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Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA  
SANTA CRUZ

**DISCOURSES OF POWER IN SCIENCE TEACHER BECOMING:  
SCIENCE AND EQUITY IN CONFLICT**

A dissertation submitted in partial satisfaction of  
the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

EDUCATION

by

**Caroline T Spurgin**

December 2021

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2021

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## **Abstract**

Discourses of Power in Science Teacher Becoming: Science and Equity in Conflict  
Caroline Spurgin

Experiences preservice teachers (PTs) have in their preparation program can directly impact their use of effective and just pedagogy in the classroom (DarlingHammond, 2000; Tolbert, 2015; Stoddart, Pinal, Latzke, and Canaday, 2002; Bravo, Mosqueda, Solis and Stoddart, 2014). However, researchers in the field of Education have struggled to make sense of the impact that teacher preparation programs have on teachers and their practice, particularly with respect to issues of diversity, equity, and justice in instructional theory and practice (Cochran-Smith et. al, 2015; Tolbert, 2016; Ladson-Billings, 1999; Waghorn and Stevens, 1996). This dissertation addresses the field's need for new analytics that can be used to gauge the actual, in-the-moment impact that equity-oriented teacher preparation activities have on preservice teachers' orientations with respect to students and equitable science instructional practices.

This study employs a longitudinal case study design and Critical Discourse analysis to investigate in depth how hegemonic power was enacted, resisted, challenged, and transformed in an equity-oriented science teacher preparation program (Creswell, 2014; Moje and Lewis, 2007; Gee, 2015; Fairclough, 1992). Analysis is guided by a critical sociocultural framework. My purpose was to add to our growing understanding of how systemic, structural, historical, and ongoing harm is sustained in and through equity-oriented science teacher preparation.

Findings from this study reveal some of the ways in which hegemonic power acts in and through science teacher preparation. Through my analysis of two classroom discussions, I highlight Discourses of power that were enacted in/through the activity system. The first discussion, presented as Vignette I, concerned learning theories and their applications in science classrooms, and my analysis highlights the competing ideological and ontoepistemic assumptions embedded in the learning theories and Discourses. The second discussion, presented as Vignette II, centered on two preservice science teachers' reading of two articles on equitable science instruction. The PSTs' differing disciplinary discourse enactments engender a subtle tension, and the disciplinary literacy practices of western natural sciences enacted by one PST become an obstacle to sensemaking for the small group involved.

My hope is that through building understanding of these issues, this study may generate new possibilities for reparation, care, and more just ways of being and learning in and beyond secondary science classrooms.



## Dedications and Acknowledgements

*“Education is about healing and wholeness. It is about empowerment, liberation, transcendence, about renewing the vitality of life. It is about finding and claiming ourselves and our place in the world” (hooks, 2003, p. 43).*

I consider myself absurdly fortunate to have had the privilege of taking this doctoral journey in and through Education. To have had this opportunity to light my mind on fire for six years is a gift I never expected to receive and one that I can only hope to reciprocate as a member of the field that has welcomed me.

I am grateful to my parents and grandparents for teaching me the joys of learning, and particularly for creating space and time and opportunity for me to fall in love with books and the rich worlds they hold. I am grateful to my siblings, Kate, Sarah Grace, and Richard, my first and favorite interlocutors, for keeping me sharp and sufficiently (in)sane. I am grateful to my other sisters and little mothers, who remind me that hard work demands celebration, and that focus is fed by expansion.

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To all those named above: thank you for helping me learn, and through learning, find healing and wholeness, empowerment, liberation, transcendence, and vitality. Thank you for helping me find and claim a place in the world.

## **Introduction**

Experiences preservice teachers (PTs) have in their preparation program can directly impact their use of effective and just pedagogy in the classroom (DarlingHammond, 2000; Tolbert, 2015; Stoddart, Pinal, Latzke, and Canaday, 2002; Bravo, Mosqueda, Solis and Stoddart, 2014). However, researchers in the field of Education have struggled to make sense of the impact that teacher preparation programs have on teachers and their practice (Zeichner and Tabachnick, 1981; Lortie, 1975; Pitkäniemi, 2010; Waghorn and Stevens, 1996; Korthagen and Kessels, 1999; Wideen, MayerSmith, and Moon, 1998), particularly with respect to issues of diversity, equity, and justice in instructional theory and practice (Cochran-Smith et. al, 2015; Tolbert, 2016; Ladson-Billings, 1999; Waghorn and Stevens, 1996). This dissertation addresses the field's need for new analytics that can be used to gauge the actual, in-the-moment impact that equity-oriented teacher preparation activities have on preservice teachers.

This study focused on preservice science teachers (PSTs) and science teacher preparation because sociopolitical issues in science teacher preparation are particularly understudied. Research in science and technology studies, and on the preparedness of science teachers to use equitable instruction with diverse learners, indicates that there are very significant equity and justice issues that intersect with science teacher preparation, making this a fruitful area for study.

The purpose of this study was to use longitudinal case study (Creswell, 2014) and Critical Cultural Discourse analysis (Moje and Lewis, 2007) to investigate in

depth how hegemonic power is enacted, resisted, challenged, and transformed in an equity-oriented science teacher preparation program.

Tolbert and Eichelberger (2014) demonstrated how Discourses of power can be enacted in teacher preparation programs, often by other PTs, that put minoritized students in the position of having to “survive” their programs. Alternatively, Discourses of power, enacted during science teacher learning activities, can preserve and perpetuate teacher beliefs and practices that are likely to engender harm once the PTs enter classrooms (Yerrick and Johnson, 2011; Sheth, 2019; Carlone, 2011). The ways these Discourses are negotiated can limit students' opportunities to learn (Moje and Lewis, 2007; Tolbert and Eichelberger, 2014), thus mitigating the potential impact that university-based teacher preparation programs can have.

Analysis is guided by a holistic, critical sociocultural framework of teacher development, described as *teacher becoming* (Nasir and Hand, 2006; Moje and Lewis, 2007; Gutierrez, 2013). In this study, I draw on several additional theoretical frameworks that are commensurate and synergistic with critical and sociocultural perspectives, including Critical Discourse Analysis (Gee, 2015; Moje and Lewis, 2007; Foucault, 1982), and feminist notions of care (Haraway, 2016, Puig de La Bellacasa, 2017; Stengers, 2018; Tuck, 2009).

This project is guided by the following research questions:

1. How is hegemonic power reproduced in and through classroom discourse in an equity-oriented science teacher preparation program?
  - a. What Discourses of power are called into play?
    - i. What Discourse models and identities are enacted that perpetuate Discourses of power?

- ii. How does this shape opportunities to learn in activity?
- 2. How is hegemonic power challenged, resisted, and transformed in and through classroom discourse in an equity-oriented science teacher preparation program?
  - a. How do PSTs respond to Discourses of power when they are enacted by peers?
    - i. What Discourse models and identities are enacted that challenge, resist, transform, or perhaps imagine beyond hegemonic power?
    - ii. How do PSTs exercise agency to disrupt hegemonic power in classroom learning activity?
    - iii. How does this shape opportunities to learn in activity?

This study is designed in part as a response to Tolbert and Eichelberger's (2014) call for greater attention to the ways that Discourses of power place undue burden and suffering upon minoritized preservice teachers. It is a response to activity theorists' calls to expand activity analysis to forefront the workings of power (Nasir and Hand, 2006; Moje and Lewis, 2007; Gutierrez, 2013). It is a response to the many preservice science teachers I have worked with over the last six years who have wondered: *How do we teach science equitably? Is equitable science teaching actually possible? Isn't science just science? What does it have to do with justice?*

**Teacher Becoming: Teacher development as a sociocultural process involving learning, identity, agency, and power**

Because this project focuses on pre-service teachers in a preparation/educational setting, and is concerned with science teacher development, it is necessary to explicate exactly what is meant by *teacher development*. *Teacher becoming* is the term I'm using to describe the process through which novice teachers

develop and wield *identities, agencies, knowledges, and power as teachers*. I follow Nasir and Hand (2006), Rahm (2010), and Settlage (2011) in doing so. Many would call this process simply teacher learning, teacher identity development or teacher agency development--but I desired a term that would implicate all these terms without implying primacy of any of them. This term has been used by others to refer to different phenomena, for example, Mensah Moore (2008) (among others) uses the phrase *becoming* to reference teacher identity development, specifically. I respectfully claim it for a different purpose.

### *Critical Socioculturalism in Teacher Becoming*

While it may be unusual to refer to this particular phenomenon as teacher becoming, it is not at all strange to conceive of *agency, identity, learning, and power as integrated and mutually constituting*. Sociocultural theories of human development and social practice introduced the mutually constitutive nature of identity, agency, and learning decades ago, at the beginning of what is now being called *the sociocultural turn* in the social sciences.

Diverging from his individualist contemporaries in Western Psychology, Vygotsky incorporated Marxist thought to construct learners as social beings first and foremost -- as historically, culturally, and socially contextualized (Vygotsky, 1978). In Vygotskian thought, human action, and thus human agency, subjectivity, and learning, is always mediated by sociocultural/sociohistorical artifacts.

Sociocultural theories have become ubiquitous (at least nominally) in

Education research, providing the theoretical foundation for a significant proportion of current research on science teacher preparation. Sociocultural scholars like Lave and Wenger (1991), Holland, Lachicotte, Skinner, and Cain (1998) are particularly popular sources for scholars interested in identity, agency, and learning.

However, it isn't until more recently that the failure of much socioculturally-oriented education research to adequately treat power has been seriously taken up (Moje and Lewis, 2007; Gutierrez, 2013). This critique can be seen as representative of what some have called the sociopolitical turn in math and science education research (Gutierrez, 2013; Tolbert and Bazzul, 2014).

Gutierrez (2013) posits that the sociopolitical turn in mathematics education research is a movement born of the sociocultural turn, which takes seriously sociocultural theory's attention to equity. These scholars "privilege the voices of subordinated groups and forefront the politics and power dynamics that arise from sites of interaction".

Moje and Lewis (2007) draw on Foucauldian theory (Foucault, 1980, 1984) to argue that power relations in classrooms are a fundamental part of the equation of learning and being in classrooms. How students are labeled as students and people by broader discourses, their command of social resources in the class, and ability to transform the object of the lesson are examples of enactments of agency, identity, and power that mediate learning in the classroom.

The *teacher becoming* framework I employed in this dissertation - that is, the construction of teacher development as mutually constitutive enactments of agency,

identity, power, and knowledge - draws heavily from Moje and Lewis (2007) and other critical sociocultural scholarship and is designed to align with the sociopolitical turn in education research (Gutierrez, 2013).

In the remainder of this section, I define the components of teacher becoming (agency, identity, power, knowledge) and discuss the methodological implications of each. Each definition is infused with sociocultural theory as well as with the other components of teacher becoming--because they are mutually constituting, it is impossible to treat them discretely. In considering this fact, it is helpful to me to see these components of teacher becoming as a prism--each component has its face, yet they are all facets of one object and utterly synergistic.

### *Agency in Teacher Becoming*

I conceive of agency as fundamentally affirmative of the complex personhood of all people. Tuck's (2009) framework for desire-based research theorizes the nature of human social practice in a way that frames all individuals as complex, multifaceted, and whole. This framework rejects deficit theorizing, historically damaging narratives about marginalized individuals and communities, and other reductive forms of theorizing and positioning of research participants and science teachers more broadly. According to Tuck:

“Desire is a thirding of the dichotomized categories of reproduction and resistance. It is neither/both/and reproduction and resistance. This is important because it more closely matches the experiences of people who, at different points in a single day, reproduce, resist, are complicit in, rage against, celebrate, throw up hands/ fists/towels, and withdraw and



participate in uneven social structures—that is, everybody” (Tuck, 2009, p. 419-420).

In this study, I integrate Tuck’s construction of agency as desire with the overarching critical sociocultural framework to understand agency in the science teacher classroom along these lines: the unit of analysis is the activity system of the classroom, where the decisions about the objective (e.g., what will the topic of the lesson be? Who gets to participate? What counts as good participation?) is more or less the prerogative of the teacher educator. Mediational means include assigned readings, written assignments, technology in the classroom, heuristics, metaphors, and Discourses--any tool that is leveraged towards the purpose of achieving the objective. Agency can be seen as individuals’ transforming *or* maintaining the activity system - the objective, mediational means, or subjectivities - in accordance with their desires.

Drawing on Bourdieu (1977), I also view agency as inherently dialectical with structures--the material and discursive constraints that give shape to agentic possibilities. Agency and structure co-constitute one another, but remaining in line with Tuck, agency itself can never be measured, curtailed, truncated, stymied, or, for that matter, increased or enhanced. Agency, situated within the spatiotemporal context of activity, is complex and amorphous and cannot be quantified. However, in line with Foucault (1982), agency can be routed by power--a phenomenon I will discuss in the section of this chapter titled “Power in Teacher Becoming”.

Though sociocultural theorists, such as Engestrom and Sannino, theorize agency in various ways that correspond to the specifics of third and fourth generation CHAT, I prefer Tuck's (2009) construction because it is more attuned to power, and to the fundamental worthiness of personhood.

### *Identity in Teacher Becoming*

I find several constructions of identity useful in this work of investigating teacher becoming. Different constructions of identity are useful in theorizing and analyzing different kinds of teacher becoming scenarios. I begin, as always, from a sociocultural standpoint, which begins with Vygotsky. Vygotsky himself wrote very little about identity, though he did discuss the self (Rahm, 2010). Several scholars influenced by Vygotsky have used such writings to develop copacetic theories of identity--Holland (Holland, Lachicotte, Skinner, and Cain, 1998; Holland and Lachicotte, 2007; Holland and Leander, 2004), for example, is widely cited by socioculturalist researchers thinking with identity.

For Holland, et. al, 1998, identities are both social processes and products, "the imaginings of self in worlds of action" (p. 5). They write:

"...we begin with the premise that identities are lived in and through activity and so must be conceptualized as they develop in social practice. But we are also interested in identities as psychohistorical formations that develop over a person's lifetime, populating intimate terrain and motivating social life... they are important bases from which people create new activities, new worlds, and new ways of being... persons are malleable, changeable, and subject to discursive powers... [as well as having] generativity, [they have] capacities--embedded always in collective meanings and social relations--to imagine and create new ways of being" (p. 5).

Building from Holland's work, Rahm (2010) highlights the dialogic nature of identity and *identity work*. She emphasizes that identities are "social positions" which enable and constrain action, while identity-contingent actions (i.e., all actions) "transform and constitute identity work" (p. 36). Rahm's work touches on two concepts that are important for how I theorize identity in my research: the concept of positionality and the notion of identity work.

While developmental psychology has often described the notion of "identity" as a relatively stable, fixed, coherent sense of self (in contrast to notions of identity popular in education research, e.g., that identities are contingent and fluid--though Rahm points out that our "multiple selves" always have a degree of "integration and coherence" (2010, p. 36), the related concepts of "position" and "subjectivity" highlight the flexibility, contingency and play in doing identity. Doing identity - performing, revising, reifying identities - is identity work.

Moje and Lewis (2007) refer to this process of identity work as "subject formation", or "identification with particular communities" (p. 19). For Moje, et. al (2007), such identifications "can be demonstrated through the enactment of particular identities one knows will be recognized as valuable in particular spaces and relationships" (p. 19).

In this case, Moje, et. al are drawing on sociocultural theory as well as Gee's theorization in conceptualizing identity as "a kind of person (or not)", with differentially afforded allocations of social goods (p. 19). Discourse communities predefine what kinds of identities are "valued" and recognizable. In this framework,

Discourse communities are defined as “groupings of people - not only face-to-face or actual in-the-moment groupings, but also ideational groupings across time and space - that share ways of knowing, thinking, believing, acting, and communicating (Moje and Lewis 2007, p. 16).

In this study, drawing on Rahm (2010) and Moje and Lewis (2007), I define identity as affiliations with certain Discourse communities (e.g., scientist, good student, teacher), and ways of being recognized as a certain kind of person within the context of a particular activity (e.g., good student, smart interlocutor, good person). In this sense, identity is both a longitudinal phenomenon and a fleeting one. Where Moje and Lewis use Gee’s Discourse-based construct of identity to highlight the broad cultural narratives and ideologies that shape how students in classrooms are seen and positioned by others, Rahm’s (2010) construct highlights the work that individuals do in interaction to position or author themselves. Where Moje and Lewis (2007) make links between identity and power, Rahm emphasizes identity and agency. In my analysis of science teacher classroom activity, I concern myself with both lenses.

### *Power in Teacher Becoming*

In this study, I rely primarily on Foucault’s (1982) theory of power, and analytics which build upon Foucault's theorizations to make sense of power in preservice science teacher classrooms (Gee, 2015; Moje and Lewis, 2007). Foucault defines power as a quality of relationships, a “mode of action” which, rather than acting “directly and immediately” on others, “acts upon their actions”. He

distinguishes power from violence, which, characterized by the material application of force, “closes the door on all possibilities”; in other words, violence constrains the material opportunities for action for the receiver of violence, e.g., if person A forcefully grabs the wrist of person B and refuses to let go, person B is now constrained in their opportunities for bodily action. Foucault points out that a natural response to violence is resistance, which in turn forces the hand of person A, so that they are now at risk of receiving violence, and experiencing material, bodily constraint. This, according to Foucault, is not power.

Power is defined by two characteristics: “that ‘the other’ [over whom power is exercised] be thoroughly recognized and maintained to the very end as a person who acts; and that, faced with a relationship of power, a whole field of responses, reactions, results, and possible inventions may open up” (Foucault, 1982, p. 220). In other words, power constrains opportunities of the imagination, shaping the conditions of possibility and the agency of individuals, while allowing recipients the experience of autonomy.

Given this definition of power, and as part of an overarching critical sociocultural framework, I position Discourses of power as mediational means. Like other mediational means, Discourses of power shape activity dialectically--i.e., they both shape and are shaped by activity. They are both artifacts of historically unfolding activity, tools, purposefully designed and employed, to steer activity towards particular objectives.

There are many kinds of enactments of power in the classroom; For example, Tolbert, Calabrese Barton, and Moll (2017) used Bourdieu (1989) to argue that teachers' power to label and group students is "power *par excellence*" [emphasis in original] (p. 12). Wortham (2006) used ethnography to study the power of positioning of students in classroom interactions overtime, from which he drew similar sentiments. Delpit (1988) framed power in the classroom as a culture with rules for participation. In this dissertation project, I, like Moje and Lewis, 2007, use Gee's concept of Discourses and Discourse models to highlight power and its enactments in classroom activity.

Gee (1996) defines Discourses as "ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing, that are accepted as instantiations of particular identities (or 'types of people')" (p. 3). He expands:

Such socially accepted associations among ways of using language, of thinking, valuing, acting, and interacting, in the 'right' places and at the 'right' times with the 'right' objects (associations that can be used to identify oneself as a member of a socially meaningful group...), I will refer to as Discourses... Discourses are about being different 'kinds' of people. The key to Discourses is 'recognition" (2015, p. 34-35)

Gee differentiates "big D" Discourses from "little d" discourses, a word he applies to "language-in-use or stretches of language" (2015, p. 34). Gee's theory of Discourses builds on Foucault's (1966) *discourse* and Lave and Wenger's (1991) *community of practice* constructs (2015, p. 40).

Discourses operate in spaces, e.g., schools and universities, to "integrate and sort persons, groups, and society" (p. 4). Gee posits that individuals' multiple

identities are rooted in different Discourses, and that we can participate in multiple, overlapping, and sometimes incommensurate Discourses. Conflicts exist between Discourses, and “each of us lives and breathes these conflicts as we act out our various Discourses” (p. 4). For example, Gee points out that out-of-school Discourses often conflict with school-based Discourses in ways that are “many, deep, and apparent” (p. 4).

Discourses hinge on collectively held beliefs about what is “normal”. These beliefs constitute a “taken for granted and tacit set of ‘theories’ about what counts as a ‘normal’ person, and the ‘right’ ways to think, feel, and behave” (p. 4). These tacit norms include rules about who has a right to “‘social goods’ like status, worth, and material goods” (p. 4). Gee calls such “theories” Discourse models (2005). Said differently, Discourse models are “the ‘theories’ (storylines, images, explanatory frameworks) that people hold, often unconsciously, and use to make sense of the world and their experiences in it” (p. 61). Gee calls sets of theories (or Discourse models) *ideologies* (1996, p.4)

For example, the Discourses of western scientists, and “scientifically literate adults” typically include norms about what kind of knowledge is valid and valuable. These Discourses value empiricism and hierarchy (among other things), and they “say” that it is “normal” to see humans as separate and distinct from nature (one kind of Discourse model), and it is *not* “normal” to see humans and the natural world as intertwined (another kind of Discourse model), as is the case in much indigenous scientific thought and posthumanist scholarship. Thus, these Discourses position

indigenous scientists as “other”, as fundamentally irrelevant, depriving them of various social goods (Bang and Marin, 2015).

Discourses position different individuals and collectives differently, with different positions afforded differential access to resources. Gee calls the sets of norms which inscribe these positions *ideologies*. Certain Discourses possess (retain, consolidate, manage) more power than others. For example, in the U.S, white Discourses (ways of being recognized as white, or racially *normal*), heterosexual Discourses (ways of being recognized as straight, or sexually *normal*), Discourses of Western science (ways of being recognized as a scientist, or disciplinarily *normal*) command incredible legal, financial and social power. In other words, being seen as normal by White communities, straight communities, and scientific communities gives one access to incredible material and discursive privilege, while being seen as “not normal” by these communities means the denial of one’s access to these privileges.

In sum, power acts through certain Discourses, reifying and reinforcing relationships of domination, control, and unequal distribution of social goods across heirarchicalized social strata--these are Discourses of power (Gee, 2015, Foucault, 1980, 1982).

### **Discourses of Power in Science Teacher Preparation**

Tolbert (2015) and Tolbert, Calabrese Barton, and Moll (2017) highlight deficit Discourses in science teacher preparation as a major structure that teacher



educators and mentors need to help PSTs confront. Tolbert (2015) highlights the way that deficit ideologies constrain teachers, arguing that teachers must “reject” deficit ideologies in order to effectively provide equitable learning opportunities for minoritized students.

Tolbert’s (2015) study takes place in New Zealand, where minoritization of Maori students has contributed to a significant learning debt (p. 26). The Te Kotahitanga project, a teacher mentoring program designed to combat the effects of this minoritization in science classrooms, has already been shown to be effective. Tolbert analyzed mentoring conversations between Te Kotahitanga teacher mentors and teacher mentees and, based on themes encountered in these conversations, presented a “framework for culturally responsible mentoring in science” (p. 1). This framework addresses racism, relevance, relationships, and instructional complexity (p. 17).

