DEVELOPING URBAN ELEMENTARY TEACHERS' EQUITABLE DISCIPLINARY RESPONSIVENESS TO STUDENTS' SCIENTIFIC SENSE-MAKING

By

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ABSTRACT

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Despite its potential to capitalize on children's inherent curiosities about their worlds around them, elementary science is typically taught with either a transmissive model in which students are passive recipients of scientific knowledge or a conceptually incoherent model of disconnected science activities with little scientific knowledge construction or sense-making. This is a problem for all students, and it is particularly problematic for students from marginalized communities who have more limited opportunities to experience authentic science inquiry outside of the classroom than their White, native English-speaking, male peers.

In this dissertation, I adopt an expansive definition of equity in order to foreground the ways in which science can be taught which broaden traditional norms of what counts as knowing and doing science in elementary classrooms to be more inclusive of students' diverse cultural and linguistic backgrounds. In so doing, students have increased opportunities to engage in scientific sense-making. Specifically, I am interested in the affordances of teachers' responsiveness during science lessons towards these expansive equity outcomes. I explore both teachers' disciplinary responsiveness—that is, teachers' responsiveness to students' scientific sense-making—as well as teachers' equitable responsiveness—that is, teachers' responsiveness to students' cultural repertoires of practice, linguistic resources, or racialized life experiences. My central research question is to investigate how teachers navigate these two approaches to responsiveness—disciplinary and equitable—in their science teaching.

I conducted a qualitative embedded multi-case study with two urban elementary teachers. One teacher taught in a building serving a predominantly emergent bilingual Arab American Muslim community, and the teacher is also Arab American Muslim and bilingual. The other teacher taught in a school serving a predominantly emergent bilingual Latinx community, and the teacher is White and monolingual. I worked with each teacher over seven weeks, conducting pre- and post-interviews, observing science lessons, and debriefing after many of their lessons about how they went, decisions they made, students' engagement, and their plans moving forward. I conducted multiple rounds of coding on transcriptions of the audio-recorded conversations, selected compelling lessons from the video-recordings for further analysis, and constructed narratives around select lessons which illustrated moves made by teacher participants to answer my research question.

Findings from these cases suggest that the foregrounding of building relationships with students is a critical part of what it takes to be equitably responsive in science teaching. Also, taking into consideration a teacher's biases when interpreting her science teaching practices is crucial for gaining a more complete understanding of her responsiveness. In conclusion, I propose a model of Equitable Disciplinary Responsiveness which merges the two approaches to responsiveness into one framework for future use in research and teaching with elementary science teachers. Gaining a better understanding of how equitable disciplinary responsiveness can be enacted in elementary science classrooms is one small step in a broader effort to move towards more equitable science teaching and learning for students.

This dissertation is dedicated to the participating teachers who invited me into their classrooms, were generous with their time, and were vulnerable in their conversations with me. I hope that my writing in this manuscript honors their gifts by allowing us all to learn from them.

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I would also like to thank my dissertation committee. Two members of my committee have been a part of my journey from the beginning, mentoring me on a larger NSF-funded study (RC103139) investigating novice elementary teachers' noticing and responding to students' scientific sense-making. My dissertation was also supported by this grant. From Angela Calabrese Barton, I learned early on that the most effective way for me to learn in graduate school would be to vocalize my ideas in order to enter conversations and get feedback on my ideas from others. This was daunting, but over time, I learned to trust that critical feedback was intended to help me grow as an early academic. I thank Angie for continuously pushing my thinking and helping me move towards a more critical understanding of equity in science education. From Melissa Braaten, I learned over time how to construct an argument in my writing. Melissa generously gave of her time to read various pieces of my writing over the years,

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The other two members of my committee are Alyssa Hadley Dunn and Niral Shah. Alyssa and I started at Michigan State University in the same year, and we discovered early on that we were both alumni of the teacher preparation program at Boston College. This early connection developed into a mentoring relationship during my tenure as a graduate student in which Alyssa helped increase my awareness of my own Whiteness and learn how to enter a critical discourse community within the academy. Thank you, Alyssa, for your incredible dedication to me. I did not have the pleasure of meeting Niral until I was forming my dissertation committee. My first impression sitting down with him was the way in which he engaged me in conversation about my research, positioning me as an expert and someone he could learn from. At every turn, Niral's feedback has always been delivered with care—care for my ideas, care for his understanding of the field, care for my potential contributions to the field. I thank Niral for his manner of engaging with me and my scholarship in ways which carefully pushed my thinking in important directions.

In addition to my committee, I have had the distinct honor and pleasure of working with and learning from other faculty, including Andy Anderson, Amelia Gotwals, and Tanya Wright. From each of these individuals, I have learned different perspectives on engaging in qualitative inquiry, writing for publication, and creating educative curriculum materials. In graduate school, I have frequently likened myself to a ball of clay, and with each interaction I have with various faculty members—through coursework, research projects, or teaching assignments—I can feel myself being shaped and pushed in different directions as I form my academic identity.

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KEY TO ABBREVIATIONS

AERA	American Education Research Association
AP	Advanced placement
CEO	Chief executive officer
EDR	Equitable disciplinary responsiveness
ELL	English language learners
GPA	Grade point average
ICS	Independence Charter School
IRB	Institutional Review Board
KLEW(S)	Know, Learned, Evidence, Wonderings, (Scientific Concepts/Words)
NARST	National Association of Research in Science Teaching
NGSS	Next Generation Science Standards
NSTA	National Science Teachers Association
NWEA	Northwest Evaluation Association
PD	Professional development
STEM	Science, Technology, Engineering, and Mathematics

CHAPTER ONE:

Introduction

Elementary science teaching and learning has the potential to pique students' natural curiosity about their worlds, promote scientific literacy, increase science content knowledge, and foster positive science identities for young students (Brown, 2017; Eshach & Fried, 2005) to help them function, thrive, and potentially improve the world around them. Young children are naturally curious about phenomena that are occurring all around them. For example, they might ask questions such as:

Sometimes it is still light out when I have to go to bed. Why?

