem to agree on the characteristics of the citizens of the Territory of Physics Practice. All did fine in high school but each experienced undergraduate physics quite differently.

Critical Incidents and Border-Crossing

Data from this study indicate that there is a difference between a teacher who always felt comfortable in school science culture and one who experienced an explicit border-crossing. If a (student) teacher remembers crossing a border into science, chances are that the border-crossing was difficult. Two of the participants recounted incidents of border-crossing – Franco and Renate. Franco said:

I really noticed that just the kinds of people that get turned on by physics or who end up taking physics, they all sort of fit into one sort of category that I never felt that I belonged to. And even in my classes I felt almost secluded in a way because I didn't fit in with these people on a personal level or my professors.

When Franco first arrived at the university for his undergraduate studies, he felt alienated. His dormitory had been deliberately filled with other physics students to encourage camaraderie among them but he felt out of place:

For me, I guess I felt maybe not as prepared. It seems like I had, in a sense, chosen physics on a whim, almost just because I found it interesting. But most of the people there seemed to have been into physics since grade school....They knew a lot more about it than I did. It almost seemed like they were partners in the school culture that I just wasn't a part of. A lot of their parents were into the physical sciences, whether engineers or physicists or what have you. So, it seemed close knit because they all knew certain things that I necessarily didn't know about right away.

Franco had obviously crossed some sort of border that he hadn't known had existed. It appears that he had thought physics study was content but had discovered all at once that it was much more than that. He appears to have decided that this difference was a deficiency on his part – not being prepared – and he knew he was not like them. Franco never mentions an explicit act of rejection on the part of his peers. What he does indicate, though, is how he felt like an outsider. His numerous references to that first moment in the

dormitory during interviews indicate how that incident colored all of his experiences in undergraduate chemical physics from then on. Paul, too, had noticed that he was different from his classmates:

Yes. I'm not like them. Because I'm really not that good at math....with my colleagues when I was a student and when I was in research, I would always be explaining it physically and they would just be writing equations on the board. I would say, "No. No. You don't need those. You know we can explain it without the equations." They would say, "Well, why would you do that?" So, there's no doubt I think a bit differently about it....that's almost certainly why I see that there are different ways to teach it....I think you can certainly teach some concepts of physics without ever putting a number or an equation on the board....[but] you have to be careful that you have to provide other opportunities for students who really want the physics and need and can appreciate the physics the way it's taught now.

Paul is apparently comfortable with physics as a category of knowledge but is aware of and dislikes the way school physics has shaped that category. He sets himself in opposition to the dominant group while arguing for an equal but parallel way to understand and do physics. Yet, he does not reject physics as it is currently practiced and is careful to try not to disturb it. Again, he argues for a broader conception of merit without threatening the dominant structure.

Renate, too, recognized she was different within school physics:

Maybe it was a pride issue as a kid but it was an area that I seemed to do well at that not everybody did well at. So I enjoyed that very much. In high school I pursued physics....but I pursued physics partially as a challenge because I enjoyed the mathematics so much and also, again, there were two women, two girls in grade 11 and in grade 12 and so it was kind of a challenge I looked forward to taking on. And I was never belittled for trying it by any of my male teachers. I was always very much encouraged, kind of, as if they were surprised, partially, because I was a female, that I was interested and also that I would then proceed to do well....it boosted my confidence.

Renate clearly recognized that as one of only two women in her physics class, that women, in general, are rare in physics (Götschel, 2014). There is some evidence that the assignment of various school subjects to gender categories is an open secret among high school students and that such assignments affect the social status of girls and boys who take courses that counter the stereotypes (Kessels, 2005; Tonso, 2007). However, Renate was also proud of the fact that these stereotypes did not negatively affect her achievement. There may be a connection to the critical incident she had

recounted about the classmate who was rejected by the community because, in her view, he was too emotional. It could relate to the dichotomies our society ascribes to gender: emotion tends to be connected to the feminine rather than to the masculine (Anderson, 2002), and Renate, the only female among the four participants, was the only one who found lack of women and emotion in physics interesting enough topics to raise and discuss.