Tolbert (2015) argues that in order to reject deficit theories, teachers should:

“[Recognize] the institutional and structural conditions that have led to inequitable educational opportunities for minoritized students... [and] not attribute blame to students, families, and communities for inequitable social or educational outcomes disproportionately affecting minoritized communities (e.g., such as lower achievement rates, higher truancy/dropout rates, etc.)” (p. 6).

In other words, science teachers must be equipped with a critical awareness of the material and discursive structures (e.g., Discourses of power) in order to adequately perform their job (to create equitable and meaningful learning opportunities for all

students, including minoritized students). In particular, deficit ideologies must be addressed.

In Tolbert, Calabrese Barton, and Moll's (2017) case study of Andy - a 23-year-old, white, male preservice science teacher - science teacher agency is the ability to creatively draw from appropriate discourses about teaching and learning to move beyond deficit ideologies and apathy.

During Andy's student teaching placement, the authors observed him engaging in deficit ideologies to rationalize his students' apparent disengagement in his class (p. 4). Andy's methods course instructor diverted him from increasingly punitive and controlling classroom management practices to a more student-centered approach oriented towards engaging students' individual and community funds of knowledge (p. 4-5). This latter approach led to increased student participation, students having access to more authentic and intimate science learning experiences, and a reorientation on Andy's part to positioning all students as capable of science learning. In this case, like in Tolbert's (2015) study, these authors construct deficit ideologies as constraints on science teachers' agency with respect to teaching science for all their students.

This framing opens up the possibility for the inverse to be true as well - teachers' agency can be expanded when deficit discourses are interrogated. In this vein, they show how preservice teachers who rely on deficit discourses can be rerouted through "sustained opportunities to critically reflect on the power of labeling, how they have come to label students, and how the ways that they label

students contribute to a reproduction of the larger economic and political inequities in society” (p. 13). The aspect of science teacher agency highlighted in this study could be thought of as critical discourse dexterity.

Both of these studies (Tolbert, 2015; Tolbert, Calabrese, and Moll, 2017) provide examples of how PSTs can be constrained by ideologies (and the Discourses that support them), and how teacher educators can help PSTs reject those ideologies in the service of providing meaningful learning opportunities for all students. In these cases, the primary concern is opportunities to learn for the k-12 students of the teachers in the studies.

In contrast, Tolbert and Eichelberger’s (2014) study attends to some of the ways that Discourses of power can constrain PSTs’ opportunities to learn, and how one PST, Serina, enacted agency in the face of/because of/through these structures. Often, research on science PST agency development focuses on helping white PSTs increase agency with respect to their capacity for teaching science to all students (p. 3), but these authors use the construct of agency to highlight how the experiences of PSTs of Color in science teacher preparation programs in Predominantly White Institutions (PWIs) can run quite counter to mainstream narratives about PST agency. Tolbert and Eichelberger present a “counter-narrative” of a teacher of Color who entered her preparation program with a strong identity as a change agent (p. 2) that, along with her emotional and psychological wellbeing, was under attack as she suffered from microaggressions, institutional silencing, Discourses of Whiteness and discourses of professionalism throughout the program (p. 12).

In the article, the authors describe Serina’s experiences with Discourses of Whiteness in the program. She is quoted, saying:

“The majority of students in the [elementary or secondary certification] program – of course there were exceptions – were straight out of college with zero work experience and full tuition paid for by their parents. Oh yeah, and most of them were white, too. I knew I was in for a tough year when a colleague asked ‘What is white privilege?’ and refused to believe it existed when explained. In some of my [quarter-long] classes my teachers were able to differentiate for me and take me to a new level of understanding, but in the [year-long] classes that I had – and also the administration – I was not encouraged to share my experiences or opinions because it made other students uncomfortable” (p. 8-9).

Such negation of White privilege is a standard component of Discourses of whiteness in teaching and teacher preparation programs (Sleeter, 1993; Solomon, Portelli, Daniel and Campbell, 2005; Matias and Mackey, 2015; Marom, 2018).

Eichelberger also describes how Discourses of professionalism, i.e., the dominant ideologies about “normal” ways to behave in her university classes and teaching placement classrooms, directly contradicted the social justice perspectives that she enacted in those spaces, and that the program purported to promote.

“I feel like as a teacher it’s my role to be an agent of change but I think if anything this program has separated me a little bit more from that identity [as a change agent] ... I definitely didn’t get that from the program and I feel like in fact I got the complete opposite – of more of follow the norm, follow the norm, that’s professionalism in the field of education ...” (p. 9).

“I would not agree with colleagues [i.e., other students in the certification program] who said ELLs [English language learners] could never catch up or that students in underserved communities could not be as successful as their white, affluent counterparts. I wouldn’t back down in class

conversations and was told by the teacher that people were not comfortable with me in class and that I needed to be more respectful of their opinions. *Their silencing of my point of view...is not social justice – this is supported by research!* (emphasis added) In this way, it was really hard for me to form a positive identity with this program, or Academia in general” (p. 10) These authors use Yosso’s (2005) framework of community cultural capital

(which, when paired with agency theorizing, is somewhat reminiscent of Sewell’s (1992) discussion of resources and capital) to explicate the kinds of resources Serina - the second author and focal teacher in the analysis - “invoked” in order to persist in the program (p. 12) in the face of these Discourses.

For example, Serina “found a way to meaningfully connect her student teaching experiences to her identity as a change agent for underserved students (e.g., by providing her students with rigorous learning activities they would not have had otherwise), [otherwise] she may not have been able to conjure up the emotional energy she needed to carry on” (p. 12).

In another instance, Serina “asserted agency” by “drawing on resistance capital” when she traded out a traditional science activity for an inquiry-based project at her teaching placement while her cooperating teacher was out of town (p. 11). The authors conclude that Serena’s experience of having to “survive” her science preparation program can help teacher educators consider 1) the ways they reproduce mainstream, systemic oppression in their own classrooms (p. 2) and 2) the ways in which PSTs community cultural capital might be leveraged in the program for those same PSTs benefit (p. 12).

All three of these studies (Tolbert, 2015; Tolbert, Calabrese Barton, and Moll, 2017; Tolbert and Eichelberger, 2014) were influential in my thinking as I conceptualized this study. They were the only studies I was able to find that explicitly highlighted Discourses of power and ideologies as significant kinds of structures engaged by preservice science teachers in preparation programs. Tolbert and Eichelberger's (2014) call for greater understanding of the ways that PSTs "survive" Discourses of power in teacher preparation programs, especially PSTs of color in PWIs, was acutely motivating. My intent is to investigate Discourses of power, such as these, in one science teacher preparation program, as well as how diverse PSTs engage with these Discourses.

### **Western Natural Science and Education**

Science education in the US is primarily concerned with the institutions of natural science that emerged from the enlightenment--what we might call *western natural science*. Western natural science is characterized by a strict adherence to the Liberal values of rationality, objectivity, progress, and practices such as observation of phenomena through human sensory experience, usually aided by human-made technology, i.e., a microscope, typologizing, concise communication, etc. It is also characterized by a general belief in a universal truth, and hierarchy as the natural order of things, usually with the Enlightened (i.e., wealthy European) human man as the apex (Wynter and McKittrick, 2015; Painter, 2010; Bordo, 1986; Harding, 1992;

Haraway, 2016; Stengers, 2018; Braun, 2014; Lemke, 1990; Calabrese Barton and Tan, 2010; Bang and Marin, 2015; Todd, 2016).

Contemporary practitioners of Western Science are also particularly prone to disciplinary chauvinism, rooted in the general belief that the onto-epistemology of Western science is *the* onto-epistemology, that *its* knowledge producing practices are *the* knowledge producing practices, and that *its* lenses alone are “unbiased” (Haraway, 2015). The Next Generation Science Standards (NGSS) framework itself reifies the view of western natural science as objective, stating, for example, that:

“Over time, ideas that survive critical examination even in the light of new data attain consensual acceptance in the community, and by this process of discourse and argument science maintains its objectivity and progress” (NRC, 2012, p. 71).

However, in recent years, science and science education practitioners, researchers, and philosophers have begun pushing for an ontological turn in science education, due to growing recognition of the limitations, as well as the inherent and historical violence, of these collectively held values and practices. Feminist, indigenous, and decolonial science scholars provide a robust critical imaginary to draw from in thinking through how western science and science education practitioners can re-vision the values and practices that constitute their work in ways that are less harmful to human and more-than-human beings, and more adaptive to the “wicked problems” that we currently face (Sharma, 2020; Haraway, 2016).

Many preservice science teachers have spent countless hours in classrooms becoming enculturated into Western Scientific ways, and relatively few being

exposed to rigorous critique of those ways. Participants in this study often reflected on their lack of experience with cultural critique in general, and in some cases, a pointed disdain for research coming from other disciplines, e.g., social sciences and humanities. In this sense, Western scientific disciplinary chauvinism rather directly limits the PSTs' opportunities for learning as it rendered social scientific research and peer testimony illegible as a potential source of knowledge and/or rendered the PSTs incapable of participating in the learning activity.

I am also guided by the scholarship of indigenous women in this field, particularly Eve Tuck and Megan Bang. Both of these scholars incorporate deeply theorized and elegantly operationalized notions of care in their work. Tuck's (2009) *Suspending Damage* insists upon the unrelenting, inalienable, and messy agency of individuals, and that when researchers frame participants as possessed of anything less, they cause harm to those individuals and their communities. Tuck thus insists that the failure to acknowledge and position participants as fully human is inherently harm-ful and argues for a more care-ful approach to research that emphasizes what she calls complex personhood (which I illustrate in the previous section on agency). With Tuck in mind, part of my commitment to care in this research is through my application of complex personhood as an analytic.

Bang's talk at the (2020) Speculative Education conference, titled "Midwifing the Next World" also gifted me with a notion that grounds my approach to care-ful research. She argued that critique is not particularly useful in and of itself; that critique, without the persistent, paired application of critical imagination, simply



adds more destruction to an already destructive world. She argues that critical scholars cannot simply describe the unjust world, that they must also work to build a new one. Critical imagination asks scholars to envision, re-vision, dream, and scheme of possible futures that are more just, more life-giving, and more care-ful. I incorporate Bang's notion of critical imagination in my work through the pairing of critical analysis of PSTs' Discourses with critical speculation about the possible futures enabled by their enactments, with particular attention to openings for future care.

### **Section Summary**

In this study of science teacher development in and through an equity-oriented preparation program, I employ a combined theoretical and analytical framework encompassing critical sociocultural theories of learning, and feminist and decolonial perspectives in science education. This framework centers preservice science teacher (PST) learning as a cultural-historical phenomenon, material-Discursively situated, and shot through with power (Sannino and Engestrom, 2018; Vygotsky, 1986; Bazzul, Tolbert, Kayumova, 2019; Gee, 2004; Fairclough, 1992; Moje and Lewis, 2007).

In analyzing classroom teacher learning activity (the primary unit of analysis), the components of the activity (subject, object, mediational means), and the components of teacher development (identity, agency, power, knowledge) are considered mutually constitutive but distinct elements (Sannino and Engestrom, 2018;

Gee, 2004; Bourdieu, 1977; Tuck, 2009; Sewell, 1992; Vygotsky, 1986).

Furthermore, science teacher development is positioned as a process of *becoming* - never a static state, never “finished” - but a situated, multifaceted, social activity that integrates identities, agencies, power, and material-discursive knowledges (Nasir and Hand, 2006; Rahm, 2010; Settlage, 2011; Moje and Lewis, 2007; Stetsenko, 2020).

Fundamentally, this framework is designed to highlight implications for care and/or harm in science teacher education and secondary science education (Gunckel and Tolbert, 2018; Puig de La Bellacasa, 2012; Tallbear, 2019; Tuck, 2009; Stengers, 2018; Haraway, 2016). The framework invites identification of identity-based harms that PSTs experience through classroom activity in preparation programs (e.g., minoritized PSTs feeling compelled to overshare personal experiences of being racially stigmatized), as well as enactments of discourses of power in the PSTs classroom discourse which reflect possibilities for harm in the PSTs future secondary science classrooms (e.g., carceral models of classroom management). The ultimate goal in identifying the PSTs’ lived experiences of harm and possibilities for future harm in secondary science classrooms is to help preparation programs identify and root out conditions that render such harms possible.

## Methods

### Project Overview & Context

This study investigates how preservice science teachers negotiate Discourses of power through their lived experience of *becoming* science teachers in an equity-oriented preparation program. More specifically, the research questions that guided this study are:

1. How is hegemonic power reproduced in and through classroom discourse in an equity-oriented science teacher preparation program?
  - a. What Discourses of power are called into play?
    - i. What Discourse models and identities are enacted that perpetuate Discourses of power?
    - ii. How does this shape opportunities to learn in activity?
2. How is hegemonic power challenged, resisted, and transformed in and through classroom discourse in an equity-oriented science teacher preparation program?
  - a. How do PSTs respond to Discourses of power when they are enacted by peers?
    - i. What Discourses models and identities are enacted that challenge, resist, transform, or perhaps imagine beyond hegemonic power?
    - ii. How do PSTs exercise agency to disrupt hegemonic power in classroom learning activity?
    - iii. How does this shape opportunities to learn in activity?

Such a study required multiple layers of analysis. The broadest layer takes the form of a case-study of the teachers in the program. The PSTs were observed in their university classrooms, as well as interviewed multiple times throughout the program. The purpose of the case study was to gain a general sense of the PSTs multiple identities, their desires for their time in the program (e.g., what did they want to get

out of the program? What did they want to get out of particular class sessions or particular courses?), and the Discourses and Discourse models they subscribed to or consciously rejected.

At the micro-level, this study took the form of a Critical Cultural Discourse Analysis (CCDA) (Moje and Lewis, 2007). CCDA unites sociocultural theory with Critical theory (e.g., Foucault, 1980, 1984; Bordo, 1993) and Discourse analytic methods (e.g., Gee, 1996; Fairclough, 1992) to analyze agency, identity, power, and opportunities to learn (the components of teacher becoming) as they are enacted moment-to-moment through discourse in learning environments (Moje and Lewis, 2007).

Such a study is significant because the way that Discourses of power (e.g., Discourses of whiteness, of professionalism, of scientific elitism) show up in teacher preparation has an impact on PSTs experiences during teacher preparation (Hilferty, 2008; Tolbert and Eichelberger, 2014; Matias and Mackey, 2016; Levine-Rasky, 2000; Horton and Scott, 2004; Mensah, 2011; Lemke, 1990), yet is a relatively understudied phenomenon.

### ***Prior experience in the STP context***

Prior experiences as a researcher of, and observer and participant observer in, science teacher preparation classrooms at the research site have shed light on some of the ways that PSTs in this program negotiate Discourses of power. In 2015 I was enrolled in one of the courses I plan to observe: EDUC230 Science Education

Research and Practice. While working with the science PSTs in this class in whole class and small group work, I gained significant insights into the ways that they were experiencing and negotiating ideologies about meritocracy, and stereotypes (or discourse models) about rural students of color. I also noticed gendered Discourses being enacted, for example, when a group of PSTs discussed “contextualizing” science content “for girls” by designing an activity around make-up. While such an activity certainly would help many girls (and boys and gender non-conforming (GNC) students) relate to science content, it certainly wouldn't be helpful for all girls. In 2016 and 2017 I observed teacher graduates of this program in their own secondary science classrooms as part of a broader research project: the Secondary Science Teaching for English Language and Literacy (SSTELLA) project. I used these observations, as well as an analysis of 28 semi-structured interviews with PSTs, to make sense of the ways that PSTs in this particular cohort at this particular site felt constrained in their ability to teach science for all students. In this case, deficit ideologies about EL students combined with the ideologies of meritocracy to shape both the beliefs and practice of one science teacher graduate of the program.

I continued working as a research assistant on the SSTELLA project from 2016-2019, the purpose of which was to design, implement and test a science teaching methods course that integrated disciplinary content with English language and literacy development. I analyzed hundreds of hour-long, semi-structured, pre- and post-preparation program interviews with science pre-service teachers. Reading and analyzing these interviews provided me with ample examples of the kinds of

Discourses that science PSTs navigate. I noticed powerful Discourses about science as the ultimate source of truth, such as when participants positioned religious or spiritual beliefs in deficit-oriented ways. Such Discourses are connected in deep ways to the Discourses of coloniality and may be particularly oppressive for indigenous students.

Finally, during my dissertation pilot study at the same site I later studied for this dissertation study (2018-2019), I noticed Discourses of power showing up in university-based classroom discourse in new ways, implicitly shaping activities and activity systems. For example, anti-intellectualist ideologies - an important component of white nationalist Discourses (Sultana, 2018) - undergirded one student's constant, open denunciation of "overthinking" teaching (i.e., reading about and reflecting on teaching) as well as "theory" in general, setting a tone for many class sessions that made it uncomfortable for other students to engage with readings and theory freely.

I also noticed powerful examples of students enacting agency in response to prevailing Discourses of Whiteness, heteronormativity, and capitalism. For example, one student wrote their final project for one course on racism, sexism, coloniality, and heteronormativity in the outdoor science education world. The content of their paper was explicitly a counter-narrative, an act of resistance towards the Discourses of power that marginalized them as a Latinx, non-binary person of color in this case, the student had taken up the activity parameters laid out by the instructor, agentially and powerfully moving the activity system forward (as opposed to reframing or altering

it). At the same time, they were actively naming and refusing to accept oppressive Discourses of power in the broader activity system of the university and outdoor education writ large.

### **Research Worldview**

The proposed project takes a transformative worldview (Mertens, 2012; Creswell, 2014). According to Creswell (2014), a transformative research worldview means that “research inquiry needs to be intertwined with politics and a political change agenda to confront social oppression at whatever levels it occurs (Mertens, 2010) ... Moreover, specific issues need to be addressed that speak to important social issues of the day, issues such as empowerment, inequality, oppression, domination, suppression and alienation” (p. 9-10). My interest in understanding how Discourses of power play out in science teacher preparation classrooms aims towards centering the sociopolitical (Gutierrez, 2013), and providing insights that may help science teacher preparation programs better understand the way that PSTs negotiate, resist, re/place power in and through teacher becoming, and inform science teacher preparation for more care-ful science education futures.

### **Research Design**

#### *Case study*

The project takes the overarching form of a case study. According to Creswell

(2014), case studies are in-depth analyses of a case, “often a program, event, activity, process, or one or more individuals”. In a case study, “detailed information” is collected using “a variety of data collection procedures over a sustained period of time” (p. 14). This case study entailed the “in-depth” study of one cohort of preservice science teachers enrolled in a science teaching Master/Credential program at a large, west-coast, public university.

This project is distinctly a case study because while it *is* an in-depth, longterm study of a group of people, it is *not* an attempt to document their “shared patterns of behavior”, as is the case in ethnographic studies (Creswell, p. 14). The purpose of the case study was to establish the researcher's understanding of what individual participants’ more stable identities and desires as they pertain to the program (primarily through interview), as well as to gain a sense of who these participants were in the context of classroom activity (primarily through classroom observation).

### *Activity analysis*

Because this study adheres to a sociocultural framework, the primary unit of analysis is the activity system at hand. In analyzing classroom teacher learning activity, the components of the activity (subject, object, mediational means), and the components of teacher development (identity, agency, power, knowledge) are considered mutually constitutive but distinct elements (Sannino and Engestrom, 2018; Gee, 2004; Bourdieu, 1977; Tuck, 2009; Sewell, 1992; Vygotsky, 1986).



This means that, as I construct my analysis and findings, I think about individuals and their identities, the relationships between individuals interacting with one another, and the objectives that motivate activity, accumulation, and transformation of concepts through activity, and the mediational means that coconstruct activity. I do not position the identities or the concepts or notions that participants articulate as fixed or integral to any individual participant. Rather, in my analysis, I discuss what kinds of identities, concepts, discourse models, and ideologies have been enacted in the discourse.

Keeping activity as my unit of analysis means that I work to avoid making the participants themselves the objects under study. In other words, I will not claim to know what any participant was thinking or feeling at any point (though I will speculate, based on data triangulation) --aside from what the participants have explicitly reported thinking or feeling.

I want to be particularly clear that when I describe participants as enacting particular Discourses and identities, I in no way mean to imply that those are fixed characteristics of the participants. Identities are fluid and context-dependent, alignments with Discourses can be contradictory, multiplicitous, and fleeting. In this dissertation, I work to be critical of the workings of power, but generous and caring towards those it works on and through in the learning activities I observed. Through this critical activity analysis, I hope that my focus on activity (as opposed to the participants themselves) helps illustrate the way that power works subtly, through individuals in a science teacher preparation program, implicating individuals

generally in the re-placement of power, without blaming or denigrating any *particular* individual.

### *Discourse analysis*

Within the case study, I use Critical Cultural Discourse Analysis (CCDA) (Moje and Lewis, 2007) as a framework for performing a fine-grained analysis of enactments of Discourses and Discourse models in moment-to-moment interaction in the classroom. For example, Moje and Lewis (2007) used CCDA to highlight prevailing cultural models of “goodness and badness, power and authority, risk and safety, individual and group” (p. 31).

The decision to house the Discourse analysis within a case-study was informed by similar studies of dialogue in learning environments. Ash (2004) has argued that it is always necessary to cocoon microgenetic (interaction-level) analyses within a broader, context-giving analysis. She accomplished this by analyzing diagnostic scaffolding events, sometimes only moments in duration, positioned within a broader analysis of a family’s entire day-long visit to the science museum. Moje and Lewis (2007) also point out that it would be nigh impossible to draw conclusions about identities and Discourses in classroom interactions without the foundation of a broader, more longitudinal study. The case-study provides the context necessary for making sense of PST discourse.

## **Participants**

At the broadest levels of analysis, I included all science PSTs enrolled in the 2019-2020 cohort of the science master's and credential program at a large, west coast, public university, situated in a semi-rural setting, except for one individual who opted not to participate (n=10). I also selected five focal participants, from whom I collected more data, which I analyzed in much greater depth (see data collection for more detail on this). All participant names included in this report are pseudonyms. In order to protect the anonymity of the participants involved in this study, I have chosen to background identifying characteristics, thus I do not provide thorough descriptions or profiles of the participants. However, when asked to describe their racial identities, seven PSTs identified as white, one identified as white and Peruvian, another as Filipino, and another as Mexican American (I understand that these terms blur the technical lines between race and ethnicity, however, I respect the participants self-identification nonetheless). In terms of gender, six identified as female, four as male. All participants identified as coming from middle-class socioeconomic backgrounds. When asked an open-ended question about ways that they identified themselves, two participants described strong religious identities, and one identified as neurodivergent.