Squirrels have lots of different fur colors. Why?

Opportunities to notice, wonder about, and explore phenomena like these can foster scientific dispositions, interests, and identities in students to prepare them for engaging in both personal and greater sociopolitical issues plaguing our local and global communities. Those issues include questions such as:

Should I vaccinate my children? How can I know it is safe?

What kinds of meals should I prepare for my family? Where should I buy my groceries?

Kids in Flint, Michigan cannot drink their tap water. Why?

Sea levels are rising and forcing people to move away from coastal areas. Why?

We are experiencing the sixth mass extinction in Earth's history. Why?

Fostering youths' natural curiosity about the world around them prepares them to address personal health issues in their futures as well as to advocate for others—for other humans and other living things who all cohabitate this planet. Among the serious issues affecting our personal and global communities, many of them, including those listed in the above quotes, have helpful scientific explanations. Those scientific explanations, along with other social and cultural considerations, can inform the decisions we make as we seek to understand and to determine

next steps. Through supporting youths' inherent curiosities in elementary science classrooms about their worlds around them, we foster their ongoing engagement with science and better position the next generation to make informed personal decisions and take action on pressing global issues.

Unfortunately, elementary science teaching and learning infrequently provide students with authentic opportunities to notice, wonder about, and explore their science curiosities. First, science is rarely taught in elementary schools in the United States, especially in the early grades (Blank, 2013). Second, when there is time for science, instruction is commonly didactic and vocabulary-focused, worksheet- or activity-driven, with little intellectual engagement (Blank, 2013; Clegg & Kolodner, 2014; Colley & Windschitl, 2016; Engel, 2011; Horizons Research Inc., 2013). This is problematic for all students, but it is especially problematic in urban schools in the U.S. which serve historically marginalized and minoritized groups of people facing challenges of poverty, discrimination, and a lack of access to shape the culture of power (Delpit, 1988; Massey & Denton, 1993; Milner, 2012). Didactic science teaching in these communities decreases students' opportunities to develop interest or identities in science thereby decreasing their likelihood of using science as a tool to function, thrive, and improve their world around them. This happens because in didactic science teaching, the emphasis is on science content transmission—a content developed by and for those in the culture of power (Calabrese Barton & Yang, 2000).

Instead, science should be taught in ways which leverage the heterogeneity of students' linguistic resources, epistemological stances, lived experiences, and funds of knowledge (Calabrese Barton & Tan, 2009; Rosebery, Ogonowski, DiSchino, & Warren, 2010) so that students can connect science with their own lives, ways of knowing, and interests. Doing so is

critical for students' participation in science as well as being able to help them take up science in deeper, more authentic ways that are called for in the Next Generation Science Standards (NGSS Lead States, 2013). One approach to this kind of teaching is through responsiveness—that is, teaching which notices and interprets students' science ideas as valuable to their learning, responds in ways which leverage students' funds of knowledge, enacts curriculum which is meaningful and authentic for students, and contributes to developing anti-oppressive relationships with students.

In this study, I closely investigate the responsiveness of two urban elementary teachers in two different schools. One school is a traditional public school serving a community of largely immigrant and refugee students who speak Arabic at home and practice Islam. The other school is a public charter school serving a community of largely first- and second-generation immigrants from Mexico and Central America. Both schools are located in cities with a depth of cultural resources and a dearth of economic resources being invested in public services. I enter this work with a conviction that students have a right to be taught science in a way that allows them full access to the culture of power, the ability to shape the culture, and the opportunity to use and develop scientific practices to make sense of the world (Tate, 2001). For this reason, it is critical to address this need for improving science in urban schools. As a result, I worked with teachers at schools that serve groups of students who are often disenfranchised from science and school science in order to focus my attention on equity in science education in these underserved spaces.

This chapter provides an overview of the problem which prompted the need for this research study; the significance of the study's results to the fields of science education, multicultural education, and teacher education; and an overview of each chapter contained in this

dissertation. First, I briefly define how I define equity in this project, which I define in more detail in Chapter 2. In this study, equity refers to an expansive notion of teaching and learning science which broadens opportunities for and ways of participating as knowers and doers in science to students who are traditionally marginalized in science and science classrooms (i.e., students of Color, emergent bilinguals, girls, and so on).

Problem Statement

Science is critical for human functioning as a society and as individuals. It is also often fun or joyful for those who engage in it. However, science is also fraught with problems which maintain power and privilege for some while marginalizing others. As in all fields, science is a socially- and culturally-constructed endeavor—though scientists themselves do not always acknowledge this contextualization or their positionality and culture in this process. Professional science has "particular ways of observing, thinking, experimenting, and validating conclusions that have become a part of the scientific way that people explore the world" (Bryan & Atwater, 2002, p. 826). These ways of exploring the world are influenced by the cultural repertoires of practice of those individuals who have, over time, constructed this field of knowledge (Nasir, Rosebery, Warren, & Lee, 2006, p. 489). As those individuals have been predominantly White and male having come from Western European traditions, it is their cultural repertoires of practice which have been normalized as being scientific, while other cultural repertoires of practice are deemed non-scientific. Many understand science practices to be hypotheticodeductive—or rather, a straightforward process of deducing facts or knowledge from empirical studies (Nasir et al., 2006). This logical way of using numbers and other "objective" measures to better understand the world is a commonly held assumption about the nature of science. However, if we understand science practices instead "as an intricate intertwining of

conceptual, imaginative, material, discursive, symbolic, emotional, and experiential resources," space opens up for multiple epistemological stances to count as science (Nasir et al., 2006, p. 494). An expansive, rather than reductive, stance toward science creates more avenues for learning science.