In the end, Renate reacted to her experience of being one of few women in physics by using it as an instrument to build confidence rather than to diminish it. This may be why, when she encountered information that contradicted the ideal descriptions of science she had gotten in high school, she was able to dissociate from it (as she had with the incident with her classmate) or embrace it positively when her heroes were pushed off of their pedestals. As she put it:

That sort of opened my eyes because we hear one official story in the textbook....Then we hear a little bit of the story and it's just a snippet and its one person's perspective. And hearing, then, from [this professor] some of the other [parts of the story, such as], "You know you've probably never heard this about Newton but there's also a story that says he behaved in this sort of way." We think if someone is brilliant and they gave us this formula then we should honour their story and not be concerned; so it was interesting for [my professor] to say, "Yes, maybe he didn't really come up with this on his own. It was something he probably snatched from this person." Those kinds of dynamics came out in that [physics] class.

Her recounting was calm, with an "isn't that interesting" tone. This is in contrast to Franco, whose experience seemed more disturbing.

I was very upset when I took the philosophy [of science] course because it was an elective. I chose to take it. And, I thought, "Holy smokes. There's all this to physics and I haven't even been introduced to it yet? And I would have graduated not knowing what I'm learning now?" I was very upset with that because I wanted to ask them, "How could you design a program and send me out and not let me know about the whole impact of the ethical and moral and the whole social implications of everything that I've been learning?"

He was very agitated about his experiences in this course, as if he felt betrayed. He had done very well in chemical physics and begun a Masters in the subject. Perhaps his anger alludes to how he had invested emotionally in a physics that he now no longer believed to exist. It seemed that, in the past, his challenges joining the school physics culture could be attributed to interpersonal conflicts and tensions. The messiness of physics practice itself,

however, was another thing altogether. Perhaps, Franco had depended on the stability of physics as a subject in order to navigate across the social border from home to physics class. Perhaps now, from his perspective, that stability was gone.

Bill described no personal incidents of discomfort about his own experience as a physics student, though he did repeat critical incidents relating to others' discomfort. In fact, he reported always feeling at home and only mentioned discomfort when he was asked directly during the interviews. Similarly, Paul described feeling different but recounted no critical incidents or conversations or events to which he could point that illustrated how he felt about being different. Thus, while Paul's alternative take on physics created discomfort for him due to both the interpersonal (thinking differently) and the structural (only particular ways of thinking are rewarded), his border-crossing was qualitatively different from a situation where his very personhood felt threatened. Who he was as a person was never under scrutiny. Indeed, as he said himself, he could look around and see others like him everywhere.

Renate had grown up in a religious community that deliberately set itself apart. She had spent her whole life consciously and deliberately crossing borders between public and private life, surrounded by a community that was constantly doing the same. However, Franco, a man of Portuguese descent, had grown up in an urban center where he was a member of an identifiable group that, at that time, was much more likely to drop out of school than the general population (Brown, 2006). For Franco's community, his decision to go to university, start a Master's degree, and eventually become a teacher was unusual. Though he never said that his family disapproved of the decision, when he felt out of place, he had very few resources for navigating the educational borderlands. Thus, according to Alston's (2004) scheme, Bill's and Paul's cultural border-crossings were done via enculturation (smooth transitions between congruent worlds). For Renate, it was via acculturation (managed border-crossing between different worlds) and Franco's was via assimilation (difficult border-crossing between different worlds).

Here, it makes sense to describe the borderlands implied by the participants' experiences. Then we can move on to their teaching practices and their methods of traversing these borderlands. Alton (2004) describes three types of border-crossing (see Table 9.1): Type I represents a student who is already a member of the dominant culture. Type III (assimilation) is a method which amounts to succumbing to the symbolic violence of the transition. Type II (acculturation) is a method that requires a high level of skill and self-awareness. Bill's borderlands may be imagined as a well-manicured and professionally landscaped one. The borders inscribed on it are solid and heavily guarded. Bill is a full citizen of school science, born and raised, thus his approach to border-crossing was enculturation (Type I). Paul's borderlands may be described as relatively rocky and sometimes difficult to navigate.