### *Sampling and recruitment.*

I recruited participants via a brief recruitment presentation in a PST class session in the second week of the preparation program. This session included all

single-subject preservice teachers, and every one of the preservice teachers agreed to participate in video observations during graduate classroom activities and signed media releases (except for one). I additionally invited the preservice science teacher cohort to participate in at least two semi-structured interviews and offered the science PSTs \$75 in payment for their time spent during the interviews and close observation. All accepted (except for one).

As I performed pre-interviews with each of the 10 PSTs and observed the first round of courses, I performed initial data analyses to ground my selection of five focal participants. For the focal participant subset, I sought participants who would be representative of some of the kinds of Discourses I have observed in prior years. For example, in my prior research experience with PSTs, I had identified certain kinds of Discourses that were common among PST cohorts, for example, anti-intellectualism, white supremacy, neoliberalism, and genderism. Throughout these preliminary analyses, I looked for cruces (Fairclough, 1992), moments of tension in the learning activities, or conflicting Discourses in interviews to begin to identify which participants might be thought of as representative of conflicting Discourses. Primarily, I was interested in focusing on students who speak to Discourses of power and counter-hegemonic Discourses (whether that be in classroom discourse, in interviews, or in written assignments) in different ways.

## **Data Collection**

### *Semi-structured interviews.*

I performed semi-structured interviews with each participant (including nonfocal participants) at the very beginning of the program, and again at the end of each quarter. Interviews were audio-recorded and transcribed by me (see theory of transcription section below for more on this). These interviews will be designed to elicit (1) participants' desires for themselves in the program and in teaching, (2) ideas about what makes a good science teacher, and (3) life history information (probing for information about identities and Discourse affiliations). Semi-structured interviews were audio-recorded, and notes were taken during the interviews. After the first round of interviews, I performed subsequent interviews over Zoom. At the beginning of each interview on Zoom, I requested permission to use Zoom's screen recording function, and all participants gave permission.

### *Example interview questions.*

1. Tell me about what brought you to enroll in this program?
  - a. Probe for explanation in terms of desire to teach, life experiences and circumstances that made science teaching, and this specific program, appealing.
2. How do you imagine yourself as a science teacher?
  - a. Probe for science teacher role models (real and fictional)
  - b. Probe for major objectives, e.g., “helping students connect to science”, “helping students feel the wonder in science”, “helping students gain access to highly valued and highly compensated careers”, or “helping students become better democratic citizens”.
3. Tell me about how you think your life experiences, identities, interests, hobbies, etc., shape the way you think about teaching?
  - a. How do you think your racial identity shapes the way you think about teaching?

- b. How do you think your language history shapes the way you think about teaching?
- c. How do you think your gender identity shapes the way you think about teaching?
- d. Is there anything else that you think significantly shapes the way you think about teaching? For example, political identity, where you grew up, or where your parents or grandparents grew up?

*University classroom observations.*

I observed all 10 PST participants in four of their university courses (see table 1 below). I chose to observe these courses (and not others) based on preliminary analyses from the pilot study of this project, conducted during this academic year 2018-2019. In the pilot study, I observed the 2018-2019 cohort of PSTs at the same site in all of their summer, fall, and winter courses for at least one full class session, 10 sessions at most. In the preliminary analyses from the pilot study, I had identified these four courses as the richest in cruces, and thus most likely to invite cruces in the dissertation year.

The first two courses -*Teaching, Learning, & Schooling in a Diverse Society* and *Social Foundations of Education* - were both offered in the summer and were part of the students' first round of classes. These were my primary considerations in choosing these courses to observe: First, during this first quarter, the students' primary obligation is to their courses, as opposed to later in the program when they become preoccupied with credentialing demands and teaching in their placements. In the pilot study, it was during this quarter that the students were the most engaged in their coursework and had the most energetic classroom discussions. Second, these

courses covered topics and readings that were very generative for discussions around power, ideology, and the students' own identities.

The next two courses - *Science Education: Research and Practice* and *Teaching Science in Secondary Classrooms* - which take place respectively in Fall and Winter, are the core foundation courses specific to the science cohort. These courses also instigated rich discussions around power, ideology, and the students' identities, while also focusing more narrowly on issues and instances related to teaching science.

Each class has approximately 10 sessions and I observed at least five sessions of each course. I selected observation dates based on which sessions were most likely to include student discussions around power, identity, beliefs about science teaching and teachers, and beliefs about science students. For example, in the pilot study, the first session of *Teaching Science in Secondary Classrooms* centered on having students reflect on who they wanted to be as science teachers and what characterized a "good science teacher", an activity which invited enactments of identity, cultural models and Discourses about teaching and science teaching, more specifically. In selecting course sessions to observe for the dissertation, I consulted pilot study data, the course instructors, and course syllabi to identify sessions to observe that would similarly invite those kinds of power-rich discussions.

University classroom observations were recorded using a smartphone and a small kickstand for the phone. I initially planned on using a tablet and a tripod for video observation, but after experimenting with a few set-ups I found that the phone

was the least intrusive, most mobile, and the easiest device for data transfer. I video recorded every observed class session using my phone camera positioned in a corner of the classroom i.e., in a location where I could observe the classroom as a whole. When the class broke up into small group or partner work, I moved to a table to sit with a small group, and video and audio recorded the group's learning activity from there. In selecting which small groups to observe in the moment, I chose groups that had at least one focal participant and attempted to choose groups to observe so that I would be somewhat evenly observing the five focal participants. While I considered using multiple cameras to observe multiple small group activities at one time, I decided that I wanted to be personally present for every conversation/activity that was video recorded so that video data could be triangulated by my field notes.

Table 1 – Courses Observed

<b>Courses Observed</b>
Introduction to Education
Requirement for Education Master's degree. Subjects covered include teaching and learning, development, pedagogy, and social psychology, schooling as a social and institutional context, reform movements, sociocultural contexts of education, cultural and historical structures of schooling, political and economic forces in education, families, and communities.
Cultural Foundations of Education
Social and cultural foundations of education in the US with an emphasis on community perspectives. Topics include critical perspectives in education, feminist perspectives in education, economic and political structures of schooling, historical and current education inequity.



Research and Practice in Science Education
Topics include research perspectives on equitable science instruction including
science learning research, approaches to classroom discourse, and approaches to science instruction in diverse classrooms.
Methods in Secondary Science Instruction
Contemporary, research-backed methods of science instruction for secondary students. Curricular critique and design are a central component.

### **Data Analysis**

In this study, I use activity analysis (Sannino and Engstrom, 2018; Moje and Lewis, 2007) and Critical Discourse Analysis (Gee, 2014; Moje and Lewis, 2007; Fairclough, 1992) in combination with traditional qualitative methods including in vivo and thematic coding (Saldana, 2009) to explore science teacher becoming. I use Critical Cultural Discourse Analysis (CCDA) (Moje and Lewis, 2007) as a framework for performing Discourse analysis in conjunction with Activity analysis. CCDA is a very fine-grained, detailed analytic method that I used to analyze certain texts (written, spoken, or gestured) but not others. I analyzed the bulk of my interview and observation data using thematic analysis (Creswell, 2014, p. 186).

*Critical Cultural Discourse Analysis (CCDA).*

Moje and Lewis (2007) provide a methodology for making sense of teacher becoming through classroom discourse. In their methodology they emphasize their integration of critical theory with sociocultural theory, calling their method Critical Cultural Discourse Analysis (CCDA).

They begin their analysis by first identifying the activity at hand, which they define as “the actions observed and the goals, needs, motives, and desires of the participants engaged in those actions” (p. 26). Next, they code transcripts by utterance for Discourses and *cultural models*, using methods defined by Gee (1999), Fairclough (1992, 1995), and Lewis (2001). Citing Gee (1999), they define cultural models as micro-interaction level instantiations of Discourses (p. 26). This involves a first iteration where the analysts ask what Discourses “seem to surface in the discourse of the text” (p. 27). The second iteration involves a closer analysis to “establish the flow of ideas and examine the microstructures and macrostructures of the talk as a way of examining how identities get positioned, activities are structured, and worlds are built” (p. 27).

In the next phase, they perform a more fine-grained analysis of the discourse, investigating “turn-taking, exchange structures, topic control, setting and policing agendas, formulations (foregrounding and backgrounding of different ideas, perspectives, terms), modalities (how present individuals made themselves or others in their language), politeness, and ethos (embodied and spatial relations)” (p. 27). Finally, the authors overlay an analysis of “how language choices positioned

participants and others” (p. 27), looking at grammar, syntax, inclusion, and exclusion of participants, what assumptions were made and what ideas were made explicit in talk. In the following section, I provide an example of how CCDA can be used to analyze PST classroom discourse to elucidate how agency, identity, and power are enacted in moment-to-moment interaction.

### *Cruces as red flags in data analysis*

At the outset, my goal was to identify what my committee and I had agreed to call *cruces* (Fairclough, 1992). Cruces, moments of discursive crisis, index tension in the activity system. Such tensions may be fleeting, but a primary goal of my project was to identify patterns in the tension and trace connections between recurring cruces in activity and broader Discourses of power. Identifying cruces and tracing Discourses required close observation of dozens of hours of classroom activity, iterative coding, using in-vivo and thematic methods, critical discourse analysis, paired with similar analyses of semi-structured interviews with participants. Doing this tracing work reveals some of the myriad ways in which hegemonic power is instantiated, reiterated, subverted, deconstructed, formed, and transformed in and through fleeting interactions in science teacher preparation programs.

In the following sections, I describe the reverberations of some of the primary tensions that played out in/through the learning activities I observed. I illustrate some of the cruces I identified in the learning activities that indexed these tensions, and discuss some of the expressions of, and implications for, agency, identity, power, and

care that I observed. Each findings section is structured around a particular classroom vignette, each containing multiple cruces, illustrating a primary theme of findings.

### *Theory of transcription*

Ochs (1979) asserts that researchers analyzing interview data must have and explicate a theory of transcription. She rightly points out that, like the researcher wielding a camera to capture data, the transcriber sets the aperture on her lens as she observes real-life unfolding and transforms it into data on a screen. She must decide how much information to include--too much makes the transcript unreadable, not enough makes it incomplete. Ochs argues that this “selectivity” should be explicit, should draw on existing studies in connected fields, and should reflect the interests and agenda of the researcher (p. 168).

Bucholtz (2000) complicates this notion in arguing that the transcriber must also consider the power dynamics inherent to interviewing and transcribing: “the two basic transcription styles, naturalized transcription, in which the text conforms to written discourse conventions, and denaturalized transcription, in which the text retains links to oral discourse forms, have equal potential to serve as politicized tools of linguistic representation” (Bucholtz, 2000, p. 1439).

In my transcription I take these points into account by 1) being cognizant of and explicating my theory of transcription, 2) modeling my transcription method based on those employed in similar studies so that my degree of selectivity is consistent with other related research in the field of science education, with my

theoretical framework and with my research agenda, and 3) settling somewhere between naturalized and denaturalized transcription, leaning heavily towards: the transcribed text “retains links to oral discourse forms” (Bucholtz, 2000, p. 1439) in terms of its structure, the inclusion of “um,” “like,” pauses, false starts and nonstandard English grammar usage, in some cases.

Specifically, I follow Gee’s (2015) methods for transcription, because it is consistent with my proposed methodology, which also relies heavily on Gee (2015). He emphasizes the discourse organization (line and stanza structure) and discourse system (prosody, cohesion, contextualization, and thematics) to “make sense” of text (p. 119). Gee starts with a transcription style that breaks text up by lines and stanzas. Lines are “clauses” and “simple sentences” (p. 119), stanzas are “sets of lines about a single minimal topic, organized rhythmically and syntactically so as to hang together in a particularly tight way” (p. 119). Gee (2015) uses this transcription style as the foundation for an analysis of the “sense of text” from which he draws conclusions about the language practices and cultural models subscribed to by the speakers. For the purpose of clarification, in the findings section I label classroom observation transcript stanzas numerically, and interview transcript stanzas alphabetically.

Table 2 – Transcription Markers and Indications

<b>Transcription Marker</b>	<b>Indication</b>
^	Rising tone (as in to indicate a question)
//	Closure tone (as in to indicate that the speaker has finished)
..	Pause
:	Extended vowel sound
<u>Underline</u>	Verbal emphasis, usually indicated by modulation in pitch or volume
<i>CAPITALIZATION</i>	Major emphasis

Both interview and observation data were transcribed using Temi.com, a virtual transcription service using speech-to-text software. Temi’s software offers an initial transcription that I used as a “base layer”, as I went back and manually transcribed critical incidents we wanted to focus on analytically. This method was very productive for me, because I was able to develop a much more extensive library of transcribed interviews and classroom events than I would have been able to create on my own. Critically, the digital database was searchable, allowing me to quickly identify the salience of various terms in the transcripts. Because I had already identified the major cruces, I was interested in exploring based on my observation experiences, interview experiences, and field notes, having the ability to search the database for key terms related to the events was incredibly helpful. Temi.com also facilitates varying playback speed, which came in handy while I transcribed for

Discourse analysis, allowing me to notice different details in the Discourse at .5x and 1x speeds, for example. I analyzed the data iteratively using in vivo and thematic coding techniques (Saldana, 2009), as well as analytic memoing, and finally Critical Discourse Analysis. For Discourse analysis, I used Gee's (2004) transcription conventions and Building Tasks analytic framework.

### **Prior Work**

As previously mentioned in the introduction to this methods section, a significant amount of prior work informs this study. Perhaps the most informative has been a pilot version of this study that is currently underway.

The goal of the pilot study was to investigate the Discourses, ideologies, and Discourse models for “good science teacher” that science PSTs and their teacher educators (at one liberal, predominantly White university) negotiated. Beyond identifying these Discourses, ideologies, and Discourse models, I am also investigating *how* these Discourses, etc. were negotiated by PSTs and their teacher educators in university classroom discourse, and if and how they changed over the course of the program year.

The pilot study began in July 2018, when I began observing all the courses that the current science MA/Cr students were enrolled in. In the First quarter of their program, I observed the science cohort in Introduction to Education, Cultural Contexts in Education, Healthy School Communities, and Child Psychology in Education. In the Fall Quarter, I observed the science cohort in Instructional Methods for English Learner Language Development, Research and Practice in Science

Education, Teaching Special Populations, and Introduction to Student Teaching.

During the Winter Quarter, I observed Methods in Secondary Science Instruction. For each of these classes, I observed between 3-10 sessions, observing the core science teaching courses (Research and Practice, and Methods) much more frequently, and observing others less frequently.

For each observation I collected extensive and detailed fieldnotes, attending to the Discourses, ideologies, and Discourse models about what makes a “good science teacher” during classroom discussion.

Early in the program I also performed semi-structured interviews (designed to elicit participants’ Discourse models, ideologies, and Discourses about what makes a “good science teacher”) with five science MA/Cr students and all of the professors teaching that quarter. At the beginning of each quarter, I also interviewed the professors of each new class. I performed follow-up interviews with all MA/Cr student participants after the end of the program. I audio recorded each interview and also took detailed notes during interviews.

The data collected during the pilot study informed my decision-making around which classes to observe for dissertation study, which assignments to collect. Additionally, the level of familiarity with the program I attained during the pilot study was very useful as I negotiated interviews and observations with faculty and helped me make sense of the incoming students’ experiences in the program.



## **Findings: Talking Science in an Equity-oriented Preservice Science Teacher Classroom**

### **Introduction: 10 minutes in a science teacher preparation classroom**

In this findings chapter, I explore the ways that several preservice science teachers (though I largely focus on one) “talked science” in an equity-oriented teacher preparation course in ways that ultimately limited their own and their peers’ opportunities for learning. I consider Discourses of power and identities enacted, agency expressed, conceptual terrain negotiated, and possibilities for care embedded in the classroom activity segments.

I focus my analysis on two brief segments of activity - or vignettes - that unfolded (in interconnected ways) during classroom activities in the Research and Practice in Science Education course, which took place in the Fall (Vignette I and Vignette II). I begin with a central vignette and its analysis, to which I patch in complementary discourse events (from earlier/later activities or interviews) in order to illustrate patterns I observed across data points. Taken as a whole, this analysis provides a brief snapshot of the PSTs’ overall process of becoming science teachers in the program.

#### *Why these vignettes?*

Though I encountered and analyzed dozens of cruces and rich themes relating to power and teacher becoming throughout the data I collected for this study, I selected two vignettes, which each include various and overlapping cruces, to illustrate and analyze in the following sections based on my belief that the lessons for

equity-oriented science teacher preparation specifically were the richest and most promising in these veins.

For example, though I collected observation data during four of the PSTs program courses, this analysis highlights two vignettes from just one of those courses. I chose to focus on observation data from the Research and Practice in Science Education course for several reasons: 1) this course was exclusive to the preservice science teacher cohort, whereas the Summer courses included all single-subject preservice teachers, meaning the discussion was more focused on topics relevant to this study (e.g., equitable science instruction), and the participants in my study had more opportunity to talk; 2) this course, more-so than the Winter course I observed, was strongly discourse-oriented. The Winter course was designed to follow the Fall course, and be more methods-oriented, while the Fall course was designed more as an introduction to research and theory in science teaching. In the Research and Practice in Science Education course, activity focused on facilitating PST's discursive sensemaking around the theoretical components of the NGSS that the PSTs would be expected to apply as teachers, as well as equity in science teaching and learning. The orientation towards discourse tended to invite richer, more reflective, and personal discussions on equity in science education.

#### *Analysis as a formative, not summative evaluation*

Because identities, agencies, power dynamics, and conceptual applications are contextually situated and not fixed or stable, I am not claiming that the characteristics

of activity I identify in this chapter are somehow permanent characteristics of the participants. However, these characteristics become relevant to the PSTs' future classroom practice when we think of them as the conditions in which their initial teaching practice is forged. Any one of the characteristics I describe may become salient to the PSTs' future practice, or it may not. An analysis of how the PSTs carry these components of becoming forward into classrooms is beyond the scope of this study and would require longitudinal case study. Essentially, I think of this study as an analysis of the soil composition in which these PSTs grow into their initial teacher selves.

### **Vignette 1: Talking learning theory in a teacher learning activity**

It is around 4 pm on a Monday in a windowless, beige room, in a stuffy building at the heart of Central Coast University's campus. The walls are lined with boxes of secondary science curricular materials and colorful, hand-drawn posters evidencing learning activities past. Ten PSTs, their instructor, and I have converged upon this room to participate in (or observe, in my case), the second session of a course dedicated to science education research and practice.

It is the second week of the preservice science teachers' (PSTs') second quarter of their preparation program. They will have five quarters of instruction in total, with one down and four (including this one) to go. This is an intense program, and the PSTs are usually pretty burned out by mid-Winter quarter, but right now they are fresh off completing their first round of graduate courses and excited to be in their

first science subject-specific course. The California Committee on Teacher Credentialing (CTC) requires that preservice teachers (PTs) be exposed to theories of child development and learning, which they will hear about extensively in several of their courses, including this one, today.

Judging by my observations in the program and reading of program recruitment literature, this preparation program, in particular, has a strong orientation towards sociocultural theories of learning, and aims to assimilate PSTs into a sociocultural pedagogical culture. Additionally, the PSTs in this cohort are being trained to teach using the Next Generation Science Standards (NGSS), which are, in many ways, and by design, predicated on sociocultural assumptions about teaching and learning. In this discussion, the PSTs are prompted to discuss a set of learning theories, including behaviorism and socioculturalism, including one particular sociocultural pedagogical framework: Community of Learners (Rogoff, 1994).

Having just finished a small-group activity in which the PSTs collectively filled out a learning theories chart via live doc, Zach, the course instructor, prompts the PSTs to discuss the theories and to pose any questions of their own. In the discourse that ensues, the PSTs (facilitated by Zach) negotiate the potentialities of sharing power with and ceding control to, students, the meaning of teaching and learning, and the perceived practicality of constructivist and sociocultural reforms. In the following transcript, we will hear from seven PSTs: Molly, Olivia, Valerie, Ernie, Leo, Ivan, and Stella.

In the first part of this discussion, which focuses on behaviorism, students take up various positions with respect to the applicability of behaviorist practices in schools. At the outset of the whole-class dialogue, one PST (Molly) observes that a peer has written on the collective live document exploring the learning theories that “extinction has replaced punishment” and asks the author (unknown to her at that time) to expand.

Olivia (another PST) remarks that she was the author, and she expands, describing a classroom practice she has observed in which teachers make certain kinds of “undesirable” student behaviors go “extinct” by ignoring them. She positions the practice as an acceptable use of behaviorism, and, in the written (on the live doc) and spoken statements, suggests that “extinction” is not a punishment, but merely a “way to diminish undesired behavior”.

Olivia’s framing of “extinction” as a useful, non-punishment classroom “input” represented a cruce that I explore below.

### **Olivia**

#### **Stanza 1**

*I feel like nowadays*

*In behavioris Uh*

*like*

*applied behaviorist theory^ Uh*

*we don't really use punishment anymore^*

**Stanza 2** *but if you want to: stop like  
the child who acts out regularly^  
rather than like constantly calling  
their name and calling their name  
and telling them to stop and telling*

*them to stop instead we just ignore  
the behavior^ and that's extinction//*

**Stanza 3**

*Which is I think a pretty common practice  
and I think it also just helps take some of the like 'ugh, behaviorism' and kind of put a  
little bit more of a like 'yeah I'm cool with that' like...  
I dunno//*

**Valerie**

**Stanza 4**

*One question we also had was  
Isn't punishment also a form of beha:viori:sm^*

**Olivia**

**Stanza 5**

*Yeah  
Reward and punishment is all behaviorism  
but extinction also is U:h  
behaviorism just has to do with what kind of  
inputs do you have to provide in order to get the desired output right^*

**Stanza 6**

*So extinction is another way to diminish  
an undesired behavior//*

*“New Taylorism” in Preservice Science Teacher Discourse: Aligning with  
Behaviorism*

In Stanza's 1-2 and 5-6, Olivia indicates an appreciation for certain forms of punitive behaviorist pedagogical strategy. Though she sets up a discursive distinction between “punishment” and “extinction”, intentionally ignoring a student clearly is a form of punishment, aligning with instructional methods that prioritize control, and positioning students and their bodies as objects to be managed (Giroux, 2011; Au, 2011, 2017; Tuck, 2013).