School science itself—that is, the way that science is taught in schools—is also cultural. The culture of school science in the United States is driven by White, middle-class repertoires of practice (Calabrese Barton, 1998) due to the historical, political, and cultural forces that have shaped it over time. For example, deficit perspectives shape whose knowledge and stories are perceived as valuable and what smart looks like (Bang, Warren, Rosebery, & Medin, 2013). These practices establish power dynamics in classrooms that dictate what counts as knowing and doing science and whose knowledge is valued when. Bang et al. (2013) refer to White, middle-class repertoires of practice as "settled expectations" in school science and argue that such practices "reproduce the privileging of whiteness" (p. 303). Particularly for students from marginalized communities, this culture of school science presents a barrier to their learning (Aikenhead, 1996). However, science is much broader than this limited vision allows, and elementary science can potentially expand and transform both how school science is taught and who gets to participate.

I propose that elementary teachers can make an early impact on marginalized students' interest in science by leveraging young students' innate curiosity to engage them in sense-making about the natural world around them. Sense-making is a process of constructing explanations for and figuring out the mechanisms behind scientific phenomena (Odden & Russ, 2018). Being open to the heterogeneity of students' ideas, linguistic resources, experiences, epistemological stances, and funds of knowledge as they figure out science phenomena can de-

settle, or disrupt, settled and inequitable norms in science education (Bang et al., 2013; Calabrese Barton & Tan, 2009; Rosebery et al., 2010). This can result not only in the broadening of participation in science, but also in the broadening of who gets to shape the culture and practices of science, expanding our notions of what counts as science and who counts as knowers and doers of science (Bevan, Calabrese Barton, & Garibay, 2018).

As a result, the purpose of this study was to examine the responsiveness of two teachers' science teaching. I embarked on this work in order to further theorize about what responsive science teaching can look like in elementary science classrooms and to characterize practical teaching moves which elementary teachers may enact that aligns with theory. In order to address the study's purpose, I analytically considered both disciplinary and equity aspects of responsiveness. This is important because the field tends to foreground either a disciplinary lens on responsiveness with implications for equity outcomes, or an equity lens on responsiveness with embedded disciplinary outcomes. For example, research related to Ambitious Science Teaching (a framework developed by a group of scholars centered at the University of Washington to improve science teaching through high-leverage practices) tends to foreground teachers' responsiveness to students' disciplinary ideas in science with identified equity outcomes for students (i.e., Windschitl, Thompson, Braaten, & Stroupe, 2012). On the other hand, research out of TERC (Technical Education Research Centers—an independent research organization with a mission to improve science and mathematics teaching in diverse communities) tends to foreground teachers' responsiveness to culture and power with identified disciplinary outcomes for students (i.e., Rosebery et al., 2010). Cobb (1994) suggests that there is little reason to position disciplinary or equitable responsiveness as binary goals, as they each have advantages for thinking about teaching and learning. Even more importantly, the field of

science education knows little about how teachers navigate these two approaches to responsiveness, nor about what it takes to support teachers to improve their responsiveness (or responsive teaching practices) in both equitable and disciplinary ways.

Research Question

To address my research purpose, I designed an embedded multiple-case design (Yin, 2014) in order to answer the following research question: How do urban elementary teachers navigate disciplinary and equitable aspects of responsiveness in their science teaching? In particular:

1) What do teachers' enactments of responsiveness look like?
2) What do teachers foreground in their enactments of responsiveness? Why?
3) What aspects of responsiveness seem to come more easily to these teachers and what seems to be more challenging? Why?
4) In what ways and when do disciplinary enactments of responsiveness co-occur with equitable enactments of responsiveness? In what ways and when do they seem to happen independently of one another? Why does this seem to happen?

Significance

While the particular paths and outcomes of cases within this research are not generalizable, this study generates a potential framework and practical applications that can be used in advancing equity work in science education. This study adds to literature in science education around disciplinary responsiveness in science (e.g., Hammer, Goldberg, & Fargason, 2012), equitable responsiveness in urban elementary classrooms (e.g., Parsons, 2001), high leverage responsive practices in science (e.g., Thompson et al., 2016), and responsive moves to elementary students' equitable science sense-making (e.g., Haverly, Calabrese Barton, Schwarz,

& Braaten, 2018). Through foregrounding equitable and disciplinary perspectives in my data analysis, I propose a framework for Equitable Disciplinary Responsiveness in the concluding chapter which draws on literature from the field as well as results from this dissertation.

The proposed framework for Equitable Disciplinary Responsiveness, and the accompanying classroom narratives I gathered from my case studies, contribute to the field's understanding of what more expansive visions of elementary science teaching and learning can look like. This vision suggests a path forwards towards broadening participation for traditionally marginalized students in science classrooms, and ultimately towards greater participation in and contributions to the fields of science, personal health decisions, and global sociopolitical issues.

A concern left empirically unaddressed by this dissertation is whether disciplinary responsiveness can ever be equitably responsive considering the history in science and science education of racism and colonialism. For example, if disciplinary responsiveness simply maintains racist and colonial norms and big ideas of mainstream science disciplines (such as humans as operating distinctly from the natural world, or the impact of applied sciences on the militarization of police forces), then students' sense-making may be supported, but racist and colonizing features of the sciences may be maintained. This dissertation does not examine the possibilities of disciplinary responsiveness to critique science, nor a critical responsiveness perspective of engaging in community-driven science in justice movements (see Philip & Azevedo, 2017). While these are important to promoting equity, such orientations are difficult to enact in short-term engagements within formal school science contexts. Rather, this dissertation focuses on teachers' attempts to engage students in expansively participating in authentic science inquiry as knowers and doers of science (Philip & Azevedo, 2017). To the extent that not all students are positioned as knowers and doers of science because of their minoritized identities

and that what typically counts as school science is limited to White, western, and male epistemologies and experiences, this dissertation works towards addressing inequity by expanding what counts as science knowledge and sense-making in elementary classrooms. In this way, through this work, I attempt to address this critical, though not all-inclusive aspect of what makes this world inequitable.

Dissertation Overview

To help the reader understand the flow and purpose of this dissertation, I use this section to describe the focus of each chapter. As you have read, chapter one began with a foundational overview of the problem in which I situate my research, the purpose of the study, and its significance.