The borders inscribed on it are solid with numerous and clearly marked checkpoints for crossing. He seems to believe that the border guards require some supplemental training on identifying talented immigrants who have what it takes to be successful. Paul, then, is a full citizen of school science, born and raised, though he occupies a sub-culture within the larger one; thus his method of border-crossing is also enculturation (Type I). Franco's borderlands are similar to Paul's except that the checkpoints on his borders are not clearly marked. He cannot speak the language of the border guards. Having treated his home culture as something to leave behind, Franco has chosen assimilation (Type III) as his method of border-crossing. Renate's borderlands were rocky with checkpoints along the borders. Using her ability to negotiate with the border guards while living in one place and working in another, her approach to border-crossing is acculturation (Type II).

Having defined the territory and described the state of the educational borderlands thereof, we are ready to reexamine the participants' intentions with respect to ushering their own students across the border.

Navigating the Borderlands

Bill expressed no intention to usher students through the borderlands of school science. His main concern was student motivation, though, interestingly, he seemed to assign the root of motivation to [literal] immigration status. As he put it:

I knew that there were a lot of students who were there who didn't really want to be there. And because of that there were some behavior problems and that was what I pretty much observed from students who did not want to be there. Students that wanted to be there, well, they're pretty much going through the same thing I went through....I guess the school is mostly people that recently immigrated. So people that aren't really...not necessarily stable families that they're living in. And, I guess those could be two different things...and, because of that, I guess, your concentration wasn't necessarily on academics, on school work. That was quite different from the school I had gone to in which quite a few of the courses I was in then were either AP or IB. So, pretty much all the students want to be there and because the school has those two programs I think it influenced all the other students that were there as well.

I include the entire quote to illustrate that, in Bill's mind, if students in grade 9 were acting out, it was because of the individual students and their circumstances and not because of the way the course was being taught or the relevance of the material or anything else within the classroom. He also expressed problematic views about a link between students' status as immigrants and the stability of their families. Further, he noted that the students

who wanted to be there were like him and they were, one assumes, the only students he needed to focus on. Since, for Bill, school and home culture were congruous, and the border around school science invisible, it is not surprising that he blamed lack of engagement on his students. In the absence of an awareness of structure (the borders), Bill simply saw the agent as fully responsible for their success (or failure) with no recognition of structural barriers.

Paul seemed to struggle with the implications of an approach such as Bill's. On the one hand, he wanted to open up physics to different ways of thinking. On the other, standards needed to be maintained:

But there are limits to what people are capable of and the trick is finding the five students who are interested and, of those five, probably one are capable....if you don't teach to them, to some extent, at least, then they won't be prepared and they won't go forward....I think there's a social responsibility even to do that.

Paul's clear intention is to preserve the meritocracy that he believes to be part of the structure of physics. His intentions for physics teaching are about ability, not culture, about efficient recruitment and not inclusivity of students from various cultural backgrounds. His borderlands may have been rocky, but he still wished to maintain the border as it was – tweaking the rules of admission to be more aligned with talent than with students' favorite approach to thinking about physics (abstract or concrete).

Paul is an interesting case because, in spite of his discomfort entering the community of practice of physics, I do not think his discomfort is the type described in the literature (see, for example, Allen, 2013; Gotschel, 2014; Holmegaard, Madsen & Ulriksen, 2014; Hyater-Adams et al., 2018) when a student's border-crossing is hazardous. In other words, he did not describe a clash between home and school culture or difficulty seeing himself as a physicist, either by recounting a critical incident or otherwise. In line with this experience, although Paul resolved to teach physics using more concrete terms, the students who would have done well in any case are still his priority.