Here, students are framed not as unique individuals who act agentially in accordance with their needs and desires, as Tuck (2009) urges, but rather as less-than-human beings who either behave correctly or incorrectly, in ways that are desirable or undesirable to the teacher, and who must be formed into “correct” beings through specific “inputs”, including harmful ones (like extinction). In the language of Lugones (1987), Olivia describes students, in this instance, at least, through a decidedly arrogant lens, rather than a loving one.

In these utterances, Olivia integrates multiple Discourse identities (described in interviews) into a subjectivity that reflects her affiliation with natural scientist and preschool teacher Discourse communities. Before coming to the program, Olivia had been an environmental educator working with young children for around 10 years, and based on her utterances in the above transcript, it appears that she had had the experience of interpreting a child as “acting out”, desiring to “diminish” that “behavior”, and finding that ignoring that “behavior” felt more effective as a means of “diminishing” that “behavior”, compared with “telling them to stop and telling them to stop” (as she describes in stanzas 1-3 and 5-6).

Of course, teachers’ conceptions around what students’ behavior (i.e., students’ bodies) should look and sound like during a learning activity are largely subjective--aside from the very real need to prevent harm to student bodies, and the general requirement that teachers be able to “prove” that the students “learned” something (where passing quizzes and tests generally for the basis for evidence of learning). Teachers’ imaginaries concerning students’ bodies are rooted in cultural

notions of what teaching and learning looks, sound, and to a degree, feels like, and such cultural notions are always co-constituted through Discourses of power (Oakes, 1995, Tyack and Cuban, 1995).

Behaviorism, historically connected to scientific management theory applied in a factory setting, is geared towards mass production of “desirable behavior” (as Olivia put it) (Au, 2011). In other words, the behaviorist paradigm in schools has deep roots in the Discourse of American neoliberal capitalism (Au, 2011).

Contemporary American schools, as crucial sites of cultural re/production, are deeply infused with American neoliberalism and have been aptly described as New Taylorist institutions (Au, 2011). Therefore, it is not surprising that Olivia, drawing on her experiences as a teacher, is also drawing from a behaviorist discourse model to think through teaching and learning in this preparation program learning activity.

Olivia also identifies as a scientist, which I see reflected in the way that she discursively distances herself from the object of the utterance: an imagined (or perhaps remembered) student. The discursive distancing of self and not-self (in this case “the child who acts out regularly”) is a hallmark of western scientific ontoepistemology, hailing back to the Cartesian split, and is the bedrock of the western scientific insistence upon notions of rational objectivity, (Harding, 1992; Bordo, 1986; Wynter and McKittrick, 2015).

Bordo (1986, p. 449) described how the Cartesian split, the episteme-busting notion that the human is distinct from the rest of universal matter, led to the



hegemony of “objective” thought over “subjective” thought in western scientific thinking:

The medieval sense of relatedness to the world had not depended on such ‘objectivity’ but on *continuity between the human and physical realms*, on the interpenetrations, through meanings and associations, of self and world. *Now, a clear and distinct sense of the boundaries of the self has become the ideal*; the lingering of *infantile subjectivism* has become *the impediment to solid judgment*. The state of childhood, moreover, can be revoked through a deliberate and methodical reversal of all the prejudices of childhood-and one can begin anew with reason as one's only parent.

As a practitioner of western science, Olivia’s allegiance to the objectivity episteme is evidenced in her language choices as she expresses her thoughts about behaviorism in classrooms.

In her choice to use phrasing like “diminish undesired behavior”, and “the child who acts out”, I see a preference for technical, emotionally distanced discourse. To expand on this point, the phrasing “diminish undesired behavior” implies that there is an objective measure of “desired” vs. “undesired” behaviors. In reality, no such objective measure exists, and the choice by a teacher to punish certain kinds of student behaviors comes down to the teachers’ judgement, their own subjective preferences. This framing discursively erases the teachers’ agency, power, and subjectivity in judging who is punished and who is not and elides the mechanisms through which the teacher makes those choices.

Similarly, the phrasing of the utterance “the child who acts out” discursively erases the students’ agency, needs, subjectivity, and the complex decisions students

make about their own behavior.

The pretense of objectivism allows Olivia to describe neglecting students in the classroom as a non-punishment by obscuring the relational components of classroom management. This framing negates opportunities for relating with student as fully human beings, for deeply considering what needs might motivate a student to “act out”, and what it would feel like to be ignored by the teacher. It also negates opportunities to critically reflect on what her own needs are as a teacher that compel her to demand specific behaviors from students.

These are subtle examples, but their subtlety is precisely what makes their ideological reifications uniquely pernicious. Olivia may enter the teaching profession genuinely believing that a practice of ignoring students who behave in displeasing ways is a good and kind practice. What's more, Olivia's PST peers in the class, having become aware of the practice through this discussion, may venture out into their teaching career sharing this belief.

In these utterances, Olivia drew on and enacted (at least) two Discourses of power as she considered behaviorism and its possibilities as a model for teaching and learning: a Discourse of Behaviorism and a Discourse of Western Natural Science. As she enacts these Discourses, she offers them up to be put into tension with potentially contrasting ideas in the collective classroom discourse. In setting conditions for expansive thirding that include these Discourses, she is also opening up possibilities for the recycling of their genetic material, i.e., the simultaneous transformation and reproduction of these Discourses of power. If, and how, these Discourses are carried

forward in the activity, and if, and how, these Discourses become entangled with the novice teachers' teacher subjectivities, could have significant implications for the possibilities the PSTs engender for care and/or harm in their future classrooms. However, Olivia's utterance was only the opening overture in the discussion, in the next sections we will see what happened with this conceptual map.

*Aligning with Socioculturalism in Preservice Science Teacher Discourse*

Valerie engages with Olivia's discursive positioning from a different standpoint with a distinctly sociocultural bent, emphasizing student agency and gently critiquing the control-oriented culture of schools. Valerie observes that behaviorism is so prevalent in classrooms that teachers can sometimes struggle with how to supply feedback to students that isn't simply rewarding a student for good behavior (i.e., getting the right answer) with praise.

**Valerie**

**Stanza 1**

*To add on to that [Olivia]*

*you reminded me*

*that*

*we use a reward system when we're talking to students*

*for getting the right answer praising them not praising*

*them and I think someone was saying like*

*'I'm not sure how to respond to a wrong answer but still like encourage the student'...*

*I think behaviorism can show up in that sort of way...*

... [several minutes of dialogue elapse]

**Stanza 2**

*I think [Community of Learners (a socioculturalist pedagogical method) is] interesti:ng*

*in tha:t*

*it*

*It also reflects like the work*

*is mostly done by the students*

*they're active participants in their learning*

**Stanza 3** *The:y a:re u:m... you're utilizing different funds of knowledge within the classroom where EL students for example would be resources and not like... something that is not good//*

**Stanza 4** *So:*

*I like this 'learning may appear as chaos'... this organized chaos I think is very attractive*

*'cause you can have science happen in a classroom with like a lot of talking^*

*but it can be productive talking*

**Stanza 5**

*so there's a difference between like that kind of noise^ and just like them not at all focused*

In Stanza 1, Valerie remarks on the pervasiveness of behaviorism in American school culture. On its face, Valerie's observations about behaviorism in schools is similar to Olivia's--however, where Olivia subtly encourages the use of extinction (a behaviorist method), Valerie subtly *critiques* the common use of IRE as another form of behaviorism. She comments that some teachers' pedagogical imaginations, or perhaps, identities, may be constrained by constructions of teaching that are centered around evaluative dialogue: "... someone was saying 'I'm not sure how to respond to a wrong answer but still encourage the student'".

Valerie's observations of the limitations of teaching in a pervasively behaviorist context are contrasted by her positive evaluations of sociocultural methods in stanzas 2-5, in which she highlights Community of Learners' centering of student agency (emphasizing learning that 'appears as chaos' over behaviorist methods which emphasize learning that appears orderly and controlled) and students' funds of knowledge. In this utterance, Valerie enacts a set of Discourse models that contrast pretty significantly with those previously enacted by Olivia.

In interviews, Valerie identified strongly as an academic - describing herself at one point as an "education research nerd" - an identity which I see reflected here in the way her utterances reflect models of teaching and learning she would have encountered in the research literature the PSTs had been assigned to read.

Whereas behaviorist models of thinking and learning are commonplace in schools, and broader American culture, socioculturalist models, like those Valerie described, are dominant in the research literature on teaching and learning. In her utterances, she implicitly contrasts the *equity*-orientation of Community of Learners (and other socioculturalist) models, which allow for difference (e.g., the appreciation for diverse experiences and knowledge accounted for in a "funds of knowledge" framework), with the *equality*-oriented behaviorist models which do not (e.g., EBLs are seen as "bad" because they have different linguistic knowledges compared with "normal" - i.e., "monolingual" speakers of "standard" English - students). In this sense, Valerie enacts a different kind of Discourse of power - that of mainstream

science education research - which prizes equity-oriented and socioculturalist models of teaching and learning.

Also of note is the way in which Valerie begins her utterance: “To add on to that [Olivia], you reminded me”, in which she is almost certainly referring to Olivia’s utterances illustrated in the previous section. From an activity analytic standpoint, Valerie’s discursive analysis of behaviorism in schools was co-constituted by Olivia’s discussion in the previous section. Olivia’s utterances, though they re/instantiated harmful discourses of teaching, also became a mediational means by which Valerie was able to develop a nuanced critique of those very discourses. Perhaps it is partly through her reflection on the problem of behaviorism in schools that the relevance and value of socioculturalist methods become apparent to Valerie. If so, this may be an instance of expansive learning through the double stimulation of Valerie desiring to teach school science, but also desiring to avoid behaviorist pedagogical methods and center student agency.

Ernie picks up where Valerie left off, pointing out the equitable power-sharing characteristic of CoL, and offering another positive evaluation of the learning theory:

**Ernie**

**Stanza 1** *U:h the shared  
endeavor^ So when I  
thought about this  
I was just like  
Maybe I can simplify it  
like really really simplify it*

**Stanza 2**

*Just thinking about like any  
task like  
doing yard work with your parents or something  
like there's a goal that's like  
shared*

**Stanza 3**

*Like it's not like there's somebody like in front of you saying  
'this is what you need to accomplish'  
It's like  
'we're going to accomplish it together'*

**Stanza 4 So I**

*think that...  
that's kinda attractive to all people^  
because there's no: like power  
dynamic^  
You know^//*

Ernie, like Valerie, was consistently willing to discursively entertain pedagogical notions, like CoL, that disrupted normative relations of power in favor of more care-ful ways of being in classrooms.

In interviews, Ernie explicitly related his orientation to science teacherly carefull-ness to his personal experiences with childhood trauma and teacherly care. He had developed identities related to healing and body-mind wellness that were deeply connected to the natural world, which he wanted to be able to share with students-particularly students who were dealing with traumas of their own. The visions of science teaching that he described in interviews were oriented towards care, relationality, outdoor exploration, and subject matter content--but not at the expense of the former.

In class, Ernie's contributions to discussions tended to stretch the collective discursive imagination towards creativity and care, and away from the normative limiting views and deficit perspectives of students and curricular possibilities.

In the following sections I will explore more deeply the ways in which Valerie and Ernie's creative impulses towards equity and care tangled with the competitive, objectivity-oriented discourse practices of some of their peers who were more deeply aligned with western natural scientific disciplinary practices.

### *Resisting Socioculturalism*

At this point in the discussion, it has been generally established that the behaviorist models of thinking and learning have significant drawbacks. Leo and Molly have pointed out that using behaviorist methods with secondary students is akin to treating them "like dogs" and/or very young children, i.e., disrespectful at minimum, dehumanizing at worst. And it has also been established that the socioculturalist model is, in contrast, significantly more respectful and humanizing. However, discursive tension between the models, in terms of their appropriateness for classroom activity, remains, as the PSTs struggle over how practical and/or doable the socioculturalist models really are.

Both Leo and Ivan enact significant discursive resistance to the notion of applying sociocultural methods in schools: Ivan contested the possibility of sharing control with students, while Leo more broadly contested the notion that sociocultural methods are compatible with science disciplinary learning at all.



**Leo**

**Stanza 1**

*I don't think that you can teach u:m every  
subject in that manner I think it's very  
limited in what can be taught*

**Stanza 2** *I guess maybe it was the  
paper itself^ I found it to be very  
philosophical and it almost seemed to  
be intentionally vague^  
None of the examples were very concrete^*

**Ivan**

**Stanza 3**

*I agree with that Because  
today in my placement the kids  
built  
Some folding microscopes and if it  
was not entirely adult driven  
they would have messed it up^*

...

**Stanza 4**

*I kept saying to them  
'Okay You watch her in  
the video then you watch  
me and then you do but  
right now hands-off*

**Stanza 5**

*I had to say that every single step  
And then some of 'em still messed it up^*

**Stanza 6**

*Like if I did just kind of say  
Hey  
Yeah  
In your groups just follow the instructions in the book on how to build it'*

*I'm 100% certain they would've messed it up//*

**Valerie**

**Stanza 7**

*But is that necessarily a bad thing^*

In their utterances, both Ivan and Leo seem disinclined to imagine students as broadly capable, or to imagine a form of teaching that considers and creatively expands upon students' capabilities. Ivan explicitly argues tightly controlled procedural instruction focused on behavioral replication was the only way to ensure that the microscopes were built. However, Valerie, Ernie, and a third PST, Stella, continue engaging with the tension that is building around the applicability to sociocultural methods in the science classroom.

*Imagining Beyond Behaviorism*

In contrast to Leo and Ivan, Valerie, Stella, and Ernie position themselves as more open to imagining this new (to them) form of schooling that allows students to be framed as capable, knowledgeable, and agentic. Presumably, like Ivan and Leo, Valerie, Stella and Ernie haven't seen many (or any) examples of sociocultural pedagogy, or CoL specifically, applied in the classroom, given that they themselves underwent secondary education under the New Taylorist American educational regime of the early 21st century (previously discussed) (Au, 2011). Yet Valerie pushes back firmly on Ivan's statement that his students needed extreme structure in order to build their microscopes without "messaging it up". She said:

**Valerie**

**Stanza 1**

*I'm compelled^ towards this like shift of having students make mistakes  
Because  
that is ultimately what will drive the problem-solving skills*

**Stanza 2**

*I agree and I'm still kind of torn  
I like  
Like Leo's comment ho:w it might be difficult to: have students practice  
and learn information^ but I'm wondering if like a flipped classroom  
could help facilitate like doing their own work... I have no idea...*

**Stanza 3** *but to get back*

*to Ivan's point u:h...  
What if they make mistakes? It  
would take more time  
but wouldn't that experience perhaps be more meaningful^//*

Ivan responds to Valerie's utterances by disputing her proposal that allowing students to build their microscopes without strict procedural supervision might be a fruitful endeavor. Again, Ernie picks up where Valerie left off, proposing a learning design strategy for Ivan's microscope activity using CoL:

**Ernie Stanza**

**4**

*what if it was a community of learners for building the first one*

**Stanza 5**

*Like everyone figures out how to build one  
and then you could break it down again And  
then like a few kids that were like  
'I really get it' they  
could run Like  
their little group  
and build like  
The next four or something*

...

### **Stanza 6**

*It is interesting like to  
me I'm like 'I love  
this' but then I'm like  
'ooh how do I plan it'//*

Like in the previous section, Ivan resists imagining a socioculturalist version of a particular activity which he had managed in a strictly behaviorist way, while Valerie discursively tugs back (stanzas 1-3). Valerie's pull on Ivan generates an opportunity for Ernie to narrate his own critical pedagogical imagination (stanzas 46). As I will discuss in Vignette II, this was a role that Ernie often played in the activity, and more broadly, this discursive pattern of resistance (often from Leo), pull (often from Valerie), expand/imagine (often Ernie and sometimes Stella) was common in the learning discourse of the classroom.

At this point, Leo re-entered the discussion (he initiated this line of discourse in Stanza 1 of *Resisting Socioculturalism*) to reiterate and expand on his initial question:

### **Leo**

#### **Stanza 7**

*So  
I guess I don't understand you completely [gaze directed at Zach, the instructor] I  
know  
in one part of the paper they talked about I think writing a research paper or paper  
U:h  
on a subject  
but it didn't really talk about that much more than that*

**Stanza 8**

*So could you teach a subject like relativity just write  
it up on the chalkboard that day and be like  
'all right so we're learning relativity'  
you know  
'have at it'*

**Stanza 9** *And in*

*that case  
isn't it kind of just self-teaching at that point wouldn't it be^  
just going on to Google and taking out a book and going through the book and  
teaching it to yourself^*

**Stanza 10**

*Like that would be an example of one subject where  
is there a way to teach that subject U:h  
with that method^*

**Stanza 11** *O:r*

*is that something that would be impossible to do//*

In stanza 7, Leo again implies a critique of the article he had read as insufficiently concrete (as he had in Stanza 2 of *Resisting Socioculturalism*) --a critique likely rooted in western natural scientific disciplinary training, which values empirical, "concrete," data above all, which I will discuss at length in Vignette II.

Notably, he also directs his question towards the instructor, rather than his classmates, positioning the instructor as the primary arbiter of knowledge for the moment. Zach refuses this positioning by maintaining his role as a dialogic facilitator and allowing space for a PST to respond to Leo's question.

Stella takes advantage of the churned discursive soil to recall and offer a response from the reading:

**Stella**

**Stanza 12**

*I think there is [gaze directed at Leo] And  
there was a quote in the:re  
that*

**Stanza 13 it**

*wasn't against  
either the child driven or the adult driven one  
or was against the child driven one A  
critique I think that Dewey had  
and ho:w  
with the child driven education it takes out the wisdom from a mentor figure^*

**Stanza 14 And**

*so  
like with the community of learners I think it still acknowledges the fact that there is  
this  
there is someone who might have more knowledge but  
it's  
And you're helping facilitate the activity or the discussion about relativity and helping  
the students to  
build their knowledge on that^ But  
it's not just like  
like spewing out information for you to just write down//*

Stella's response in Stanzas 12-14 indicates a close listening to Leo's questions, and close reading of the text, and a positive, equitable view of teachers and students. Where Leo's proposition in Stanzas 8-9 suggests that teaching must be either entirely teacher-centered or entirely student-centered (either way, a hierarchy), Stella suggests (using the text as evidence) that power can in fact be fluidly shared between teacher and students.

In Stella's response, I see her drawing on her faith identity, which she described and strongly affiliated with in interviews. In interviews, Stella described it as her spiritual duty to "love people" "for who they are". In interviews, she directly related this to her emerging teaching philosophy, which very much centered around care, humility, deep listening and learning, and appreciating students for their unique ways of being.

Stella described her orientation to conflict - internal or external - as "taking a very humble posture of learning", which I see reflected in the way she navigated this tension between Valerie, Ivan, and Leo, and the readings. She refers to the text as evidence, though in a different way than Leo had previously.

For Stella, textual evidence takes the form of a reference to an Education theoretical heavyweight, John Dewey, and a nuanced theoretical point articulated by the author. Where evidence for Leo must take the form of "concrete" examples, for Stella, evidence can be explicitly subjective expert opinions.

I could speculate that, given that Stella has had a similar natural scientific disciplinary education to Leo, the particular literacy practice she leverages in her close reading and evidence-finding in this text might come not from school, but from a practice of sitting with spiritual texts (Leo did not identify as a spiritual or religious person, or indeed make any references to spirituality or religion, in interviews or in classroom activities that I observed).

**Valerie**

**Stanza 15**

*And just add on to [Stella's]*

*Like*

*I remember reading when they explained the instructional models adult-run childrenrun in the community of learners*

**Stanza 16**

*They disti:nctly say like*

*it's not that there's like a balance or an optimal plan*

*Right^*

**Stanza 17**

*So it is up to Us*

*to figure out*

*'Okay*

*what's going to work for kind*

*of disseminating' Obviously*

*'the*

*knowledge they*

*need to*

*somehow*

*accumulate'*

**Stanza 18**

*But at the same time like*

*how do you make that Um*

*how do you make it so that they're able to apply that knowledge*

Finally, Valerie extends Stella's utterances by also citing the author's expert opinion as evidence, and also remarking on the fluid power-sharing aspects of CoL and concluding with a vision of teachers' work: that the teachers' job is to manage the balance of power/control with the ultimate objective of students "accumulat[ing]" and creatively "apply[ing]" "knowledge".



### *Section Summary*

With this vignette, I explored in detail the ways that a cohort of preservice science teachers negotiated competing ideologies around power, control, and student agency as they discussed theories of learning (behaviorism and socioculturalism/Community of Learners) and their classroom applications.

My analysis highlights how PSTs' alignments with, and resistance to, behaviorism and socioculturalism, were rooted in Discourses and Discourse identities that the PSTs brought with them into the classroom. This analysis also introduced the disciplinary discourse practices of the western natural sciences as particularly salient in the classroom discourse. Western natural scientific discourse practices also served as discursive tools which mediated activity towards more behaviorist discursive alignments that suggested harm-ful teacher-student relations, and away from sociocultural alignments that suggested more care-ful teacher-student relations. I continue my analysis of the role that western natural scientific disciplinary discourse practices played in the classroom learning activity in the following section.

### **Vignette 2: Talking Equity in a Science Teacher Preparation Program**

The following learning activity unfolded roughly a month into the Research and Practice in Science Teaching course (approximately 2 weeks following the activity described in the previous vignette). This course session was dedicated to exploring the question "How can we create equitable learning opportunities?", and was accompanied by these readings: Framework *Chapter 11: Equity and Diversity in*

*Science and Engineering Education; What's language got to do with it?: A case study of academic language instruction in a high school "English Learner Science" class* (Bruna, Vann, and Escudero, 2007); and *Toward the sociopolitical in science education* (Tolbert and Bazzul, 2017).

This week's class sessions focused on the topic of equitable science instruction, another dominant theme in the course and the program as a whole. With this vignette, I highlight the ways that one PST in particular, Leo, grappled with conceptualizing equitable science instruction, and the Discourse enactments that complicated that struggle.

The vignette in this section centers on a small group discussion. The PSTs were asked to discuss, in small table groups, what had stuck out to them from the assigned readings for the day (Bruna et. al, 2007, and Tolbert and Bazzul, 2017), and to discuss how each reading had conceptualized "equity in science education". I sat and observed one of the small groups, including Leo, Stella, and Ernie.