Chapter two provides a review of relevant literature aligned to two main conceptual frameworks for this research: (1) teacher noticing from mathematics education and science education to conceptualize a disciplinary frame of reference on responsiveness, and (2) research from multicultural education and science education to conceptualize an equity frame of reference on responsiveness. I problematize the current aspects of this work and indicate how I leverage this work in this dissertation study.

In chapter three, I describe the qualitative research methods I used to conduct this dissertation research. These methods leveraged an embedded multiple case study design. I also describe my two teacher participants and their teaching contexts in addition to my own positionality in this work. I describe the data I gathered to conduct this research, and I describe how I analyzed these data.

Chapter four is the first of two findings chapters. Each findings chapter profiles one of my two cases. In this chapter, I profile Hoba's case. Hoba's science teaching and responsiveness was the most equitable of the two cases, and I consider reasons why this was true for her.

Chapter five is the second findings chapter, and I profile Karen's case. Karen's disciplinary responsiveness was the strongest of both cases. However, Karen betrayed many troubling orientations towards her students and their families that were informed by White supremacist ideologies. These orientations surfaced in ways that reified Whiteness in her practice and left behind two students in particular. As a result, I argue that Karen's teaching cannot be considered equitably responsive.

In chapter six, I conclude by proposing a framework for understanding this data and for pursuing similar lines of research in the future. Equitable Disciplinary Responsiveness positions teachers' relationships with students as equally important to their responsive teaching practices as their enactment of equitable curriculum and pedagogy. I use findings from the two cases to suggest practical applications of this framework in elementary science classrooms. I include implications for this work to researchers, teacher educators, and practitioners.

CHAPTER TWO:

Conceptual Framing

I argued in Chapter 1 that responsiveness in elementary science teaching has the potential to disrupt settled epistemological orientations in science which disadvantage historically marginalized youth in the science classroom. In this chapter, I provide the conceptual frameworks which inform how I think about responsiveness with a disciplinary lens as well as with an equity lens. When considering responsiveness with a disciplinary lens, I draw on the Noticing frameworks leveraged by scholars in mathematics education and science education. When considering responsiveness with an equity lens, I draw on a variety of multicultural education tenets which present an ecology of equitable practices. Before sharing the conceptual framing for this study, I present some definitions for constructs related to my conceptual frameworks for clarity: culture, race, urban schools, equity, and sense-making.

Definitions

Throughout this dissertation, I use terms which are often used in educational research, but do not necessarily have commonly understood definitions. Therefore, in this section, I present definitions which inform my own thinking of these terms throughout this manuscript.

Culture

For this research, I draw on work by Nasir et al. (2006) who define culture as "the constellations of practices historically developed and dynamically shaped by communities in order to accomplish the purposes they value" (p. 489). Culture can be produced, and there is fluidity to culture which cannot be essentialized entirely according to group affiliation though is informed by shared histories and values of communities. While science is often perceived as a-cultural, the production of scientific knowledge is heavily informed by the histories and values of the individuals who participate in scientific fields (Bryan & Atwater, 2002). In a U.S. context, these individuals have primarily been males from Western cultures (Brickhouse, 2001).

Race

Race is a socially constructed way of grouping individuals according to the color of their skin (Delgado, Stefancic, & Harris, 2017). This system of grouping according to race has been, and continues to be, used by White people to provide structural advantages to ourselves while subjugating people of Color (Omi & Winant, 1994). Historically and present-day, science and other STEM fields are dominated by White people which is problematic on multiple levels. (1) This denies advantages to people of Color of lucrative career opportunities in the sciences. (2) This denies opportunities to people of Color to contribute to scientific knowledge production to the benefit of their own (and others') communities. (3) The fields of science themselves are limited without the skills and knowledges that people of Color could contribute in order to expand our collective ways of understanding the natural world. (4) Science has historically been used to perpetuate racism, for instance, by attempting to prove scientifically that people of African descent are less intelligent than those of European descent (Kendi, 2016).

Urban Schools

In this dissertation, I adopt Milner's (2012) typology of urban schools which uses the following three categories: urban intensive, urban emergent, or urban characteristic. Urban intensive schools are in large U.S. cities including New York, Los Angeles, and Chicago. These schools face challenges associated with maintaining an infrastructure to educate such large quantities of students, housing availability for families, poverty, and transportation options. Urban emergent schools are in cities which are not as large, such as Nashville, Tennessee; Austin, Texas; and Columbus, Ohio. Urban emergent schools generally have similar challenges as urban intensive in terms of resource allocation, teacher quality, and student achievement. Urban characteristic schools may be in rural or suburban areas but face some similar challenges

associated with urban schools, for example with increasing numbers of students who are emergent bilingual.

Equity (in Science Education)

In this dissertation, I adopt an expansive view of equity with the goal of not only valuing students' differences based on "culture, race, gender, religion, nationality, language, sexual orientation, and ability/disability" (Cochran-Smith, 2010, p. 451), but of expanding what counts as knowing and doing science based on students' varied repertoires of practice and funds of knowledge (Rosebery et al., 2010). This kind of expansiveness creates space for multiple ways of participating in and contributing to science, engaging in authentic inquiry experiences, and positioning students with epistemic authority to make scientific claims based on evidence and their lived experiences. These ways of participating in science learning represent a step towards de-settling established power hierarchies which marginalize many science students. Through responsive science teaching, I consider ways in which elementary teachers' practices (and orientations) allow for expansive science learning.

This expansive definition of equity translates well into an elementary classroom in which science instruction has a tendency of being transmissive, rather than capitalizing on the diverse funds of knowledge students bring to contribute to collective knowledge building experiences. A limitation of this expansive definition of equity is that it does not take on a critical, transformative, or social justice orientation to equity. Critical and social justice orientations to equity make important contributions to the field by considering how science (or engineering, environmental, and so on) teaching and learning can be used by students to address injustices in their communities and lived experiences (for example, see work by Bang & Marin, 2015;

Gutiérrez & Jurow, 2016; Schenkel, Barton, Tan, Nazar, & Flores, 2019). These orientations seek to transform unjust structures and epistemologies through the agentic actions of learners.