Franco, though, had different goals based on his reflections on what he believed school physics seems to hold up as the ideal:

If you look at different subjects, people who take geography or any other subjects like English or something, the personalities are varied. You get people from all sorts of walks of life who for some reason get drawn to a certain subject but in physics you don't see that as much and I'd like to change that in teaching physics....I really wanted to show that it's not that the subject is restricted to the kinds of people who historically have been taking it.

In order to open up physics to other kinds of people, Franco's approach was to personalize science. Having had an alienating experience entering school physics and having been keenly aware of how out of place he felt, Franco's response had been to assimilate. This had resulted in his becoming a successful science student. Although he wondered at the consequences of that decision, he did not question its necessity. His response was to try to help his students to assimilate by making things more personal. His expressed hope was that his students would not feel the way he had felt when he had arrived at the university. Franco was very unsure how he would realize his goals and, though he certainly had the potential to relate school science content to students' interests, effective methods described in the literature (see, for example, Brown & Kloser, 2009) seem to require an understanding of the border that Franco did not possess. As noted earlier, I imagine that Franco's borderlands had checkpoints along the border, but he was unsure of where they were because the structural aspects of his journey seemed largely obscure to him. It was as if he had stumbled across the border in the dead of night and now, in the light of day, although it was obvious that he had accomplished his goal of gaining citizenship, the terrain on which the border was drawn seemed unfamiliar. He was therefore unable to map a route to help his students across. Instead, he focused on helping them to see that they did not have to *be* anyone but themselves to do so.

Renate, too, had as her main concern, a desire to teach her students to relate what they learned in science to their own lives. However, she realized that because this approach, while mandated by the jurisdiction's curriculum guidelines, was not the way science tended to be taught, a cultural shift needed to occur within school science:

It's the expectation of the curriculum that you will cover this topic [through] [science, technology, society and environment] and applications. And I think...it might be poorly received at first....It's maybe not the conception that even this generation of teachers has grown up with. So once we've started working through it and once those students that are coming through the system now have seen it, I think it will become more integrated.

To her, changing the way science was taught was a prolonged negotiation. Her autonomous acculturation within high school and undergraduate physics meant that she could think about and analyze the implications of many citizens with dual citizenship, over time. In other words, it could take a few generations, but a culture could change simply by virtue of the fact that more and more diverse immigrants bring their own worldviews and ideas to their work. There appeared to be no reason, in Renate's mind, for an immigrant not to believe that they could have this sort of influence. Apparently,

having learned how to navigate cultural border-crossings by virtue of her religious affiliation, she was able to extend this to her education. Renate's borderlands may have been just as rocky as Paul's and Franco's. However, she had a clear picture of where she had come from, where she was, and where she was going at any given time. Consequently, her approach to facilitating her students' border-crossings as she began teaching was to make the border's fluid nature more apparent to her students and colleagues. There are not many examples of what this would look like in the literature. Most research seems to focus on getting marginalized students interested in science but very little is written about how to help them to enter school science designed for science-technology-engineering-mathematics (STEM) majors. In fact, in her first year of teaching, Renate struggled with realizing her goal of opening up physics to young women.

Conclusions and Implications

Clearly, the experiences of these four novice teachers negotiating the educational borderlands of high school and undergraduate physics influenced their intentions with their own students. All four had surprisingly stereotypical views not only of school physics but of physicists. Yet, all had successfully navigated the borderlands of a highly exclusive discipline (Teo, 2015).

The participants' choices in their border-crossings had a profound effect on how they approached or intended to approach helping (or not helping) their students to do so. Both Bill and Paul had been enculturated into school physics. Bill was satisfied with his entry and perceived no unjustifiable barriers. Paul, on the other hand, was uncomfortable with the criteria for judging who is capable of doing physics well, though not quite willing to challenge the culture that developed those criteria. Renate had crossed the border via autonomous acculturation and so viewed her task as helping her students to bring their home cultures and science culture together for resolution within themselves. Franco had assimilated and wanted to help his students to assimilate less painfully – perhaps not recognizing that, at some level, assimilation is always painful because of the rejection of cultural heritage that is necessary to do it. He was the one who experienced the full brunt of symbolic violence that the dominant culture can inflict on members of marginalized groups.