Stella began the discussion by offering some initial thoughts (all positive) on the readings, and then summarizing one of the articles for Ernie, who commented that he had not had time to read it. Leo entered the discussion after several minutes to offer his summation of Bruna et. al's conceptualization of equity--using a "funds of knowledge" approach:

**Leo**

**Stanza 1** I think^ f-funds of  
knowledge was something That..  
Was u:h.. prevalent//

**Stanza 2**

I guess maybe it's because the spiral curriculum on  
our part  
We're seeing it over and over again//

**Stanza 3**

Just..  
taking into account where each person has come from A:nd  
u:m..

**Stanza 4**

Yeah  
Making sure that you use something that they can identify with^..  
In the:..  
In the learning^.. Is  
u:m..  
Important In  
In equity..  
If you will//

**Stanza 5** Uh..

The second paper  
I was having a hard time following on the first part of it//  
I don't know English THAT well^  
so I didn't know a lot of the terms they were using and the sentence structure  
but I did appreciate it when it actually got into like the cases// Yeah//

A "Good Science Student"

Leo's entry (stanzas 1-5) is notable in that he shifts the object of the discussion in order to very specifically respond to the instructor's prompt to reflect on the readings and how they construct equity. Again, this is Leo's first utterance into

the small-group table discussion, which had previously been relatively unstructured, and had been orbiting around the fact that Ernie hadn't been able to do all the reading. His object seems to be to respond to the prompt thoroughly, and likely to be recognized by peers and the instructor, who will be checking in on the group soon, (and possibly the researcher, who is filming) as having done the assignments accurately. I see Leo's (agentic) move to shift the object of the small-group activity to more exactly align with the prompt as an expression of Leo's Good Science Student identity.

Leo had identified strongly as a focused, hardworking student in interviews (see Stanza E, below). Identifying as a "good student" in Western natural science education generally demands not just diligence and attention to detail, but also the ability to locate oneself at or near the top of a student hierarchy. Said plainly, being a Good Science Student is a competitive sport.

To illustrate, in his initial interview, I asked Leo to reflect on his selfdescribed identities, and how his experience in the preparation program might shape his identities. He began by reiterating some of his most salient identities (e.g., outdoorsy), before expanding on his academic identity, which he had previously described as very important for him:

**Leo**

**Stanza A**

Academically...

*I think in this [cultural foundations] course so far*

*I don't know what my grades are gonna be... but*

*I'm not gonna feel...*

*as prou:d^*

*O:f^ The:m^...*

**Stanza B**

*For one reason I think they're*

*gonna try not to fail anyone and*

*we can only get an A or a B*

*A:nd*

*So far I've been getting As on my papers but I don't feel like I've really been working  
that hard for them*

**Stanza C**

*So it's not going to be something where I'm like*

*'YES' you*

*know*

*'I have a high GPA in this program'*

**Stanza D**

*Just seems kind of like something that's*

*happening*

*without much effort*

**Stanza E**

*Um, in my chemistry classes*

*I put a lot of effort into*

*You know doing*

*very well and*

*being very knowledgeable in every class that I took*

**Stanza F Um**

*so I think that identity might not be as important to me right now^*

Here, Leo describes an identity that he maintains as a very hard-working and dedicated student in his natural science academic work (Stanza E), which he

compares with his present experience as a student in the preparation program, and specifically in the cultural foundations course, in which he isn't "working that hard" (stanzas A-B). The main point of contrast he introduces between his previous and his current academic work is the comparative risk of failing the course or attaining a low GPA (stanzas B-C). This suggests that Leo's student identity is in some way (at this point, at least) contingent upon the fear of failure, the possibility of successful competition, or both (as previously illustrated, central characteristics of western natural science Discourse). In stanza F, he explicitly states that his diligent student identity is not feeling salient.

It seems to follow that, at the time of this interview, the graduate courses in which Leo finds himself are unrecognizable, or simply un compelling, as contexts inviting rigorous scholarly engagement, precisely because of the absence of natural scientific discourse practices like competition and hierarchy.

### *Typologizing the Literature on Equitable Science Teaching and Learning*

In Stanzas 1-2 (above) Leo also reflects on the repetitive emergence of the notion of *funds of knowledge* in program curriculum, observing that this must be an important theme, since it keeps coming up. This assessment isn't incorrect, per se, but it does not suggest a thoughtful attempt to make sense of the complexity of Bruna et. al's discussion of equity in science education.

Broadly speaking, this Bruna et. al, piece provides an example of k-12 science classroom discourse, and a science teacher's overemphasis on form over function in

student science talk. In other words, it provides an excellent example of a common form of a raciolinguistic violence in science classrooms. The piece, and the discussion activity designed around it, offered quite a poignant argument for care-ful, inclusive science instruction. However, and as briefly discussed in the previous vignette analysis, Leo seems to be approaching this text with a rather unhelpful set of discursive tools. In lieu of literacy practices more appropriate for this activity, for example, the close reading and citation of expert opinion as evidence that we saw Stella using towards the end of the previous vignette, in this instance, Leo applies a particular type of literacy practice that is prevalent in western natural sciences: typologizing.

One of the things that Western scientists do that is recognizable to other western natural scientists - particularly in the k-12 science education construction of scientist - is to categorize things, for example, types of mussels, and then to assign those things a location in broader typologies of things identified and categorized by other scientists (Sheth, 2019). For example, a type of mussel would be assigned to a sub-class (Marine, Freshwater, Zebra), a class (Bivalvia), phylum (Mollusca), kingdom (Animalia), and domain (Eukaryota). Leo's rather terse description of Bruna et. al's (2007) conceptualization of equity as simply "funds of knowledge", and the subsequent identification of a type of papers he's encountered in the program "again and again" is identifiable as an application of this kind of western natural science discourse practice.

As a subject in this small group learning activity, Leo's discursive tool use mediates not just his own access to the text, but his group's collective sensemaking process as well. For example, we will see later in this section how the awkwardness of Leo's western natural scientific discourse practices as mediational means in this activity remains a sticking point in the PST talk as Leo continues to shift the objective back to his own persistent incomprehension and away from the sensemaking propositions of others (and Ernie's in particular).

*Objective Rationality in Reading the Literature on Equitable Science Teaching and Learning*

Noticeable as well in stanzas 1-5 (above) is what Leo does not do in his reflection: he avoids opining on the text under consideration. He describes and categorizes, which are understood in the western natural science disciplines as good, objective knowledge-making practices, maintaining a distant (or non-existent) discursive relationship with the material. In contrast, two of Leo's discussion partners, Ernie and Stella, had previously given opinions about the pieces they had read. For example, Stella had described the actions of the case study teacher in the Bruna article as "very, very, very insensitive". For Stella to opine this way required her to discursively locate herself with respect to the text; her judgement of the teacher's actions indicating reference to her own personal feelings and/or beliefs. In privileging typologizing practices over opining practices, Leo maintains rational



objectivity in his orientation to the content of the texts in lieu of a more praxis-oriented approach.

Finally, stanzas 1-4 of this utterance (above) are quite choppy, full of pauses, hesitations, and false starts. Given the previously discussed contextual factors, this suggests that Leo was being asked to communicate in a sign system with which he had little fluency, or confidence. Western natural science's foundational value of objectivity equates to a general trend in the disciplines towards avoiding explicit discussion of politics, power, oppression and liberation. Therefore, these disciplinary discourses have a limited vocabulary, and discourse practices that are awkward and unproductive, for these topics. So, Leo's awkwardness as he works to reflect on notions of equity may represent another characteristic of western natural scientist discourse identity, typified by lack of exposure to, experience with, and/or interest in, critical consciousness-raising discourse.

### *Epistemic Chauvinism in Reading the Literature on Equitable Science Teaching and Learning*

In stanza 5, Leo continues sharing his reading reflection with his classmates, and shifts topic to discuss the second reading for the day. He comments that the introduction to Tolbert and Bazzul (2017), which samples heavily from critical theory and political philosophy, was essentially illegible for him.

Leo again enacts western scientific discourse practice in his preference for empirical data, when he says, "I did appreciate it when he actually got into the cases".

His use of the word “actually” here implies that the topic following “actually” - the cases - are more real or relevant than the previous topic (the introduction) (Lenk, 1998). This utterance mirrors the western scientific preference for observable phenomena, the collection of data, and “objective” analyses over consideration of expert opinion and theoretical discussion (as previously discussed in vignette 1). Leo’s enactments of western natural scientific disciplinary discourse practices, as described above, are subtle, but as a theme in his classroom utterances, they represent a powerful shaping force in the activity system.

Additionally, though the enactments are subtle, Leo’s reflections on classroom activity in interviews were far less so. For example, in one interview, Leo described how he was engaging with the readings in the cultural foundations course--which he refers to here as “the race relations class”:

**Leo**

**Stanza A**

*This is something I learned as a chemistry major to question everything^  
and don't take anything Uh  
for face value^...*

...

**Stanza B**

*You know a lot of the papers I read in the race relations class they don't seem scientific to me at all so i'm wondering how much of 'em are actually legitimate but some of 'em actually seem you know they might take one random study  
it's like okay this happened at one school*

*but that doesn't show that it was happening at all the schools for instance*

**Stanza C**

*This is someone that has  
a view and they're  
trying to  
kind of employ that view*

**Stanza D**

*so im still critical about what I'm reading  
even in all these classes at this moment  
And I want to teach my students to do the same//*

Leo refers to the cultural foundations (stanza B) as the “race relations course”. He was the only participant to ever refer to it this way in interviews or observations. This suggests that, though race was not the primary focus of the course, he was perhaps most aware of the experiences of race-forward talk in the course. In fact, Leo does describe experiences of discussions on race in the program with significant negative emotion. I read his labeling of the course as “the race relations class” as suggestive of the vivid emotionality of these kinds of discussions, which were more common in the cultural foundations course than other program courses he had taken at the time of this interview.

In stanzas B-D, Leo explicitly describes reading social scientific disciplinary literature (i.e., “*the papers I read in the race relations class*”) through the lens of natural scientific disciplinary practices - in this case, standards of objectivity, (i.e., “*they might take one random study, it's like, okay this happened at one school, but that doesn't show that it was happening at all the schools,*” “*they don't seem scientific*

*to me at all*") - and by those standards, finding them entirely deficient (i.e., *i'm wondering how much of 'em are actually legitimate*).

One can easily imagine how this way of reading and evaluating research literature renders entire areas of education research illegible to Leo. For example, critical research necessarily "employs a view" by nature of its commitment to liberatory social transformation (Creswell, 2014; Mertens, 2012); Critical Race Theoretical research in education by nature emphasizes individual narrative and also has an explicit liberatory agenda (Ladson-Billings, 1999).

Leo's disciplinary literacy practices not only render non-western natural science disciplinary literature as illegible (as discussed in the previous section), but also as *deficient*. Through the western natural scientific disciplinary lens, the research that Leo is assigned in the cultural foundations course isn't just different, it is sub-par. Given these and similar interview statements, I'm inclined to read Leo's aversion to the Tolbert and Bazzul (2017) piece as a function of it being illegible to him as scientific in the ways that are appropriate for research literature in the social sciences.

#### *Equity and "actually" teaching science*

At this point, Leo continues his initial reflection on the readings, comparing the 'funds of knowledge' equity model he perceived in the readings, with a different kind of equity model he perceived from a curriculum design workshop oriented towards critical consciousness building:

**Leo**

***Stanza 1***

*Something I was wondering about was and this is going back to: .. uh .. the workshop that we did the other weekend.. And so it seemed with that lab that we were designing the end result had to be something that was enlightening U:m .. to the class as a who:le And u:h Something that was in effect U:h*

..

*I guess ..*

*U:m ..*

*keeping them ..*

*keeping them as a: u:h ..*

*A minority .. population//*

***Stanza 2 But***

*[clears throat]*

*in these readings right here it didn't seem to really go that way//*

***Stanza 3***

*The end result of the lab didn't need to be teaching them something that's been .. Uh keeping them down as a minority population but instead just using something that was familiar with*

*Uh*

*To each student in their lives*

*to actually teach them the science//*

***Stanza 4***

*Does that make any sense^//*

*I'm getting some blank looks//*

In Stanzas 1-3, Leo describes two different conceptual constructions associated with the term equity. He observes that the term has been used in two different contexts (the reading being discussed, and an unrelated curriculum design workshop) to indicate different kinds of ideas about equitable science teaching, one

pertaining to students' access to science learning activities through the pedagogical practice of contextualization (Tolbert, Knox, and Salinas, 2019), the other pertaining to the pedagogical practice of critical consciousness-raising through science education (Freire, 1970; Schindel Dimick, 2016).

Later in the lesson, the instructor, Zach, will clarify that accessibility and critical consciousness-raising should both be considered as reciprocal, "not interchangeable", *aims* of equity in education. In other words, where Leo seems to perceive an either-or conceptual dilemma (e.g., is equity accessibility *or* is it consciousness-raising?), the instructor's objective for the lesson is for the PSTs to understand that equity is both accessibility *and* critical consciousness-raising, among other things.

As illustrated in the previous section, this is another instance in which Leo's application of typology - an enactment of Western natural science Discourse - leads the small group discussion away from the instructor's objectives, and stunts possibilities for discussion towards more critically imaginative and liberation-oriented conceptual areas (as we will see later in this section).

Leo's Discursive enactment in this situation also speaks to Leo's agency, enacted in relation to his "good science student" identity (previously discussed). Thinking with Tuck's (2009) notion of agency as desire, Leo's desires in this activity seem straightforward. His utterances align closely with the prompt the groups have been given for discussion, which indicates that he desires to follow the assigned procedure with accuracy. Perhaps he desires to see himself, or to be seen by others

(perhaps by the researcher videotaping him), as a diligent, focused, and knowledgeable student--in other words, to inhabit an identity as a good student. Given that this was an important identity for Leo, as he expressed in interviews, this possibility is not unlikely.

Judging by his perseverance in his discursive sensemaking around this perceived dilemma (accessibility vs. critical consciousness-raising), he also seems to authentically desire sense around how they should be defining equity in science teaching. Whatever Leo's desires were in this interaction, his desires - or agency - clearly shaped the conceptual trajectory of the group's discussion.

In Stanza 3, Leo further illustrates the dilemma he has perceived and introduces a new concept to the discussion: "actual" science teaching. He again uses the word *actually*, this time to distinguish between critical consciousness-raising science teaching and "actual" science teaching, e.g., science teaching that is not critical consciousness building. The dichotomy that Leo sets up here between critical consciousness-raising science education and "actual" science education is another subtle enactment of Western natural scientific disciplinary practices, echoing the objective rationality and epistemic chauvinism described in previous sections.

Of course, all activity, including activity in Western natural science and science education discourse communities, is structured in part by power, culture, and ontoepistemic beliefs and practices. The conceptual products of western natural science are all inherently imbued with the values embedded in the Discourse: humanism, objectivity, typology, and in many cases, other Discourses that are

common in liberal Western enlightenment thinking: cis-hetero-patriarchy, white supremacy, coloniality, capitalism, etc.

However, adherents of western natural science Discourses often believe that western natural scientific activity is separated from bias, power, culture, producing value-neutral knowledge about the earth, because of its allegiance to procedural objectivity (Harding, 1992). It appears that Leo ascribes to such a belief, given his implicit assertion that teaching “actual” science means teaching the conceptual products of western natural scientific activity divorced from any kind of sociopolitical context.

*“Does that make any sense?”: A chemist locates a word for power*

Particularly noticeable in Stanza 1, Leo clearly struggled to verbalize his thinking around the sociopolitical content of the workshop he attended. His reflection on the workshop is full of pauses and false starts; he seems to be searching for words, struggling for coherence, to the extent that in Stanza 4 he concludes by asking his interlocutors whether his previous utterances “[made] any sense”.

This discursive stumbling is indicative of the sentiments that several of the participants in this study expressed: that “science people” “don’t know how to talk about this [critical] stuff” --a phenomenon which I will discuss at greater length later in this section. And in fact, his peers respond that they have not understood. Leo reiterates his comments and again struggles to describe the more political orientation of the curriculum workshop.



Following Stanza 4 (transcript not shown), Zach joins the conversation and begins scaffolding the discourse. Leo reiterates his conceptual dilemma, and Zach revoices Leo's talk, introducing the term "marginalized" where Leo is struggling to index students being "[kept] down as a minority population".

This was an important move for Leo because it captures a power-laden relationship between subjects (or in this case, collectivities). The word marginalized implies a relationship between margin and center, included and excluded, less and more powerful. The power dynamic appears in the notion, not necessarily explicit in the term, but inherent to our common understanding of the word, that the marginalized individual or group has not marginalized themselves--they have been pushed to the margin by some other individual or group. Previously, in Stanzas 1-4, Leo had struggled to describe the relationship between students and "something that's been keeping them down" --now he has a term for that kind of power dynamic: marginalized.

Zach also prompts engagement, and uses mediational means (the readings, a graphic organizer) to work the students' collective ZPD. Once Leo's ideas are given language support (in the form of Zach's revoicing, and textual support), the group is finally able to harmonize their activity. Leo restates his thoughts using the new language, and Stella, who had requested clarification from Leo, says she now understands what he is saying. Ernie recalls that the distinction that Leo is describing is clarified in a chart they have been given outlining three "dimensions of equity":

“Multicultural Education”, “Social Justice Education”, and “Culturally Responsive Pedagogy”. In the next section, the small group discourse shifts as Ernie becomes a primary interlocutor.

*Critical pedagogical imagination in PST equity talk*

In this section, Ernie describes a clear desire (agency) directed at critical consciousness-raising science pedagogy--but struggles to envision it. Leo, his primary interlocutor, steers the conversation away from Ernie’s open-ended wondering, and back towards his own persistent sense-making dilemma (stanzas 1-3). After Ernie recalls the “dimensions of equity” chart, Zach offers to project the chart on the pull-down screen. As the small group discussion continues, the PSTs engage heavily with the chart that is now projected on the screen (briefly described in the previous section). Ernie points to the central column on the chart, which describes “social justice education”, and reads from the definition given for social justice education:

***Ernie: (12:55) Stanza 5***

*[reading from the chart] “Centered around raising students’ consciousness about inequity in everyday social, environmental, economic-’*

*That's what [Leo's] talking about//*

***Stanza 6 that's what I got gravitated towards too was like .. and that's why I got all confused***

*[Stella states that she now remembers the activity and is catching up to the conversation]*

**Stanza 7**

'cause I was like 'Oh, we have to like  
do this thing but I think it's the  
I think it's that education of  
of youth about equity is  
like  
a long process and it involves maybe your lesson but  
like  
[gesturing towards the chart] that's the center of it

In the opening of Ernie's statement (Stanzas 5-7), he implicitly responds to Leo's question, (i.e., *is equity in science teaching about inclusion or critical consciousness raising--see previous section*), by emphasizing the chart, which represents equity in science teaching as a three-dimensional practice that includes both inclusion *and* critical consciousness raising. Having seemingly squared away Leo's dilemma, Ernie quickly moves on to his own wondering about equitable science teaching, based on his personal commitment to care-ful science teaching.

In interviews, Ernie described an orientation to care-ful science education that was rooted in familial and medical trauma and his personal pursuit of healing, as well as in his experiences in community. Featuring prominently in Ernie's self-reflective discourse is the word "different". When I first asked Ernie to reflect on his identities, he stated:

**Ernie:** (28:39)

**Stanza A** *U:m..*

*I guess.. being  
different//*

**Stanza B**

*Like No:*

*so like  
Uh  
like when I was a kid they were like  
'you:'re ADHD' //*

**Stanza C**  
*or like you  
you aren't good in school or something//*

**Stanza D**  
*you can't follow the rules or something//*

**Stanza E**  
*And then I was like 'wait no that's a virtue'//*

**Stanza F**  
*And it's like really important to me .. to  
be: ..  
not like other people//*

**Stanza G**  
*And it's like  
it's not easy//*

This notion of difference was a major theme throughout Ernie's interviews; it had defined his experiences in school, his community, his professional moves, and his goals for science teaching. When I asked Ernie how he envisioned himself as a science teacher, he described care, community, and wellness as central pillars of his mission as a teacher, illustrating a teaching philosophy that acknowledged the complex needs of young people and as well as the importance of engaging with and learning in and about the natural world:

**Interviewer:**

**Stanza A**

How do you imagine yourself a:s a science teacher ^  
And I mean very literally like when  
you  
Imagine it in your head ^  
what do you see// Being  
a teacher// **Ernie:**

**Stanza B** Outside..

U:m..  
Snacks ^  
like work  
like working together.. ^ Having  
taking time to like..  
make food together..  
Learning.. Outside  
you know..  
Cooperating

...

**Stanza C**

They were like  
Like  
The:y like I wrote about this one English teacher ^  
That was my teacher  
Right during the year that my [familial trauma occurred].. ^  
And I was like she just absorbed some of my trauma.. Like  
she just ca:red.. ^ actually cared ^ And she was able to like  
take some of this s stuff that was happening to me ^ and she  
took some of it on ^  
and I was relieved of it//

**Stanza D**

So I think that for me .. ^  
It's  
Like Almost .. more important  
to be present ^ for young  
people ^

*and to attempt to like engage them with learning but  
also like  
to show them that there's like hope  
like that there's people that actually are like there to just be there for them^  
You know^*

I bring in these reflections from Ernie as context for understanding his engagement with the classroom learning activity involved in stanzas 5-13. Ernie's orientation towards care-ful science teaching, rooted in his identity as "different" and his personal experiences with trauma and healing, was unique in his cohort. Several of his peers, particularly Valerie, were vocal about prioritizing the care, dignity, and agency of secondary science students. But Ernie stands out in the discourse of the courses I observed in his willingness to imagine outside the "grammar of schooling" particular to early 21st-century American public schools (Tyack and Cuban, 1995).

As Ernie poses a new provocation to his small group based on his own wondering, he brings to the fore a very different set of discourse practices and commitments than had been previously centered by Leo. He asks the group: what would it be like, what could it look like, to teach science using this 3-part framework for equity? He works to pursue a collective critical imagining of a different kind of science education that works towards critical caring:

**Ernie**

**Stanza 8**

*to me it's the center of the frickin' paper and it's the center of the thing [gesturing to the chart] like  
[eyes trained on the chart] It's about raising consciousness about inequity for young  
people  
And to me that makes sense ..*

**Stanza 9**

Like for me I'm like 'Yeah' if .. Like  
As an adult I'm way less like ..  
I'm like maybe a little more closed-minded to stuff like that or like 'this doesn't apply  
to me' or something But  
I think with young people  
You can really kinda steer them ..  
To be aware of that stuff so they can kinda  
Prevent the negative effects of it

**Stanza 10**

But yeah for the lesson I was all  
'wa:it like how do  
we get that  
How do we jam that in there'

**Stanza 11 and**

then I was all  
Wha:t's equitable [rising tone]  
Like  
And then every little thing I just nitpicked and I was all  
'Who get's to decide why I  
forget what I said ..  
Everything  
You could look at everything from an equity lens ..  
You know [rising tone]

**Stanza 12 So**

like  
Is that it ^  
Or are we like supposed to be ..  
[pause as Ernie looks around at interlocutors]

**Stanza 13 That's**

just  
But then I was like 'wait but then we're just the teacher like  
designing this equitable experiment we aren't even informing like the  
young people what we're doing.. So the whole point is to inform them  
about the equity considerations//

In Stanzas 8-9, Ernie emphasizes his commitment to consciousness-raising in science education and provides some justification. He reflects that adults (he implicates himself in this category) can be more “closed-minded” than young people and may not be as receptive to learning about inequity, or critical consciousness development. He implies that science teachers, using a consciousness-raising framework, can help students “kinda prevent the negative effects of [inequity]” through critical awareness.