I leverage an expansive definition of equity in response to the constraints posed by working within two schools which serve as structures that are historically unjust as well as constraints of the amount of time I had to work with each teacher. Within said constraints, I focus in this dissertation on how equity can be realized as an expansive enactment to begin to disrupt settled norms of what counts as knowing and doing science in schools that disregard the cultural norms and practices of many students. An important next step would be to consider how to shift these enactments of equity to be more transformative and justice-oriented, to engage students as agents of change in their communities through their science learning experiences.

Sense-Making (in Science Education)

Sense-making is "a dynamic process of building or revising an explanation in order to 'figure something out'" about science phenomena (Odden & Russ, 2018, pp. 5-6). Students draw on a variety of resources in order to engage in sense-making, including everyday language, embodied imagining, gesturing, classroom science experiences, and peers' ideas and arguments (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). Facilitating students' scientific sense-making requires the teacher to also take on a stance of sense-maker as together students and teacher co-construct a science storyline through classroom discourse (Haverly et al., 2018). This co-construction of knowledge blurs the lines between novice and expert, positioning students with epistemic authority in the classroom and as knowers and doers of science (Benedict-Chambers, Kademian, Davis, & Palincsar, 2017).

This research project was situated in the classrooms of two elementary teachers who teach in urban emergent school districts with students from multiple cultural and racial

backgrounds. I studied how each teacher taught science in ways which were responsive to students' sense-making and were equitable. In the following section, I expand on the conceptual frameworks I used to understand responsiveness to student sense-making and equitable responsiveness.

Conceptual Frameworks

This study draws on two primary bodies of literature. (1) I draw on the noticing and responding literature in the fields of mathematics and science education in order to study what disciplinary responsiveness to sense-making looks and sounds like in moments of classroom discourse. (2) I draw on equity-oriented literature from the fields of multicultural education and science education in order to describe equitable responsiveness to students and their cultural repertoires of practice because these scholars look critically at how to be responsive to students who are historically marginalized in U.S. schools and society.

In this section, I synthesize literature across each of these areas, presenting the two main conceptual frameworks for this dissertation (Table 2.1).

Table 2.1

Main Components of Responsiveness Frameworks in this Study

Disciplinary Responsiveness	Equitable Responsiveness
Opportunities Noticing Interpreting Responding	Equitable Curriculum and Pedagogy Equitable Interrelationships Knowledge of Issues of Equity

Disciplinary Responsiveness

I define disciplinary responsiveness as cycles of noticing and responding to sense-making over time. To conceptualize disciplinary responsiveness I draw from prior research in several areas. In particular, I draw on a framework used in mathematics and science education often called the Noticing or Noticing and Responding framework which can refer inclusively to the

following components: providing *opportunities* to students to express their ideas; attending to, or *noticing*, students' ideas; *interpreting*, or reasoning about ideas based on the teacher's knowledge; and deciding how to *respond* (Barnhart & van Es, 2015; Jacobs, Lamb, & Philipp, 2010; van Es & Sherin, 2002). Kang and Anderson (2015, p. 866) represent the components of this framework as a cyclical process (Figure 2.1). What I am calling disciplinary responsiveness (but which many of these cited scholars term 'responsiveness' or 'responsive teaching') is a cycle of noticing and responding that entails opportunities, noticing, interpreting, and responding to students' science sense-making (Kang & Anderson, 2015) which takes place over a "sequence of episodes" (Thompson et al., 2016, p. 3). In this way, disciplinary responsiveness is "the cumulative impact of individual discourse moves as they accrue over time and throughout a lesson" (Pierson, 2008, p. 29). This discursive pattern of interactions is established through a repeated centering of student thinking or sense-making. Here I take each of the above parts in turn to more clearly define them.

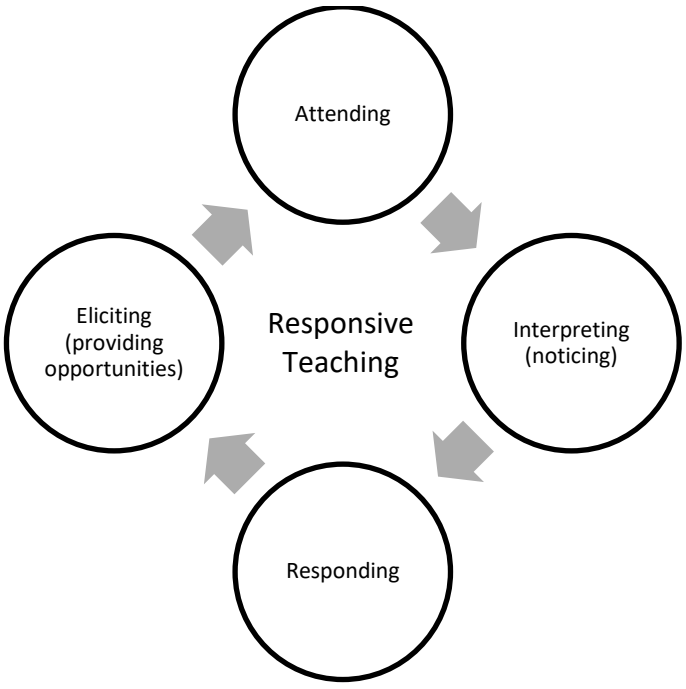


Figure 2.1. A rendering of the Noticing framework from Kang & Anderson, 2015, p. 866.

Opportunities. While not included in all representations of "noticing," many scholars contend that a precursor to noticing is providing opportunities for students to express their thinking. These opportunities may take the form of eliciting students' ideas and experiences, presenting students with stimulating scientific phenomena, constructing rich assessment tasks that elicit student reasoning, designing experiences for children to mix everyday and scientific perspectives, facilitating talk or argumentation in the classroom, or presenting students with unfamiliar tasks (Ball, 1993; Ford & Wargo, 2012; Hammer et al., 2012; Herbst, 2003; Kang & Anderson, 2015; Rosebery et al., 2010; Roth, 1995; Scott, Mortimer, & Aguiar, 2006; Windschitl, 2002). Regardless of the shape of the opportunity, all of these share a common thread of making thinking visible. Once student thinking is visible, teachers can then engage in their *noticing* practices in order to determine how to respond and promote student thinking.