Interestingly, none of the participants gave much significance to the structure of school physics and the image it holds up as the ideal scientist, ascribing all responsibility to intra- and interpersonal issues. This lack of acknowledgment of existing social structures within the culture of school physics and consequent overemphasis on individual agency may partially explain, for example, Renate's frustration opening up opportunities for women in physics as much as it explains Bill's lack of recognition that a

border exists at all. As noted earlier, a critical approach requires attention to both structure and agency (Hanson, 2007), and I would argue that a critical approach is necessary to tackle problems of inclusiveness in any social institution. Thus, in the absence of a clear acknowledgment of the structure of the educational borderlands, none of the four participants are likely to be successful helping marginalized students to navigate meaningfully through school physics.

Symbolic violence within educational borderlands is easy to overlook when it is embedded in a message of intellectual achievement. This is especially true when teachers focus on a “You can be this way, too” message, as they hold up an image of someone who is nothing like their students. This approach says implicitly to those students from non-dominant groups that if they are successful in the educational borderlands of high school and undergraduate physics, it is in spite of who they are. Whether it is processed as flattery (as Renate took it) or self-blame (as Franco took it), forcing students to internalize the idea that who they are is a liability for their ambitions is a violent act.

To be clear, high school teachers, who never engage in actual physics practice, never leave the educational borderlands. Instead, they act as the first line of border guards and that is why understanding their experience is so important.

These four cases are specific to a particular time and place but they do provide a vivid illustration of the ways in which teachers’ own experiences color their normative beliefs of how things *should* be. For example, Paul had experienced learning physics through imagining real-world applications (unlike his colleagues who focused on mathematical constructs) and so he believed physics as a discipline should be more open to other approaches to conceptualizing it. Franco had experienced the shock of recognizing that there was a social aspect to physics (beyond just concepts and theories) that he had not known about and so believed that physics classes should explicitly teach about it.

We can use discussions about the stories of these four new science educators to inform teacher education designed to support inclusive science teaching. From a teacher education perspective, since almost all science teacher candidates have managed to find their way into school science culture – with a much smaller group having found their way into school physics – introducing the idea of educational borderlands allows us to discuss the origins of teachers’ intentions for developing inclusive teaching practices and provides a rich metaphor for that discussion by making explicit connections between structure and agency.

The culture of school science is foreign to many students and bringing those students across the borders is not easy. However, the motivation for teachers to take on such challenges may require more than simply informing the teacher candidates of the existence of educational borderlands and

teaching them about inclusive approaches. For the teachers featured in this chapter, at least, their motivation came from the critical incidents that shaped their experiences of border-crossing.

Critical incidents not only define what teachers feel they *can* do to help their students navigate the educational borderlands of Physics Practice but they also define the structure of the borderlands that can render certain paths to appear impossible or seem invisible. This, in turn, leads to beliefs about what they *should* do that may be based on a misapprehension of the nature of the educational borderlands in question.

Teacher education can intervene. At the time when they were experienced, critical incidents were pivot points and crises in the participants' lives. Revisiting them from a different perspective could make their contingency apparent, highlight different choices, and inspire them to be more conscious of their intentions and the origins of them. Teacher educators can also create critical incidents for their students so that they can conceive of borderlands that are conducive to more inclusive teaching practices (see, for example, Solomon, Levine-Rasky, & Singer, 2003).

The goal of all of this should be to encourage autonomous acculturation by students because this would appear to be the least violent approach to border-crossing. It requires a great deal of skill, flexibility, and self-awareness but, given the increase in diversity of the student population, is most likely to lead to an enriched and inclusive school culture that minimizes marginalization.

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