At this point, Ernie pauses, having communicated his provocation and wondering to the group. He has established his view that “Multicultural Education”, “Social Justice Education”, and “Culturally Responsive Pedagogy” are all parts of equitable science teaching, and that consciousness-raising “social justice education” is central, and he has also posed a series of open-ended questions that might take the discussion into transformative territories: “*how do we jam [consciousness raising content] in there? What is equitable content? Are equity considerations still equitable if you don’t make them explicit to students?*” I.e., if the group were to take up these provocations, they might be adventuring into transformative territory, thinking through how to reimagine science teaching practices to center equity.

### *Rendering Critical Imagination Unthinkable*

Rather than engaging Ernie’s provocations, Leo again re-centers the discussion back on his own sensemaking dilemma (as previously described):



**Leo:**

***Stanza 14***

*With this approach..*

*But with the papers we read it wasn't geared that way so much//*

*[Zach probes: "say more"]*

***Stanza 15***

*So I feel like the papers weren't geared towards that being the center [gesturing towards the center of the chart] Um ..*

*Um .. you use*

*or the papers were talking about how you take their funds of knowledge and background and um forget about ..*

*Um .. pronunciation of the words*

*And then you teach what's familiar to them so that they can actually learn the science instead of teaching what's unfamiliar to them so that they don't learn the science Whereas this [gesturing towards chart] seems to have a very specific goal of the lab and the lesson itself um making being a revelation to them//*

In these utterances, Leo effectively turns the page on Ernie's provocation and also does not appear to have registered that Ernie had actually reconciled his dilemma.

I interpret this as an enactment, on one hand of Leo's Good Science Student identity- he may still be focused on hewing the conversation close to the prompt given by the instruction, to discuss how the two papers define equity in science teaching. He may see Ernie's provocation as off-topic (in spite of the clear relevance).

I also interpret this as an enactment of Leo's rather chauvinistic orientation towards "unscientific" forms of communication (see section above titled Epistemic Chauvinism). Leo had in fact explicitly stated in interviews that he often outright ignored Ernie's contributions to class discussions:

**Leo**

**Stanza A**

I honestly don't pay attention a lot when Ernie talks<sup>^</sup>.  
Its just like sometimes he says some really insightful  
things..

Um

but most of the time I'm just like

'really<sup>^</sup>

Okay

That's why you raised your hand<sup>^</sup>

..

**Stanza B**

I don't think his views are necessarily different than mine although  
sometimes they are..

**Stanza C** U:m..

I don't think he forms his thoughts fully<sup>^</sup> before

he: decides to raise his hand<sup>^</sup>

And that a lot of what he says it doesn't contribute in  
any way

**Stanza D**

Um

And sometimes it does

you know sometimes he has insightful  
things to say..

but other times I'm like 'why: did you need to say that<sup>^</sup>'

**Stanza E**

But yeah

So usually when he talks I'm not really honing  
in on the conversation at that point

To return to the notion of legibility, as discussed in the Epistemic Chauvinism section

(above) I interpret these comments (stanzas A-E) as evidence that Ernie, like the

“unscientific” texts the cohort read in their cultural foundations course, is almost

entirely illegible to Leo as a source of knowledge.

As I have shown throughout both vignettes, Leo and Ernie do in fact have quite different practices of engagement in classroom learning discourse. Where Leo tends to steer discussions towards the prompts provided, Ernie often pursued critical imaginative lines of collective thought that aimed beyond the specific boundaries of the prompt. Whereas Ernie's comments in stanzas 5-13 are quite complex, indexing many course-relevant concepts almost simultaneously--a common characteristic of his discursive contributions to the classroom activities I observed, Leo's contributions tended to have more of a linear quality.

However, where Ernie appears to be able to "read" Leo - as evidenced in his astute response to Leo's open question (stanzas 4-10) including the recollection of the data graphic the group was eventually able to use quite effectively - Leo appears unable to "read" Ernie. For Leo, Ernie's discourse practices are not just "different", they are totally devoid of any meaning and utterly inadequate (e.g., stanza A, above).

Because Ernie was a primary driver of critical pedagogical imagination in the activity systems, Leo's inability (and/or unwillingness) to think with Ernie meant that Leo missed ripe opportunities to engage in learning around more care-ful, transformative modes of science instruction. Of course, the very fact of the creative quality of Ernie's contributions may well have been precisely what rendered them unappealing/inaccessible for Leo.

In this instance (as in vignette I), Leo's steering of the group discussion away from Ernie's contributions also limited the opportunities his peers may otherwise have had to think with Ernie's critical imaginative provocations. In this sense, Leo's

enactments of his western natural science-aligned discourse practices mediated the collective activity away from the socially transformative conceptual areas introduced by Ernie.

*Section summary*

The second vignette explored the convergence of two very different sets of repertoires of practices, embodied by two preservice science teachers--Leo and Ernie, and how opportunities for learning were shaped in and through that convergence. Where Leo's discourse centered rationality, objectivity, competition, and hierarchy, Ernie's centered care, creativity, relationality, and liberation. Working and learning with Ernie provided Leo with a powerful opportunity to expand his quite narrow ontoepistemic repertoire--an opportunity which he was never able to fully capitalize on. Leo's disciplinary training rendered Ernie, like the critical social scientific texts he was assigned in the program, almost entirely illegible as a source of knowledge.

## Discussion

### **Ontoepistemic Underpinnings in Preservice Science Teacher Talk**

The discourse illustrated in the first vignette oscillates around the ideological poles of socioculturalism and behaviorism as educational paradigms.

Socioculturalism and behaviorism are associated with distinct (and distinctly different) pedagogical approaches, from participation structures to assessment methods, even classroom design. But they are also predicated on distinctly different ontological assumptions, and the ways these ontological assumptions play out in teachers' work have profound implications for equity, justice, and care in classrooms.

#### *Cartesian Anxiety in Preservice Science Teacher Talk*

Western, liberal, enlightenment thinking and being are at the core of contemporary Western natural science and science education. Enlightenment values are reflected in Olivia's objectification of her students as she describes their classroom activity, and in Leo's - and to a lesser degree, Ivan's - desire for tight, hierarchical control in the classroom. Leo in particular suggests that science can't be taught outside of direct, didactic instruction, and is clearly more comfortable with a more rigid, controlled, quantifiable (measured in lectures given, quizzes scored, grades calculated) (i.e., behaviorist) form of science instruction. I see these students' resistance to the sociocultural paradigm of education as a reflection of the liberal (i.e.,

Enlightened) anxiety regarding the messy, unpredictable, irrational un-Enlightened theologically ordered universe.

Bordo (1986) illustrates how new interpretations of Descartes's seminal contributions to the Enlightenment ontoepisteme indicate the profound fear that shaped - and shapes - Western scientific thought:

On November 10, 1619, Descartes had a series of dreams-bizarre, richly imaginal sequences manifestly full of anxiety and dread. He interpreted these dreams-which most readers would surely regard as nightmares- as revealing to him that mathematics is the key to understanding the universe. Descartes' resolute and disconcertingly positive interpretation has become a standard textbook anecdote, a symbol of the seventeenth-century rationalist project. That project, in the official story told in most philosophy and history texts, describes seventeenth-century culture as Descartes described his dream: in terms of intellectual beginnings, fresh confidence, and a new belief in the ability of science-armed with the discourses of mathematics and the "new philosophy"-to decipher the language of nature. Recent scholarship, however, has detected a certain instability, a dark underside, to the bold rationalist vision. Different writers describe it in different ways. Richard Bernstein speaks of the great "Cartesian anxiety" over the possibility of intellectual and moral chaos" (p. 439-40)

I speculate that Leo and Ivan's resistance to socioculturalism is not incidental, but rather a product of their many years of formal inculcation into Western natural scientific ways of being, and that they are not only skeptical of the messiness of sociocultural pedagogy but may also see it as unsophisticated and even frightening in its unwieldy complexity.

The implicit assumptions involved in Ivan and Leo's discourse not only position unregimented student activity as frightening, but students themselves as a source of anxiety. Ivan's students are positioned as incapable of constructing their

microscopes, while Leo's are positioned as passive recipients of knowledge, rather than producers of it. In both cases, students must be controlled, ordered, dehumanized.

In contrast with Leo and Ivan, Valerie explicitly positions the "organized chaos" of sociocultural pedagogy as "very attractive". Rather than indicating fear or disbelief at the possibility of dialogical, student-centered pedagogy, Valerie positions students as broadly capable of active learning and doing--as trustworthy, agentic, and whole beings. Her positioning of students is fundamentally more humanizing, in the Freirean sense (1970) and more aligned with a liberatory, care-ful ethic of teaching.

Ivan and Leo's fear based Ontoepistemic positions have implications, not just for how they engaged in learning activities in the program, but also for how they may engage hegemonic power structures in the work as classroom teachers. Ivan and Leo's subtle dehumanization, and Valerie's humanization of students become particularly poignant in the context of the "savage inequalities" of American public schooling, and of American life in the Capitalocene more generally (Kozol, 2012; Haraway, 2016).

### *Cartesian Anxiety in the Learning Activity System*

Vygotskian sociocultural theory acknowledges two forms of learning, grounded in the work of Piaget and Inhelder: assimilation and accommodation. Assimilation occurs when an individual encounters a new concept and incorporates it into their existing schema, without a need for transformation of those schema.

In the activity described in vignette I, Leo encounters the concept of sociocultural (i.e., community-oriented, dialogical, student-centered) instruction, and is asked (by nature of the instructor's objective for the activity) to consider the infusion of this new concept into his prior schema for science teaching (e.g., individualist, didactic, teacher-centered instruction). Based on his utterances in the activity, it appears that Leo is inclined (at this point) to assimilate the concept of socioculturalist pedagogy as incommensurate with his concept of science instruction. Rather, he seems more inclined to develop a parallel schema for socioculturalist instruction that includes the notion that it applies only to certain, non-natural science subjects.

Alternatively, Valerie seems to be engaged in a process of accommodation, a vulnerable process in which prior schemas are transformed. Whereas like Ivan and Leo, Valerie's prior schema seem to align with the common-sense notions of science teaching as didactic, monologic, and teacher-centered, she openly and discursively considers how socioculturalist conceptions of science instruction might transform her prior schema, and she appears to find the transformation a positive one.

While it would be easy to frame Valerie as the heroine of the vignette (and her openness to vulnerability is certainly laudable), her utterances in the activity are rooted in the discursive soil being turned by Ivan and Leo. The tension generated by their resistance creates an opening through which Valerie is able to discursively work towards equilibration and expansive learning.



Expansive learning occurs when “learners construct a new object and concept for their collective activity and implement this new object and concept in practice” (Engestrom and Sannino, 2010, p. 2). Whereas the broader object of the activity is to consider a set of concepts laid out by the instructor, Leo and Ivan's resistance to the concept of socioculturalist science instruction generates a new, micro-objective in the collective discourse: to reconcile the original objective and the resistance. Valerie responds to this new micro-objective by introducing a new concept: a positive construction of socioculturalist science instruction.

In this sense, Leo's agentic move to discursively resist accommodation generates a fruitful condition for Valerie's discursive accommodation of the same concept, which then becomes part of the broader conditions (i.e., the soil) of science teacher becoming in the course. In other words, Leo and Ivan's harm-ful positioning of students in the learning discourse may have actually directly contributed to their more care-ful positioning by Valerie. My point here is not necessarily to praise Leo and Ivan for their resistance; rather, my point is to highlight the complexity of situated agency and the complexity of implications for care and harm that follow.

Returning to Tuck's notion of agency, we can say that Leo is using his agency at this point in the activity in multiple, complex ways. In one sense, he is using his agency when he chooses not to accommodate the notion of socioculturalist methods into his schema of science instruction. Accommodation is a vulnerable, labor intensive, potentially frightening experience, and a refusal to entertain accommodation may be a self-preserving expression of agency for Leo.

Leo is also expressing agency when he moves to speak in the whole-class discussion in the first place--perhaps he desires to make better sense of the concepts at hand, or perhaps he simply wishes to be awarded participation points. Given the identities that Leo aligns with, I am inclined to believe that all of these interpretations are true. His identity as a competitive, impressive academic achiever legitimates the latter interpretations, while his identification with the Western natural sciences legitimates the former.

This interpretation of Leo's agentic moves aligns with my previous interpretation of Leo's disinclination towards complex instruction as rooted in a fear of complexity that is inherent to the liberal, Enlightened, Western natural scientist's mode of being. In essence, Leo seems profoundly fearful, and this fear drives a disinclination towards transformative learning through a self-protective refusal to consider altering prior schema.

Likewise, perhaps Leo's competitive nature, likely stemming from the Enlightened Western scientist's obsession with hierarchy and typology, is still more deeply rooted in a deep fear of cosmic disorder. To know that he is "the best" in class is to know that he has a place, that he belongs, that events and his place in them make sense.

In sum, it seems reasonable to conclude that the anxiety inherent in Leo's classroom activity, as an actor closely aligned with the WNS mode of being and all of its practices and values, is a critical barrier to his sensemaking in this activity, and therefore to the sensemaking of the student collective as well.

*The Plantationocene in Preservice Science Teacher Talk*

Haraway uses the term *plantationocene* to refer to the ecological era of the plantation and its futures (Haraway, 2015). The plantationocene is characterized as “the devastating transformation of diverse kinds of human-tended farms, pastures, and forests into extractive and enclosed plantations, relying on slave labor and other forms of exploited, alienated, and usually spatially transported labor” (Haraway, 2015, p. 162).

The term evolved from a discussion that engaged palm-oil plantations in Southeast Asia, Atlantic slave trade geographies and economies, Euclidean geometry, neoliberal enclosure, and Nazi philosophy, i.e., it is a transdisciplinary concept that connotes multiple intersections of power and violence, or harm (Haraway et. al., 2016). Haraway writes:

“The Plantationocene makes one pay attention to the historical relocations of the substances of living and dying around the Earth as a necessary prerequisite to their extraction (see also Lewis & Maslin 2015). It is no accident that labour is brought in from elsewhere, even if, in principle, there is local labour available. Because it is more efficient in the logic of the plantation system to exterminate the local labour and bring in labour from elsewhere. The plantation system depends on the relocation of the generative units: plants, animals, microbes, people. The systematic practice of relocation for extraction is necessary to the plantation system. This began prior to the mid-eighteenth-century story of fossil fuels and steam engines and industrial revolution and so on and so forth” (Haraway et. al., 2016).

The plantationocene is an important concept for sensemaking Olivia's utterance because it incorporates several dominant power Discourses that reverberate through Olivia's science teacher talk.

Behaviorism itself is a technology of the plantationocene. Contemporary school structures, including behaviorist pedagogies, evolved from plantation slavery economics and the modern neoliberal dual obsession with production (of capital, data) and scientificity (rationality, objectivity, systematicity). Desmond (2019) describes how scientific accounting logics and methods developed on American slave plantations to maximize the profitability of enslaved people (as property, not as humans) were later adapted to organize virtually all work. Large, top-down chains of command, extensive data collection, and the power to inflict harm on "out of line" workers became the status quo for US organizations, including schools (Desmond, 2019; Au, 2011).

Behaviorism as a discipline emerged from an early-twentieth century push to legitimize the field of psychology through the application of these new "scientific" methods. In the plantationocene, quantitative data collection and analysis are the most prestigious and generally the most trusted method for the production of knowledge, and behaviorist pedagogies are characterized by their emphasis on observing and changing behaviors, as opposed to conceptual understanding. "Thinking" became irrelevant because the phenomenon was incompatible with modern notions of scientificity, e.g., it is difficult to quantify and generally has to be self-reported by the learner, and therefore producing data considered unreliable by Enlightened standards.

The study of behavior, however, lent itself easily to quantitative data collection and statistical analysis (Oakes and Lipton, 1999).

Throughout the 20th century, scientific management theory flourished in schools, leading to the production of multiplicitous protocols for applying rewards and punishments to “motivate” students, to diminish “misbehavior”, and to “condition” students towards “good” behavior (Oakes and Lipton, 1999).

Behaviorism is also visible in schools in the absence of emphasis on deep, conceptual learning, and a preference for instructional design that is geared towards rote learning, measurable outcomes, and frequent assessment. Au (2011) describes the contemporary high-stakes accountability era, characterized by an aggressive regime of standardized testing, as “New Taylorism”, a modern example of the hegemony of behaviorism as a neoliberal paradigm in education.

In her utterances, Olivia discursively aligned with the language and logics of behaviorism. She takes the necessity of “diminishing undesired behavior” in students/the classroom as given. She further poses what she frames as an effective punishment for “undesired behavior”: “extinction”, or the practice of pointedly ignoring students who are perceived as misbehaving. In other words, Olivia's discourse draws on logics of control and punishment, embodying (at least momentarily).

I'm inclined to understand Olivia's application of behaviorist logics as derivative of her historical immersion in the natural science disciplines, where

“scientificity” reigns supreme, but also more broadly as a product of her lived experience as a white scientist in the plantationocene.

### **Disciplinary Discourse Practices in Preservice Science Teacher Talk**

In this second vignette, I highlight two PSTs, Leo and Ernie, through a vignette in which they are the primary interlocutors. In the vignette, Leo and Ernie’s small group, which also includes two other peers, engage in a text-based discussion about equity in secondary science teaching.

I focus on the ways that Leo engages in the discussion through Western Natural Scientific Discourse practices, which ultimately limits his and his peers’ possibilities for sensemaking. I focus as well on Ernie’s enactments of critical imaginative discourse practices, through his work to imagine beyond the limits of his own experiences in science education in order to conceive of novel forms of more equitable science education. Finally, I discuss how Western natural science and critical imaginative discourse practices were discursively synthesized in this small group discussion, and the opportunities for learning that became un/available as the synthesis unfolded.

### *Disciplinary Literacy in Science and Education*

Education research in the last two decades has given significant attention to the matter of k-12 students’, and particularly secondary students’, disciplinary literacy development. Disciplinary literacy, a notion emerging from the language and literacy

education fields, is defined as “the specialized ways of reading, understanding, and thinking used in each academic discipline such as science, history, or literature” (Shanahan and Shanahan, 2014, p. 636).

Fang and Schleppegrell (2010) provide contrasting examples of the literacy practices shared by the natural sciences compared to history disciplines: “scientists attend to data displays and the credibility of conclusions drawn from analyses of these data” while “historians read texts with particular attention to the legitimacy of their origins, the authenticity of their sources, and the point of view of the original writer” (p. 588).

In science education fields, the notion that “Learning science means learning to talk science” (p. 1) was popularized by Lemke’s eponymous book, *Talking Science*, in 1990; but it was the introduction of the Common Core State Standards (CCSS) in the 2010s that made disciplinary literacy mainstream (Duhaylonggod, Snow, Selman, and Donovan, 2015). The CCSSs expected secondary students to develop expertise in disciplinary discourse practices, and teachers to help them do so, the purpose being to “ensure that all students have the skills and knowledge necessary to succeed in college, career, and life upon graduation from high school, regardless of where they live” (CCSS Initiative, 2010).

Of course, this begs the question of who’s knowledge and skills, which colleges and careers, what lives are considered successful, and how success is defined--but what is clear is the logic of the imperative: giving students access to the

disciplinary discourse practices means access to disciplines and the opportunities that access to disciplines entails, i.e., science instruction is also language instruction.

This expanding field of research, and policies, like the CCSSs, that build on it, recognizes the immense potential power in learning to talk science; however, to my knowledge, no research has addressed the limitations that talking science may introduce in activity.

Likewise, minimal research attention has been paid to what it means to receive science talk, e.g., to *listen science*. If science learning is science talking, then science instruction must entail science listening. In this sense, science instruction is also language assessment. In other words, disciplinary literacy in schools inherently involves disciplinary legibility, or the ability to be recognized as talking science.

Whereas disciplinary literacy discourse tends to emphasize the disciplinary *speaking subject* (the student), it tends to defer attention from speaker's inherent dialectical relationship with the disciplinary *listening subject* (in a secondary science classroom: the teacher), and the power wielded by the listener to interpret and evaluate the speaker (Flores and Rosa, 2015; Inoue, 2006).

In secondary science classrooms, where students are ostensibly learning to talk science, the teacher represents the ultimate disciplinary listening subject. Secondary science teachers carry explicit power in their ability - institutional responsibility, in fact - to label students as “scientific” (e.g., through a high grade) or “not scientific” (e.g., through a low grade). These labels will shape what kinds of higher educational opportunities will be available for students, which in turn may



well have a significant impact on career and salary options. In this sense, teachers' disciplinary language ideologies are incredibly consequential.

Western natural science, a historical Discourse community generally exclusive to upper-class, white, cis-gendered male humans, is characterized by extremely narrow disciplinary discourse practices. Foundational are Liberal values, stemming from the Cartesian split and the European Enlightenment movement; secularity, rationalism and individualism (Bordo, 1986; Wynter and McKittrick, 2015).

Over time, positivism, typology/categorization, hierarchy, competitiveness, evolved as disciplinary practices. Like other liberal Western movements, natural science disciplines are also deeply entangled in, and co-constitutive of, hegemonic power lines: white supremacy, anti-Blackness, heteropatriarchy, ableism, colonialism, and their kin (Painter, 2010; Wynter and McKittrick, 2015; Braun, 2014). Western Natural science is also characterized by disciplinary chauvinism, co-constituted by the relative power and status the disciplines maintain in the US context.

Teachers of western natural sciences who understand the scientific gaze to be neutral and objective, and generally beneficent, may be unlikely to critically interrogate the complex, worldly ramifications of their work (Stengers, 2018). Moreover, they are likely to have had relatively little exposure to critical consciousness-building literature and practice.