Noticing. Noticing, or sometimes more specifically called "attending," refers to what teachers attend to in any given moment of instruction (Barnhart & van Es, 2015). This attention to particular aspects of practice can range from task- and behavior-oriented performances, to individual students' scientific ideas, to students who are withdrawn or need extra support, to students who excel and also need extra support. Teaching is a complex task which requires that teachers attune to their classroom closely with a multitude of events they must notice and attend to throughout the school day (Labaree, 2000; Lortie, 1975).

Novice teachers have a tendency to notice things such as task completion, task accuracy (e.g., articulating a researchable question), or generalized whole-class learning, rather than the content of individual students' thinking (Barnhart & van Es, 2015; Star & Strickland, 2008; Talanquer, Tomanek, & Novodvorsky, 2013). Noticing, as conceptualized here, focuses on teacher noticing of students' scientific sense-making—that is, to the science ideas that students

communicate in the classroom. In order to be responsive to student sense-making, teachers must move beyond more task-oriented noticings, in order to attend more closely to the content of what students are saying and how they are making sense of science (e.g., students' ideas about when and why solids might turn into liquids). Teachers who notice for equity additionally attend to how student groups are functioning to support student learning, individual students' histories in and outside of the classroom, and the "energy and flow" of student learning during the lesson (van Es, Hand, & Mercado, 2017).

Interpreting. Happening alongside the act of noticing is the act of interpreting. Teachers must make sense for themselves of an observed event, such as a student sharing an idea. This act of reasoning about, or interpreting, students' ideas is closely tied to a teacher's pedagogical knowledge (van Es & Sherin, 2002) as well as their sociocultural knowledge (Rosebery, Warren, & Tucker-Raymond, 2015). For instance, a teacher may hear a student's idea and interpret it as a common misconception, drawing from their pedagogical knowledge about how to make sense of this idea as they make a decision about how to respond (Campbell, Schwarz, & Windschitl, 2016). Or, a teacher may hear a student's idea and recognize it as an important experience a student is leveraging in their scientific sense-making, drawing from their sociocultural knowledge about how to leverage students' funds of knowledge for learning—that is, their everyday experiences from sources such as family, community, or popular culture that inform how students perceive the world around them (Moll, Amanti, Neff, & Gonzalez, 1992). Ball (1993) states that "the ability to *hear* what children are thinking transcends disposition, aural acuity, and knowledge" (p. 388). Part of this transcendence is captured in the *interpretation* of what the teacher hears, or notices.

Responding. Finally, the teacher will act, or respond in-the-moment, by deciding *what to do*. The teacher's response will depend on what the teacher noticed in the first place and how they interpreted this event drawing on their pedagogical and sociocultural knowledge, along with a multitude of other factors, which may include how much time is left in the lesson, what is coming up the next day, what the other students are doing in that moment, what the day's learning goal is, and so on. Responses can vary from no response at all, to probing and pressing with follow-up questions (Michaels & O'Connor, 2012), to making space for students to work together on an expressed idea (Haverly et al., 2018), to privileging space for students of Color to contribute to a discussion (Parsons, 2001), to cutting short a lesson (Schwarz, Braaten, Haverly, Calabrese Barton, & de los Santos, under review), to waiting for the next day or week to construct a lesson around the idea. Here is uncharted territory which requires improvisation on the part of the teacher (Borko & Livingston, 1989) and is perhaps the most difficult of the Noticing practices (Barnhart & van Es, 2015; Jacobs et al., 2010).

An important distinction between responsiveness and responding is that responding can happen in a single act, or episode, whereas responsiveness takes place over a "sequence of episodes" (Thompson et al., 2016, p. 3). In this way, responsiveness becomes "the cumulative impact of individual discourse moves as they accrue over time and throughout a lesson" (Pierson, 2008, p. 29). Responsiveness is a pattern of interactions and discourse established through repeated responding to and elevating of students' ideas in the classroom. Therefore, even if a teacher responds in a productive way to a student—for instance, with a probing question that helps that student to sense-make in the moment—it is not a responsive classroom if the teacher's ways of responding do not constitute a *pattern* of noticing and responding to student thinking. Disciplinary responsiveness allows teachers as a habit to attend to the substance of student

thinking and determine responses to students that meaningfully engage them in the practices of science. There is limited work that looks at urban elementary teachers' disciplinary responsiveness to students, and this study provides an opportunity to consider what elementary teachers notice in their students' sense-making and how they respond in ways which promote further sense-making.

Challenges. Disciplinary responsiveness is difficult work for many teachers. First, many teachers experience tension between valuing students' ideas in the public plane and feeling a responsibility to avoid student confusion about a given disciplinary topic (Ball, 1993). Second, finding a response to students in the moment that recognizes them as knowers and doers of the discipline can lead to a messy outcome where students are allowed, even challenged, to make sense of new topics on their own and teachers must relinquish a certain amount of control in the classroom (Pierson, 2008). While research by Manz (2015) demonstrates that this uncertainty can lead to productive student engagement in the scientific practices, it can be uncomfortable for teachers to adjust to having less epistemic control in the classroom. Third, teachers must routinely improvise in order to respond to students' sense-making as productive contributors to the learning process rather than relying on previously constructed lesson plans (Maskiewicz & Winters, 2012). This requires flexibility in how science instruction looks and feels in a responsive classroom as compared to a more traditional classroom. Finally, responsiveness is difficult for students too, who are continuously pushed to operate at the edge of their zone of proximal development as teachers guide students' sense-making beyond students' independent level of activity (Pierson, 2008; Vygotsky & Cole, 1978).

In sum, my work on disciplinary responsiveness largely draws on prior Noticing as well as Noticing and Responding research in science and mathematics education and refers to cycles

of teachers noticing and responding to students' sense-making in ways which promote further scientific sense-making for students.