Of course, many people trained in the western natural sciences have developed critical consciousness outside of school. But many, particularly individuals whose identities hold significant privilege, have not. In my research and teaching with

preservice science teachers (PSTs), I have worked with several PSTs who resist meaningful engagement with curricular content stemming from cultural and other social studies, dismissing such research as invalid because it does not conform to western natural science onto-epistemic standards.

The objective of equity discourse in education is to expand upon previous discourses of equality, to embrace human diversity by emphasizing equal access in education for different kinds of learners through differentiated instruction. Whereas education equality discourse invites a homogenized view of students, equity discourse recognizes heterogeneity: different repertoires of practice are framed as valuable resources for learning, and instruction is (ideally) designed to leverage the unique assets of students. Equity discourse in education includes an emphasis on the deconstruction of deficit perspectives (Valencia and Solorzano, 1997) and the development of humanizing relationships between teachers and students.

To borrow from Tuck (2009), educational equity seeks to suspend damage, to reform or replace the educational practices that reify power and the vastly unjust burden of harm placed on minoritized students. I distinguish educational equity discourse from educational justice discourse, in that, where the former seeks to suspend damage, the latter seeks to repair it. Justice demands an investigation of prior harms and the allocation of resources towards healing.

Both educational equity and educational justice discourses are inherently sociopolitical in nature. Where equality discourse pertains to rather blunt appeals to notions of fairness and mathematics (1 person = 1 person), equity discourse is more

complex, it is a qualitative question more than a quantitative one. In order to consider educational equity, one must rigorously consider the nature of the resources afforded to students, and the intersecting barriers that structure students' access to school. Equity discourse requires an understanding of power, agency, history, culture, and much more.

Strict adherents of Western natural science, like Leo, find themselves in a peculiar dilemma: their discipline holds methodological objectivity as one of its most esteemed principles, leading many to believe that the discipline as a whole, its activities, and its products, are somehow objective by nature--free of bias, free of power, free of subjectivity. Commonsense notions about western natural science as apolitical are structurally integral to the way that science is taught in the US (Barton, 1998).

Because Western natural science education tends to frame itself and its products and practices as a-political, PSTs, like Leo, may struggle to make sense of notions of equity in science education, and particularly, of science teaching, and the disciplinary content itself, as power-laden. In his utterances in this vignette, it appears that Leo's ability to make sense of equity in science teaching as an activity that includes critical consciousness-raising is mediated by his perception that learning science and critical consciousness development are incommensurate.

Additionally, because Leo consistently pulls the small group discussion in the direction of sensemaking his dilemma, the learning activity as a whole, and the sensemaking possibilities available within it, remain trained to objectivity Discourse

and its attendant values.

## Conclusion

In *Another Science is Possible: A manifesto for slow science* (2018), feminist science philosopher Isabelle Stengers asks that we in the broader science community focus our attention not on not on fact-finding or epistemic warfare, but rather on matters of concern. Matters of concern “[insist] that we think, hesitate, imagine and take sides...The essential thing with ‘matters of concern’ is to get rid of the idea that there is a single ‘right answer’ and instead to put what are often difficult choices on the table, necessitating a process of hesitation, concentration and attentive scrutiny” (p. 10-11).

In this analysis, my primary matter of concern is the historical, ongoing, and future harm to students in secondary science classrooms, and the experiences that preservice science teachers have in preparation programs that set the stage for some of those harms, but also for care. Acknowledging that there is always already potential both for care and harm in science education, my objective in this dissertation was to think through some of the possibilities for expanding the former while mitigating the latter.

My purpose in thinking with notions of harm in this study was to think through avenues for harm reduction. I think with notions of coloniality, liberalism, neoliberalism, notions of control and domination, whiteness and white supremacy, generally framing each as a Discourse of power, where Discourses are defined as “ways of behaving, interacting, valuing, thinking, believing, speaking, and often reading and writing, that are accepted as instantiations of particular identities (or

‘types of people’)” (Gee, 1996, p. 3).

My purpose in thinking through Discourses of power in preservice science teacher classrooms is to add to our growing understanding of how systemic, structural, historical, and ongoing harm is sustained in and through equity-oriented science teacher preparation. My hope is that through building this understanding, we can open up new possibilities for reparation, care, and response-ability with our human and more-than-human counterparts in and beyond secondary science classrooms.

In my analysis I considered multiple vectors of harm and care in science education through a fine-grained analysis of one case study of an equity-oriented science teacher preparation program. I think through some of the ways that novice science teachers develop understanding around what it means to think, learn, and teach, and what it might mean to be a teacher of students. The participants - 10 preservice science teachers (PSTs) - collectively, discursively draw upon personal experiences being teachers and students, as well as notions of teaching and learning described in literature (assigned and otherwise), and by the course instructor. Through my analysis of their discussion, I consider the potential for care or harm that exist (primarily unidirectionally) between these future teachers and their future students, and the broader school community in which they will soon be intra-acting.

In the first vignette, the PSTs explore the potential tensions, possibilities, and limitations stemming from two contrasting paradigms of teaching and learning theory: behaviorism and socioculturalism. These paradigms are fundamentally contradictory in

their Ontoepistemic assumptions, and the possibilities they afford for what it means to be a teacher and/or a student in a classroom. Where behaviorism is predicated on reductive, individualized notions of being, and of learning as mechanistic replication, socioculturalism is predicated on collectivist, situated notions of being and of learning as a complex social process.

Neither paradigm precludes harm or care, but each promise both in disparate measure. For example, briefly thinking with Tuck's (2009) notion of suspending damage, we see how the behaviorist paradigm is inherently violent in its denial of complex personhood, whereas socioculturalism opens up rich possibilities for care. As the PSTs consider which theories of learning seem reasonable and resonant, they are also implicitly/indirectly thinking through if/how/when/why they will position future students in ways that will inflict, sustain, or suspect damage.

In the second vignette, I highlight the ways that science teachers - and one in particular - talk science, and the implications this has for their engagement in preparation program learning activities and for their future work in classrooms. I analyzed a brief episode from a classroom learning activity, in which a preservice science teacher (PST) orients to a political philosophy text, as well as interview data from the same PST in which he discusses his experiences with social and cultural studies disciplinary Discourses. I think through the ways in which the PSTs talking science actually limited their desire, or perceived ability, to talk beyond science and constrained opportunities for learning key teacher preparation program content.

Taken together, these analyses shine a light on the role that western natural scientific discourse plays in learning activity in an equity-oriented science teacher preparation program.

### *Implications*

Equity-oriented science teacher preparation programs must recognize the unique challenges that many PTs who identify with the natural science communities of practice are liable to face as they attempt to engage in explicitly political classroom learning activities.

For example, PTs like Leo may find themselves more able to engage productively with the material and their peers if they are supported in becoming cognizant of their own discourse repertoires of practice so that they become tools, rather than blinders. In other words, PTs like Leo need to become ontoepistemically flexible in order to become equitable science teachers, and science teacher preparation programs should develop strategies for encouraging the development of that flexibility.

Leo's lack of ontoepistemic flexibility emerged in classroom learning activity not just as a limiting factor in his own learning, but to the collective learning of the students as a whole. His attempts to interpret the conceptual content of the course through the discourse practices of western natural science pulled whole-class discussions away from more liberatory conceptual spaces and towards more



oppressive ones. Therefore, equity-oriented teacher preparation programs can facilitate all PSTs' learning through scaffolding PTs' ontoepistemic flexibility.

I want to emphasize that I am not suggesting that science teachers abandon their disciplinary discourse practices. Rather, I am arguing that science teachers must learn to understand Western natural science as just *one* ontoepistemic practice that exists in the context of *many*--that it is far from the only ontoepistemic practice that makes truth, and that like the others, it also produces many untruths.

For example, Haraway reflects on the necessary relationship between science fact and her critically imaginative work of telling stories "for earthly survival". This work, which she refers to as *speculative fabulation*, brings Western natural scientific disciplinary knowledge into relationship with the humanities, the social sciences, and the everyday practices of living beings through worlding practices.

Haraway's work represents an alternative to disciplinary chauvinism, without sacrificing an allegiance to certain elements of Western natural scientific knowledge. In an interview on speculative fabulation, Haraway illustrates how she negotiates the line between disciplinary chauvinism and disciplinary dismissal:

I do not mean I don't tell the truth... I care about what's a fact and what isn't; how it holds together or does not... I believe that teaching intelligent design in a biology class in high school is a kind of child abuse... I think evolutionary theory is... I will enforce it with the law if necessary--by which I mean I will take part in curriculum struggles with the publishers or with the school districts... I will fight for... some ways of life and not others. And I don't think that is instead of being a fabulator. I think that this is about taking speculative fabulation seriously. Most of my biologist friends... get very upset at that language. They really want you to be...: 'science is the truth and this other stuff isn't' and 'you're talking about fabulation... is

really... wrong-headed--really crazy'... and I say 'no no, we need to talk about a speculative fabulation and science fact in the same SF figure'" (Haraway, 2015).

Returning to Stengers' notion of *matters of concern*, science teachers, like Haraway, must learn to make sense of which natural scientific practices and concepts deserve their concern, and why. An argument that "science is the truth, and this other stuff isn't" simply does not work for us--it does not interrupt the catastrophic worlding of the plantationocene, and it is not conducive to equity-oriented science teacher preparation.

Western natural science alone will not help us world new, more just and careful kinds of worlds--but neither will criticality alone (Bang, 2020). In her talk at the speculative education colloquium (2020) Bang reflected: "Sometimes I think our criticality has made us wise but not generous" and argued that "we need our creative and imaginative capacities to be as strong as our critical capacities". Expanding the ontoepistemic repertoires of preservice science teachers cannot mean simply encouraging critical perspectives; it must also encourage critical pedagogical imagination.

Ernie and Valerie's contributions to the activity described in the findings chapter of this dissertation provide excellent examples of what this might look like. It is characterized by a willingness to see their work through natural scientific *and* critical cultural lenses, and to vividly imagine new kinds of science instructional

worlds, and to discursively introduce those worlds to the collective imagination of the cohort.

Equitable science education cannot be about simply inclusion and access, roping more students into science as it has been. We, as a field and a professional community of practice, must critically reimagine what the “science” in science instruction can and should be.

### *A Final Proposal*

I conclude with a proposal. Equity-oriented science teacher preparation programs, being cognizant of the unique ontoepistemic preparation many preservice science teachers need in order to fully participate in critically-oriented learning dialogue, must encourage PTs to creatively imagine a phronetic science instruction-science instruction that is “oriented towards the public good rather than capitalism fueled destruction of the planet... [which].... embrace[s] ethical frameworks that are rooted in relational postmodern and posthumanist ontologies built on ‘webs of connectivity’” (Sharma, 2020, p. 11).

Preparation programs may consider interventions in the form of assigned readings that interrogate the alleged supremacy of Western natural science (e.g., Harding, 1992; Haraway, 2016; Bordo, 1986; Braun, 2014; Kimmerer, 2013, Calabrese Barton, 1998). Language and literacy scaffolds and supports may be effective interventions as well, to support Western natural scientist PTs in engaging in cultural critique, for example, and/or other discursive practices in which they are not practiced. Structured close reading assignments, vocabulary supports (e.g., word

walls), mixed-ability grouping, and explicit instruction around disciplinary discourse goals and expectations may be strategies worth experimenting with.

In my own STEM teacher preparation classroom, I am currently exploring the use of Augusto Boal's Theater of the Oppressed (2000) activities (based on Freire's 1968 Pedagogy of the Oppressed) as a multimodal and embodied instructional strategy to help PSTs explore and develop their critical imaginative practices and experience new ways of thinking, knowing, learning, and being. I look forward to experimenting with these methods more formally, in a research context, in the future.

Science teachers are in a powerful and unique position to influence the next generation of scientists and guide us towards more just and care-ful futures, and preparation programs have a responsibility to support preservice science teachers' development, epistemologically, ontologically, critically, creatively, and ethically, in this crucial work.

## Appendix

### Preservice Science Teacher Pre-Interview Protocol

*Hi! Thanks so much for agreeing to be interviewed! This interview should take between 35-45 minutes. You don't need to answer any questions if you don't want to, and you should feel free to ask to take a break or to end the interview any time you need. You will not be penalized in any way for declining to answer a question. Remember that I will be keeping these audio recordings private, and though I may publish sections of the transcript, you will not be referred to by name in any publication--rather, you will be given a pseudonym. I will also do my best to make sure that you cannot be identified by readers in any other way. That said, because I am collecting your name as part of the recruitment process, you are not considered an "anonymous" participant. If someone steals my data, they could figure out who you are. Therefore, you should not reveal any information to me that is potentially incriminating. Do you have any questions before we begin?.... Do you mind if I begin recording?*

*Preferred name?*

*Preferred pronouns?*

### DISCOURSES AND DESIRES IN SCIENCE TEACHING

1. Can you start by talking about the life experiences and desires that brought you to study to become a science teacher?
  - a. Probe for explanation in terms of
    - i. desire to teach
    - ii. life experiences and circumstances that made science teaching appealing
      1. Teaching
      2. Science teaching
    - iii. Why this specific program?
2. How do you imagine yourself as a science teacher? What do you see in your head when you imagine yourself as a science teacher? (Probing for images, stories, desires)
  - a. Probe for science teacher role models (real and fictional)
3. What inspires you to want to be a science teacher?
  - a. What are your goals or things you hope to be able to accomplish?
  - b. Probe for major objectives, e.g., "helping students connect to science", "helping students feel the wonder in science", "helping students gain

access to highly valued and highly compensated careers”, or “helping students become better democratic citizens”.

## IDENTITY

1. You’ve probably noticed that identity is a major theme in the Master/Credential program. For example, I observed that activity in Cultural Foundations of Education where she had everyone go outside to think and talk about aspects of their racial, gender, linguistic and class identities. These are all examples of kinds of identities, and of course there are other kinds of identities too--identities are ways of labeling yourself or identifying yourself as part of a certain group. In this next part of the interview, I’m going to ask you some questions about your identities.
  - a. What identities feel important for you in how you think about or understand yourself?
    - i. Can you tell me more about your identity as [refer to 4a]?
  - b. How would you describe your racial identity?
  - c. How about class identity?
  - d. Can you tell me about your gender identity?
  - e. How would you describe your language identity?
  - f. Are there other identities that feel salient for you?
2. Tell me about how you think your life experiences, identities, interests, hobbies, etc., shape the way you think about teaching?
  - a. How do you think your racial identity shapes the way you think about teaching?
  - b. How do you think your language history shapes the way you think about teaching?
  - c. How do you think your gender identity shapes the way you think about teaching?
  - d. Is there anything else that you think significantly shapes the way you think about teaching? For example, political identity, where you grew up, or where your parents or grandparents grew up?
3. Now can you tell me about the ways you think your identity will shape your experience in this program?
  - a. How do you think your racial identity might shape your experience in this program?
  - b. How do you think your language history might shape your experience in this program?

- c. How do you think your gender identity might shape your experience in this program?
- d. How do you think your identity as [refer to answer from question 3d] might shape your experience in this program?
4. In what ways do you think your experience in this program might shape your identities?

#### CLASSROOM DISCOURSES

1. Is there anyone in the program, including faculty and your peers, who you feel like you are particularly aligned with in terms of how you think or feel about topics in class, or other topics?
2. Is there anyone in the program, including faculty and your peers, who you feel like you are particularly *misaligned* with in terms of how you think or feel about topics in class, or other topics?
3. Feminism and feminist theory have been brought up in class by a couple of your classmates, I'm curious what your thoughts are on how they're using that term and how it makes you feel?
4. Similarly, the idea of "call-out culture" has come up in class. How do you interpret that? How do you feel about that idea?
5. I'm particularly interested in conflict in this project, since conflicts highlight differences in worldviews, which is essentially what I'm studying. Have you noticed or felt any tension or conflict between other folks in your classes or between yourself and any of your peers?

#### **Preservice Science Teacher Post-Interview Protocol**

*Hi! Thanks so much for agreeing to be interviewed! This interview should take ABOUT AN HOUR. You don't need to answer any questions if you don't want to, and you should feel free to ask to take a break or to end the interview any time you need. You will not be penalized in any way for declining to answer a question. Remember that I will be keeping these audio recordings private, and though I may publish sections of the transcript, you will not be referred to by name in any publication—rather, you will be given a pseudonym. I will also do my best to make sure that you cannot be identified by readers in any other way. That said, because I am collecting your name as part of the recruitment process, you are not considered an*

*“anonymous” participant. If someone steals my data, they could figure out who you are. Therefore, you should not reveal any information to me that is potentially incriminating. Do you have any questions before we begin?.... Do you mind if I begin recording?*

*Preferred name?*

*Preferred pronouns?*

## DISCOURSES AND DESIRES IN SCIENCE TEACHING

1. can you start by talking about the life experiences and desires that brought you to study to become a science teacher?
  - a. probe for an explanation in terms of
    - i. desire to teach
    - ii. life experiences and circumstances that made science teaching appealing
      1. teaching
      2. science teaching
      - iii. why this specific program?
2. how do you imagine yourself as a science teacher? what do you see in your head when you imagine yourself as a science teacher? (Probing for images, stories, desires)
  - a. probe for science teacher role models (real and fictional)
3. what inspires you as science teacher?
  - a. what are your goals or things you hope to be able to accomplish?
  - b. probe for major objectives, e.g., “helping students connect to science”, “helping students feel the wonder in science”, “helping students gain access to highly valued and highly compensated careers”, or “helping students become better democratic citizens”.
  - c. do you think your goals for science teaching have changed since you began the program? how so?

## IDENTITY

- (1) You’ve probably noticed that identity is a major theme in the Master/Credential program. For example, I observed that activity in Cultural Foundations of Education where she had everyone go outside to think and talk about aspects of their racial, gender, linguistic and class identities. These are all examples of kinds of identities, and of course, there are other kinds of identities too--identities are ways of labeling yourself or identifying yourself



as part of a certain group. In this next part of the interview, I'm going to ask you some questions about your identities.

- (a) What identities feel important for you in how you think about or understand yourself?
    - (i) Can you tell me more about your identity as [refer to 4a]?
  - (b) How would you describe your racial identity?
  - (c) How about class identity?
  - (d) Can you tell me about your gender identity?
  - (e) How would you describe your language identity?
  - (f) Are there other identities that feel salient for you?
- (2) Tell me about how you think your life experiences, identities, interests, hobbies, etc., shape the way you think about teaching?
- (a) How do you think your racial identity shapes the way you think about teaching?
  - (b) How do you think your language history shapes the way you think about teaching?
  - (c) How do you think your gender identity shapes the way you think about teaching?
  - (d) Is there anything else that you think significantly shapes the way you think about teaching? For example, political identity, where you grew up, or where your parents or grandparents grew up?
  - (e) now can you tell me about the ways you think your identities might have shaped your experience in this program?
    - (i) How do you think your racial identity might have shaped your experience in this program?
    - (ii) how do you think your language history might have shaped your experience in this program?
    - (iii) how do you think your gender identity might have shaped your experience in this program?
    - (iv) how do you think your identity as [refer to answer from question 3d] might shape your experience in this program?
    - (v) were there any particular moments in classes throughout the school year where you felt your racial identity strongly? other salient identities?
- (3) In what ways do you think your experience in this program might have shaped or reshaped your identities?

## CLASSROOM DISCOURSES

1. Is there anyone in the program, including faculty and your peers, who you feel like you WERE particularly aligned with in terms of how you think or feel about topics in class, or other topics?
2. Is there anyone in the program, including faculty and your peers, who you feel like you WERE particularly *misaligned* with in terms of how you think or feel about topics in class, or other topics?
3. I'm particularly interested in conflict in this project, since conflicts highlight differences in worldviews, which is essentially what I'm studying. Have you noticed or felt any tension or conflict between other folks in your classes or between yourself and any of your peers?
4. Did the protests this spring affect your experience in the program at all? did they come up in classes? how so? (Looking for interpretations of the protests, how they affected learning, how they were dealt with as part of the learning context)

### **Focal Preservice Science Teacher Interview Protocol**

#### **WARM-UP**

1. Can you start off by telling me what classes you've taken so far?
2. Now can you tell me about the highlights and lowlights of the program for you so far?
  - a. Favorite class, least favorite class, and why?
  - b. Particular activities or conversations that have been really impactful (e.g., learned a lot) (could be extracurricular)?

#### **UPDATING SELF IMAGE, GOALS AND DESIRES AS A TEACHER**

1. How do you imagine yourself as a science teacher? What do you see in your head when you imagine yourself as a science teacher? (Probing for images, stories, desires)
  - a. Probe for science teacher role models (real and fictional) 2.

What inspires you to want to be a science teacher?

- a. What are your goals or things you hope to be able to accomplish?
- b. Probe for major objectives, e.g., "helping students connect to science", "helping students feel the wonder in science", "helping students gain access to highly valued and highly compensated careers", or "helping students become better democratic citizens".

### SELF IMAGE, DESIRES AS A STUDENT SCIENCE TEACHER

1. How do you imagine yourself as a student in this program? What do you see in your head when you imagine yourself as a student in this program?  
(Probing for images, stories, desires)
  - a. What are your major objectives as a student in this program?
  - b. Do you feel like you're meeting those objectives?
    - i. If not, what's keeping you from meeting those objectives?

### IDENTITY AND LEARNING OPPORTUNITIES

1. Now, can you tell me what identities feel important for you in how you think about or understand yourself? (For example, racial, class, gender, language, or other identities?)
  - i. Are any identities feeling particularly salient recently? ii. If so, why?
2. Now can you tell me about the ways you think your identity shaped your experience in this program during the Fall Quarter?
  - a. How do you think your racial identity might shape your experience in this program?
  - b. How do you think your language history might shape your experience in this program?
  - c. How do you think your gender identity might shape your experience in this program?
  - d. How do you think your identity as [refer to answer from question 3d] might shape your experience in this program?
3. In what ways do you think your experience in this program might shape your identities?

### SOCIAL DYNAMICS AND LEARNING OPPORTUNITIES

1. Is there anyone in the program, including faculty and your peers, who, during the Fall Quarter, you felt like you were particularly aligned with in terms of how you think or feel about topics in class, or other topics?
2. Is there anyone in the program, including faculty and your peers, who, during the Fall Quarter, you felt like you were particularly *misaligned* with in terms of how you think or feel about topics in class, or other topics?
3. Having had some time to reflect since Summer Quarter, how would you describe the social dynamic in Cultural Foundations of Education vs. the one in Intro to Education?