Equitable Responsiveness

By equitable responsiveness, I mean equitable science teaching which is responsive to students in particular ways. Whereas disciplinary responsiveness is responsive to students' scientific sense-making, equitable responsiveness might be responsive to students' cultural repertoires of practice, racialized lived experiences, or linguistic backgrounds. This responsiveness is enacted through teachers' (a) curriculum and pedagogy and (b) relationships with students, which form two central components of the conceptual framework I present for equitable responsiveness. Additionally, research suggests that in order to be equitably responsive, teachers must have particular dispositions, or perspectives, which attend to issues of power and privilege in the classroom (Hand, 2012). Therefore, I additionally consider teachers' "orientations, habits, and tendencies" (Warren, 2017, p. 2) as well as their knowledge of issues of equity (Dimick, 2012) as a third component of the equitable responsiveness framework. The literature I draw on in this section is from the fields of multicultural education and science education. Though many of these scholars do not label their work as describing "equitable responsiveness," they contribute to my understanding of essential features of this construct for this dissertation.

Equitable curriculum and pedagogy. Curriculum must connect to the culture and funds of knowledge of students: "If the content of school knowledge excludes the history, art, culture, and ways of knowing of entire groups of people, these groups themselves are dismissed as having little significance in creating history, art, culture, and so on" (Nieto & Bode, 2012, p. 9). Rather, students' funds of knowledge should be leveraged as the "foundation for academic

learning inside the classroom" (Paris, 2011, p. 53). Typically state-mandated standards are used as a "foundation for academic learning." This is problematic considering the critiques that standards such as the *Next Generation Science Standards* (NGSS Lead States, 2013) reify dominant epistemologies and are tools used to sustain disparity (e.g., Rodriguez, 2015). However, rather than abandoning standards which many teachers are held accountable to, teachers can focus on "attending to, valuing, learning from, and passing on a much wider array of knowledge than that which resides in traditional bodies of school knowledge" (Sleeter & Carmona, 2016, p. 10). In other words, when teachers have the agency to re-envision curriculum, they can push the boundaries of—rather than be limited by—state-mandated standards. In so doing, they can enact an expansive vision of equitable responsiveness which considers multiple ways of doing and knowing science as relevant.

Equitable pedagogy encompasses practices that "must be generated in response to actual learners" (Moje, 2007, p. 5). Scholars alternately describe equitable pedagogy as liberatory, critical, place-based, relevant, counterhegemonic, and empowering (e.g., Dimick, 2012; Freire, 1970; Gruenewald, 2003; Ladson-Billings, 2014; Tan, Calabrese Barton, Varley Gutiérrez, & Turner, 2012). In all of the above descriptions, equitable pedagogy must ultimately be responsive to learners and to their racialized and cultural experiences and histories.

Equitable science curriculum and pedagogy engage students in critical work with science content. For example, Rosebery et al. (2010) studied third- and fourth-grade students' engagement with science talks as a pedagogical approach to student learning. They analyzed students' processes of figuring out concepts related to heat and heat transfer while also analyzing the ways in which they used everyday language to engage in heterogeneous sense-making about the phenomena during the science talks. As another example, Tsurusaki, Calabrese Barton, Tan,

Koch, and Contento (2013) studied sixth-graders' engagement in a culturally relevant science curriculum as they learned about dynamic equilibrium (energy in/energy out) in the context of food and food systems. Researchers also analyzed students' development of critical consciousness about the connections between their everyday food choices and access to food systems. These two examples demonstrate how researchers who study equitable curriculum and pedagogy, one aspect of equitable responsiveness, also attend to the disciplinary nature of student learning in regards to science.

Equitable interrelationships with students. Equitable relationships with and between students are anti-oppressive and predicated on caring for one another (Dimick, 2012). Culturally relevant, or responsive, caring occurs when teachers have an understanding of the systemic structures that oppress students (Parsons, 2005). Through this kind of caring, teachers have the potential to allow space for empowered students to transcend societal inequities in addition to advocating on behalf of their students (Ladson-Billings, 1995b). Additionally, through caring, teachers develop relationships with students which are crucial in order to help students "believe they can develop the knowledge, skills, attitudes, and beliefs to build a successful future" (Milner, 2010, p. 185). Ladson-Billings (2009) describes these relationships between teachers and students as developing both in school (for instance, in lunch groups with small groups of students) and out of school (such as a common place of worship in the community). Rather than being one more thing for teachers to do on top of expansive curriculum and pedagogy, caring is underneath everything that teachers do (Noddings, 2012). Therefore, while relationships themselves are not enactments of expansive equity as I defined it above, equitable responsiveness must prioritize the nurturing of caring and anti-oppressive relationships with students.

Knowledge of equity. Teachers working towards equitable responsiveness should have some knowledge about issues of equity impacting their communities, "particularly among students from communities that have been marginalized from participating in science education and pursuing science careers" (Dimick, 2012, p. 992). Knowledge of equity inherently operates at a different grain-size than the constructs described so far around Noticing, equitable curriculum and pedagogy, and equitable relationships. Teachers' knowledge of issues of equity directly impacts the orientations they bring to their work, which then impacts their engagement in Noticing, equitable curriculum and pedagogy, and equitable relationships. In schools, White teachers are often uncomfortable acknowledging race (Ladson-Billings, 2009). Despite possible good intentions of judging their students by their character and not the color of their skin (Bergerson, 2003), this colorblind stance is apolitical and ahistorical. It serves to deny students of Color their stories and ignores their oppression (Hylton, 2012). Teachers must recognize students' races and cultures as differences that are normal and valuable to teaching and learning (Ladson-Billings, 2009). Furthermore, teachers cannot engage in the sociopolitical work of equitable responsiveness without acknowledging their students' oppression, recognizing inequitable hegemonic structures, and acting on behalf of their students to work at dismantling such structures. Attending to participants' knowledge of equity in my data analysis allowed me to draw conclusions about why participants foregrounded particular aspects of responsiveness in particular ways, with whom, and to what ends.