- a. How would you say those social dynamics impacted or shaped your learning opportunities?
4. How would you compare the social dynamic in Research and Practice in Science Education class to Cultural Foundations of Education and Intro to Education? (Only science vs. all SS)
  - a. How would you say those social dynamics impacted or shaped your learning opportunities?
5. Can you describe the social dynamic in [another] class for me?
  - a. How would you say those social dynamics impacted or shaped your learning opportunities?

## CONCLUSION

Is there anything else you would like to add? Any questions for me?

## Preservice Science Teacher Educator Interview

*Hi! Thanks so much for agreeing to be interviewed! This interview should take between 35-45 minutes. You don't need to answer any questions if you don't want to, and you should feel free to ask to take a break or to end the interview any time you need. You will not be penalized in any way for declining to answer a question. Remember that I will be keeping these audio recordings private, and though I may publish sections of the transcript, you will not be referred to by name in any publication--rather, you will be given a pseudonym. I will also do my best to make sure that you cannot be identified by readers in any other way. That said, because I am collecting your name as part of the recruitment process, you are not considered an "anonymous" participant. If someone steals my data, they could figure out who you are. Therefore, you should not reveal any information to me that is potentially incriminating. Do you have any questions before we begin?.... Do you mind if I begin recording?*

*Preferred name?*

*Preferred pronouns?*

## DISCOURSES AND DESIRES IN SCIENCE TEACHING

1. Can you start by talking about the life experiences and desires that brought you to become a teacher educator?
  - a. Probe for explanation in terms of
    - i. desire to teach at a university

- ii. life experiences and circumstances that made teacher preparation appealing
  - iii. Why this specific program?
- 2. How do you imagine yourself as a teacher educator? What do you see in your head when you imagine yourself in an MAT classroom? (Probing for images, stories, desires)
  - a. Probe for teacher educator role models (real and fictional)
- 3. What are your major objectives in your work as a teacher educator?
  - a. What are your goals or things you hope to be able to accomplish?
  - b. Probe for major objectives, e.g., “helping students connect to science”, “helping students feel the wonder in science”, “helping students gain access to highly valued and highly compensated careers”, or “helping students become better democratic citizens”.

## IDENTITY

1. In the next section I’d like to ask you some questions about your identities. By Identities, I mean particular ways of labeling yourself or identifying yourself as part of a certain group, or ways in which others label you as part of a certain group.
  - a. What identities feel important for you in how you think about or understand yourself?
    - i. Can you tell me more about your identity as [refer to 4a]?
  - b. How would you describe your racial identity?
  - c. How about class identity?
  - d. Can you tell me about your gender identity?
  - e. How would you describe your language identity?
  - f. Are there other identities that feel salient for you?
2. Tell me about how you think your life experiences, identities, interests, hobbies, etc., shape the way you think about teaching teachers?
  - a. How do you think your racial identity shapes the way you think about teaching teachers?
  - b. How do you think your language history shapes the way you think about teaching teachers?
  - c. How do you think your gender identity shapes the way you think about teaching teachers?
  - d. Is there anything else that you think significantly shapes the way you think about teaching teachers? For example, political identity, where you grew up, or where your parents or grandparents grew up?

3. Now can you tell me about the ways you think your identity shapes your experience in this program?
  - a. How do you think your racial identity might shape your experience in this program?
  - b. How do you think your language history might shape your experience in this program?
  - c. How do you think your gender identity might shape your experience in this program?
  - d. How do you think your identity as [refer to answer from question 3d] might shape your experience in this program?
4. In what ways do you think your experience in this program might shape your identities?

#### CLASSROOM DISCOURSES

1. Is there anyone in the program, including faculty, staff, and students who you feel like you are particularly aligned with in terms of how you think or feel about topics that are salient in your class?
2. Is there anyone in the program, including faculty, staff, and students, who you feel like you are particularly *misaligned* with in terms of how you think or feel about topics in class, or other topics?
3. Feminism and feminist theory have been brought up in class some students, I'm curious what your thoughts are on how they're using that term and how it makes you feel?
4. Similarly, the idea of "call-out culture" has come up in class. How do you interpret that? How do you feel about that idea?

#### CONFLICT

1. I'm particularly interested in conflict in this project, since conflicts highlight differences in worldviews, which is essentially what I'm studying. Have you noticed or felt any tension or conflict between other folks in your classes or between yourself and any other faculty, staff or students in the program?
2. I noticed a significant conflict between [several particular students]. Can you tell me how you interpreted that conflict? What do you think lay at the center of that dynamic?
3. During your time as a teacher educator, have you experienced similar kinds of conflict in your classroom?
  - a. Can you tell me about those instances?
  - b. What exactly made them similar?

4. Did you attempt to respond to or manage that conflict at all?
  - a. Do you think you were effective?

## References

- Ash, D. (2004). Reflective scientific sense-making dialogue in two languages: The science in the dialogue and the dialogue in the science. *Science Education*, 88(6), 855-884.
- Ash, D., & Wells, G. (2006). Dialogic inquiry in classroom and museum: Actions, tools, and talk. *Counterpoints*, 249, 35-54.
- Au, W. (2011). Teaching under the new Taylorism: High-stakes testing and the standardization of the 21st century curriculum. *Journal of Curriculum Studies*, 43(1), 25-45.
- Au, W. (2017). Neoliberalism in teacher education: The contradiction and the dilemma. *Teacher Education and Practice*, 30(2), 283-287.
- Bang, M. (2020). Midwifing the Next World [conference presentation]. Speculative Education Colloquium [virtual]. <https://www.theamericancrawl.com/?p=1797>
- Bang, M., & Marin, A. (2015). Nature–culture constructs in science learning: Human/non-human agency and intentionality. *Journal of Research in Science Teaching*, 52(4), 530-544.
- Barton, A. C. (1998). *Feminist science education*. Teachers College Press.
- Barton, A. C., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. *The Journal of the Learning Sciences*, 19(2), 187-229.
- Bazzul, J., Tolbert, S., & Kayumova, S. (2019). New materialisms and science classrooms: Diagramming ontologies and critical assemblies. In *Material*



- Practice and Materiality: Too Long Ignored in Science Education* (pp. 117130). Springer, Cham.
- Beckford, G. L. (2000). *The George Beckford Papers*. Canoe Press, University of the West Indies.
- Boal, A. (2000). *Theater of the Oppressed*. Pluto press.
- Bordo, S. (1986). The Cartesian masculinization of thought. *Signs: Journal of Women in Culture and Society*, 11(3), 439-456.
- Bordo, S. (1993). Unbearable weight: feminism, western culture, and the body.
- Cochran-Smith, M., Villegas, A. M., Abrams, L., Chavez-Moreno, L., Mills, T., & Stern, R. (2015). Critiquing teacher preparation research: An overview of the field, part II. *Journal of Teacher Education*, 66(2), 109-121.
- Crenshaw, K. (1990). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stan. L. Rev.*, 43, 1241.
- Bourdieu, P. (1977). *Outline of a Theory of Practice* (Vol. 16). Cambridge university press.
- Bourdieu, P. (1989). Social space and symbolic power. *Sociological theory*, 7(1), 14-25.
- Braun, L. (2014). *Breathing race into the machine: The surprising career of the spirometer from plantation to genetics*. U of Minnesota Press.
- Bruna, K. R., Vann, R., & Escudero, M. P. (2007). What's language got to do with it?: A case study of academic language instruction in a high school "English Learner Science" class. *Journal of English for Academic purposes*, 6(1), 36-

54.

- Bucholtz, M. (2000). The politics of transcription. *Journal of pragmatics*, 32(10), 1439-1465.
- Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge-and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching*, 48(5), 459-485.
- Cazden, C. B. (1988). Classroom discourse: The language of teaching and learning.
- Common Core State Standards Initiative. (2010). About the standards. Retrieved from <http://www.corestandards.org/about-the-standards/>
- Creswell, J. W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. (4TH ed.) Thousand Oaks, CA: Sage. ISBN: 1412981255
- Darling-Hammond, L. (2000). How teacher education matters. *Journal of teacher education*, 51(3), 166-173.
- de La Bellacasa, M. P. (2017). Matters of care: Speculative ethics in more than human worlds (Vol. 41). U of Minnesota Press.
- Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard educational review*, 58(3), 280-299.
- Desmond, M. (2019). American Capitalism is Brutal. You Can Trace That to the Plantation. *The New York Times*, 14.

- Dreyfus, H. L., & Rabinow, P. (2014). *Michel Foucault: Beyond structuralism and hermeneutics*. Routledge.
- Duhaylongsod, L., Snow, C. E., Selman, R. L., & Donovan, M. S. (2015). Toward disciplinary literacy: Dilemmas and challenges in designing history curriculum to support middle school students. *Harvard Educational Review*, 85(4), 587-608.
- Engestrom, Y. (1987). *Learning by expanding (Helsinki, Orienta-Konsultit Oy)*.  
Downloaded 4/6/01 from <http://communication.ucsd.edu/MCA/Paper/Engestrom/expanding/Ch2.Htm>.
- Engeström, Y. (1999). Activity theory and individual and social transformation. *Perspectives on activity theory*, 19(38).
- Engeström, Y., & Sannino, A. (2014). Formative interventions and transformative agency: Principles, practice, and research. In *11th International Conference of the Learning Sciences, Boulder, CO*.
- Fang, Z., & Schleppegrell, M. J. (2010). Disciplinary literacies across content areas: Supporting secondary reading through functional language analysis. *Journal of adolescent & adult literacy*, 53(7), 587-597.
- Flores, N., & Rosa, J. (2015). Undoing appropriateness: Raciolinguistic ideologies and language diversity in education. *Harvard Educational Review*, 85(2), 149-171.
- Foucault, M. (1980). *Power/knowledge: Selected interviews and other writings, 1972-1977*. Pantheon.

- Foucault, M. (1984). *The Foucault Reader*. Pantheon.
- Foucault, M. (1982). The subject and power. *Critical inquiry*, 8(4), 777-795.
- Gee, J. P. (1996). *Social Linguistics And Literacies (Critical Perspectives on Literacy & Education)*.
- Gee, J. P. (2004). *An introduction to discourse analysis: Theory and method*. Routledge.
- Gee, J. (2011). *An introduction to discourse analysis: Theory and method*. 3rd edn. Routledge.
- Giddens, A. (1981) *A Contemporary Critique of Historical Materialism*. Berkeley, CA: University of California Press.
- Giroux, H. A. (2011). Shattered Bonds: youth in the suspect society and the politics of disposability. *Power Play: A Journal of Educational Justice*, 3(1), 6.
- Gunckel, K. L., & Tolbert, S. (2018). The imperative to move toward a dimension of care in engineering education. *Journal of Research in Science Teaching*, 55(7), 938-961.
- Gutiérrez, R. (2013). The sociopolitical turn in mathematics education. *Journal for Research in Mathematics Education*, 44(1), 37-68.
- Haraway, D. J. (2015). <https://www.youtube.com/watch?v=zFGXTQnJETg>
- Haraway, D. J. (2016). *Staying with the Trouble*. Duke University Press.
- Haraway, D. J., & Goodeve, T. N. (2018). Nothing Comes Without Its World: Donna J. Haraway in Conversation with Thyrza Nichols Goodeve 20th Anniversary of *Modest\_Witness* 1. In *Modest\_Witness@ Second\_Millennium*. FemaleMan© \_Meets\_OncoMouse™ (pp. xiii-xlvii). Routledge.

- Haraway, D., Ishikawa, N., Gilbert, S. F., Olwig, K., Tsing, A. L., & Bubandt, N. (2016). Anthropologists are talking—about the Anthropocene. *Ethnos*, 81(3), 535-564
- Harding, S. (1992). Rethinking standpoint epistemology: What is "strong objectivity?". *The Centennial Review*, 36(3), 437-470.
- Higgins, M., Madden, B., Berard, M. F., Lenz Kothe, E., & Nordstrom, S. (2017). De/signing research in education: Patchwork (ing) methodologies with theory. *Educational Studies*, 43(1), 16-39.
- Hilferty, F. (2008). Theorising teacher professionalism as an enacted discourse of power. *British Journal of Sociology of Education*, 29(2), 161-173.
- Holland, D., Lachicotte, W., & Skinner, D. D., & Cain, C.(1998). Identity and agency in cultural worlds.
- Horton, J., & Scott, D. (2004). White Students' Voices in Multicultural Teacher Education Preparation. *Multicultural Education*, 11(4), 12-16.
- Inoue, M. (2006). Vicarious language: Gender and linguistic modernity in Japan. Berkeley: University of California Press.
- Kendi, I. X. (2019). *How to be an antiracist*. One world.
- Kozol, J. (2012). *Savage inequalities: Children in America's schools*. Crown.
- Kimmerer, R. W. (2013). Braiding sweetgrass: Indigenous wisdom, scientific knowledge and the teachings of plants. Milkweed Editions.
- Korthagen, F. A., & Kessels, J. P. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational researcher*, 28(4), 4-17.

- Ladson-Billings, G. J. (1999). Chapter 7: Preparing teachers for diverse student populations: A critical race theory perspective. *Review of research in education, 24*(1), 211-247.
- Lakshmanan, M. S. (2011). A critical discourse analysis of neocolonialism in Patricia McCormick's *Sold*. *An introduction to critical discourse analysis in education, 68-92*.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.
- Lemke, J. L. (1990). *Talking science: Language, learning, and values*. Ablex Publishing Corporation, 355 Chestnut Street, Norwood, NJ 07648 (hardback: ISBN-0-89391-565-3; paperback: ISBN-0-89391-566-1).
- Lenk, U. (1998). *Marking discourse coherence: Functions of discourse markers in spoken English* (Vol. 15). Gunter Narr Verlag.
- Leonardo, Z. (2002). The souls of white folk: Critical pedagogy, whiteness studies, and globalization discourse. *Race ethnicity and education, 5*(1), 29-50.
- Leonardo, Z., & Porter, R. K. (2010). Pedagogy of fear: Toward a Fanonian theory of 'safety' in race dialogue. *Race Ethnicity and Education, 13*(2), 139-157.
- Levine-Rasky, C. (2000). The practice of whiteness among teacher PTs. *International Studies in Sociology of Education, 10*(3), 263-284.
- Lewis, C. (2001). *Literary practices as social acts: Power, status, and cultural norms in the classroom*. Routledge.
- Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago: University of

Chicago Press.

- Marom, L. (2019). Under the cloak of professionalism: Covert racism in teacher education. *Race Ethnicity and Education*, 22(3), 319-337.
- Matias, C. E., & Mackey, J. (2016). Breakin' down whiteness in antiracist teaching: Introducing critical whiteness pedagogy. *The Urban Review*, 48(1), 32-50.
- Mensah, F. M. (2011). The DESTIN: Preservice teachers' drawings of the ideal elementary science teacher. *School Science and Mathematics*, 111(8), 379388.
- Mertens, D. M. (2012). Transformative mixed methods: Addressing inequities. *American Behavioral Scientist*, 56(6), 802-813.
- Michaels, S., & O'Connor, C. (2012). Talk science primer. *Cambridge, MA: TERC*.
- Moje, E. B., & Lewis, C. (2007). Examining opportunities to learn literacy: The role of critical sociocultural literacy research. *Reframing sociocultural research on literacy: Identity, agency, and power*, 15-48.
- Moore, F. M. (2008). Agency, identity, and social justice education: Preservice teachers' thoughts on becoming agents of change in urban elementary science classrooms. *Research in Science Education*, 38(5), 589.
- Nasir, N. I. S., & Hand, V. M. (2006). Exploring sociocultural perspectives on race, culture, and learning. *Review of Educational Research*, 76(4), 449-475.
- National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.
- Oakes, J. (1985). Keeping track: How schools structure inequality. New Haven: Yale University Press. [Chapter 1].

- Oakes, J. , & Lipton, M. (1999). *Teaching to change the world*. Boston: McGraw-Hill.
- Ochs, E. (1979). Transcription as theory. *Developmental pragmatics*, 10(1), 43-72.
- Painter, N. I. (2010). *The history of white people*. WW Norton & Company.
- Pitkäniemi, H. (2010). How the Teacher's Practical Theory Moves to Teaching Practice—A Literature Review and Conclusions. *Education Inquiry*, 1(3).
- Rahm, J. (2010). Science in the making at the margin. *A multisited ethnography of learning and becoming in an afterschool program, a garden, and a math and science upward bound program*. Rotterdam: Sense.
- Reardon, J., & TallBear, K. (2012). “Your DNA is our history” genomics, anthropology, and the construction of whiteness as property. *Current anthropology*, 53(S5), S233-S245.
- Rodriguez, A. J. (2015). What about a dimension of engagement, equity, and diversity practices? A critique of the next generation science standards. *Journal of Research in Science Teaching*, 52(7), 1031-1051.
- Rogoff, B. (1994). Developing understanding of the idea of communities of learners. *Mind, culture, and activity*, 1(4), 209-229.
- Saldaña, J. (2009). *The coding manual for qualitative researchers*. Lontoo: SAGE Publications Ltd, 3.
- Sannino, A., & Engeström, Y. (2018). Cultural-historical activity theory: Founding insights and new challenges. *Cultural-historical psychology*.



- Schindel Dimick, A. (2016). Exploring the potential and complexity of a critical pedagogy of place in urban science education. *Science Education, 100*(5), 814-836.
- Settlage, J. (2011). Counterstories from White mainstream preservice teachers: resisting the master narrative of deficit by default. *Cultural Studies of Science Education, 6*(4), 803-836.
- Sewell Jr, W. H. (1992). A theory of structure: Duality, agency, and transformation. *American journal of sociology, 98*(1), 1-29.
- Shanahan, C., & Shanahan, T. (2014). Does disciplinary literacy have a place in elementary school?. *The Reading Teacher, 67*(8), 636-639.
- Sheth, M. J. (2019). Grappling with racism as foundational practice of science teaching. *Science Education, 103*(1), 37-60.
- Sleeter, C. E. (1993). How white teachers construct race. *Race, identity and representation in education, 157-171*.
- Sharma, A. (2020). Phronetic science for wicked times. *Journal for Activist Science and Technology Education, 11*(2), 7-15.
- Solomon, R. P., Portelli, J. P., Daniel, B. J., & Campbell, A. (2005). The discourse of denial: How white teacher candidates construct race, racism and ‘white privilege’. *Race ethnicity and education, 8*(2), 147-169.
- Stengers, I. (2018). Another science is possible: A manifesto for slow science. John Wiley & Sons.
- Stetsenko, A. P. (2020). Critical Challenges in Cultural-Historical Activity Theory:

- The Urgency of Agency. *Cultural-Historical Psychology*, 16(2), 5-18.
- Sultana, F. (2018). The false equivalence of academic freedom and free speech: Defending academic integrity in the age of white supremacy, colonial nostalgia, and anti-intellectualism. *ACME: An International E-Journal for Critical Geographies*, 17(2).
- TallBear, K. (2019). Caretaking relations, not American dreaming. *Kalfou*, 6(1), 24-41.
- Todd, Z. (2016). An indigenous feminist's take on the ontological turn: 'Ontology' is just another word for colonialism. *Journal of historical sociology*, 29(1), 4-22.
- Tolbert, S. (2015). "Because they want to teach you about their culture": Analyzing effective mentoring conversations between culturally responsible mentors and secondary science teachers of indigenous students in mainstream schools. *Journal of Research in Science Teaching*, 52(10), 1325-1361.
- Tolbert, S. (2016). *What is social justice in science education? Expanding possibilities for school science*. Unpublished manuscript.
- Tolbert, S., Barton, A. C., & Moll, L. C. (2017) What can teachers do to restructure power dynamics in science classrooms? Exploring the personal and social transformative power of science learning through a funds of knowledge approach.
- Tolbert, S., & Bazzul, J. (2017). Toward the sociopolitical in science education. *Cultural Studies of Science Education*, 12(2), 321-330.

- Tolbert, S., & Eichelberger, S. (2016). Surviving teacher education: a community cultural capital framework of persistence. *Race Ethnicity and Education, 19*(5), 1025-1042.
- Tolbert, S., Knox, C., & Salinas, I. (2019). Framing, adapting, and applying: Learning to contextualize science activity in multilingual science classrooms. *Research in Science Education, 49*(4), 1069-1085.
- Tuck, E. (2009). Suspending damage: A letter to communities. *Harvard Educational Review, 79*(3), 409-428.
- Tuck, E. (2013). Neoliberalism as nihilism? A commentary on educational accountability, teacher education, and school reform. *Journal for Critical Education Policy Studies, 11*(2), 324-347.
- Tyack and Cuban. 1995. *Tinkering Toward Utopia: A Century of Public School Reform*. Cambridge: Harvard University Press.
- Valencia, R., & Solórzano, D. (1997). Contemporary deficit thinking. In R. Valencia (Ed.), *The evolution of deficit thinking in educational thought and practice* (pp. 160–210). New York: Falmer.
- Vygotsky, L. (1978). *Thought and language*. Cambridge, MA: Massachusetts Institute of Technology Press.
- Waghorn, A., & Stevens, K. (1996). Communication between theory and practice: How student teachers develop theories of teaching. *Australian Journal of Teacher Education, 21*(2), 7.

- Wells, G. (1993). Reevaluating the IRF sequence: A proposal for the articulation of theories of activity and discourse for the analysis of teaching and learning in the classroom. *Linguistics and education*, 5(1), 1-37.
- Wells, G. (2002). The role of dialogue in activity theory. *Mind, culture, and activity*, 9(1), 43-66.
- Wideen, M., Mayer-Smith, J., & Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of educational research*, 68(2), 130-178.
- Wortham, S. (2006). *Learning identity: The joint emergence of social identification and academic learning*. Cambridge University Press.
- Wynter, S., & McKittrick, K. (2015). Unparalleled catastrophe for our species? Or, to give humanness a different future: Conversations. In Sylvia Wynter (pp. 989). Duke University Press.
- Yamagata-Lynch, L. C. (2007). Confronting analytical dilemmas for understanding complex human interactions in design-based research from a cultural—historical activity theory (CHAT) framework. *The Journal of the Learning Sciences*, 16(4), 451-484.
- Yerrick, R., & Johnson, J. (2011). Negotiating White science in rural Black America: A case for navigating the landscape of teacher knowledge domains. *Cultural Studies of Science Education*, 6(4), 915-939.
- Yosso\*, T. J. (2005). Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race ethnicity and education*, 8(1), 69-91.

Zeichner, K. M., & Tabachnick, B. R. (1981). Are the effects of university teacher education 'washed out' by school experience? *Journal of teacher education*, 32(3), 7-11.