To summarize, teachers who take on these orientations, habits, and tendencies of equitable science teaching can make moves in their classrooms which are equitably responsive. **Equitable curriculum and pedagogy** are possible when science teachers recognize students' funds of knowledge as assets to students' learning that they can build on in their curriculum

rather than as insufficient or barriers to learning (McLaughlin & Calabrese Barton, 2013). Additionally, when teachers use students' cultural repertoires of practice to expand what counts as science knowledge and participation, they can transcend settled epistemological expectations of knowing and doing science (Bang et al., 2013; Rosebery et al., 2010). **Equitable interrelationships** can be described as privileging "authentic caring" relationships over scientific knowledge when, for instance, students show up for class angry or disengaged (Rivera Maulucci, 2010). In science education, teachers' **knowledge of issues of equity** surface when they recognize oppressive structures that limit students' of Color access to rigorous and relevant science instruction, and make intentional instructional decisions to reverse that trend (Aikenhead, 1996; Brown et al., 2016). This multi-layered way of conceptualizing equitable responsiveness presents a more holistic picture of what this kind of teaching might look like, and also presents distinct challenges to teachers, to which I turn next.

Challenges. Equitable responsiveness can be difficult for teachers. First, there is tension between valuing students' cultural resources in the classroom without essentializing, or making assumptions about individuals based on group affiliations (Milner, 2010). Second, there is the challenge of teachers' implicit biases towards students of Color and lack of awareness about systemic inequitable structures that inhibit students' access to opportunities (King, 1991). Third, teachers may experience a disconnect between their own cultural resources and those of their students, thus creating a barrier for being responsive (Irvine, 1990). Fourth, urban teachers often feel extra pressures of high-stakes testing which are accompanied by stricter policies about what and how to teach (Sleeter & Carmona, 2016). This can result in teachers thinking of equity as something "extra" to do on top of what is required by strict accountability structures. Finally, there is a psychic toll that can accompany authentic caring leaving teachers at times feeling

powerless or discouraged (Espinosa, 2008; Lortie, 1975). Taken together, these challenges demonstrate some of the complexity faced by teachers who feel a genuine desire to be equitably responsive during their science teaching.

Both disciplinary and equitable responsiveness have associated affordances and challenges, as described above. In the next section, I conclude this chapter by summarizing key points about each type of responsiveness, and considering what a responsive classroom could look like which attends to both disciplinary and equitable aspects.

Responsive Science Classrooms

Equitable and disciplinary responsiveness can be powerful teacher practices in a science classroom. To summarize, disciplinary responsiveness is "an attempt to understand what another is thinking displayed in how a conversational partner builds, questions, probes, clarifies, or takes up that which another has said" (Pierson, 2008, p. 25). In other words, a responsive classroom is one in which the teacher routinely elicits, notices, interprets, and responds to students' ideas and opens students' ideas up to "become the terrain for discussions and investigations" (Maskiewicz & Winters, 2012, p. 433). In this way, the students do most of the intellectual work by engaging with one another's ideas. This necessitates that the teacher refrain from always being the "knowledgeable other," but instead privilege opportunities for students to grapple with their own and others' ideas. Additionally, equitable responsiveness requires an understanding of the historical and "cultural influences on the behaviors and mental ecology of the classroom, and using this knowledge to guide actions" (Gay, 2010, p. 58). Thus, a key aspect of responsiveness is embedded in how one interprets a student's sense-making—for instance, as deficient or productive—and based on that interpretation makes a decision of how to respond. A responsive teacher and classroom can strengthen students' identities in science, create positive classroom

cultures with empowered students, and elicit students' ideas to the benefit of not just the speaker but the whole classroom community (Pierson, 2008).

In this chapter, I defined key constructs for this dissertation and synthesized literature to present my conceptual framework. In the next chapter, I describe how I designed this research project to learn more about two teachers' enactment of disciplinary and equitable responsiveness in their science teaching.

CHAPTER THREE:

Methodology

In this chapter, I describe the methods I used to investigate and answer my research question: How do urban elementary teachers navigate disciplinary and equitable aspects of responsiveness in their science teaching? In particular:

1) What do teachers' enactment of responsiveness look like?
2) What do teachers foreground in their enactment of responsiveness? Why?
3) What aspects of responsiveness seem to come more easily to these teachers and what seems to be more challenging? Why?
4) In what ways and when do disciplinary enactments of responsiveness co-occur with equitable enactments of responsiveness? In what ways and when do they seem to happen independently of one another? Why does this seem to happen?

I begin by describing my study design and context in order to provide an overview of the study. Next I describe my data collection process, including what data I collected and for what purposes, and my methods for analyzing the data. I include several research instruments in the appendices to provide more detail about my methodology.

Study Overview and Context

In this section, I provide an overview of this research study. I begin by describing my research design as a qualitative embedded multiple case study approach. Then, I introduce my two teacher participants and their teaching contexts. I follow this introduction with a statement of my own positionality in this research.

Case Study Design

My dissertation study is an embedded multiple case design (Yin, 2014). I designed the study to investigate my work with, and the practices of, two urban elementary teachers. The work with (professional learning experiences) and the practices of (teacher responsiveness) the

two teachers are the two embedded units of analysis in the design. The professional learning experiences of the teachers fall outside the scope of this dissertation. Data gathered related to teachers' learning will be analyzed in future publications and primarily occurred during the debriefing conversations, which I describe below as context for understanding my findings.

I focus this manuscript on the teachers' responsiveness. The two urban elementary teachers served as two cases, with each being a case of elementary science teaching. In order for students to engage in equitable sense-making, I theorized that teachers must teach in a way that is not only responsive to students' sense-making, but equitably responsive. I was interested in learning what this would look like in practice, and I used the case studies to investigate this phenomenon in two contexts in order to answer my research question.

Participants

I worked with two teachers over the course of my study (Table 3.1). The first of my participants was Hoba, a K-5 science enrichment teacher at Warren Elementary School, a predominantly Arab Muslim traditional public school in a mid-sized industrial city in the upper Midwest United States (an emergent urban school according to Milner's (Milner, 2012) typology). She was a Lebanese-American Muslim woman in her sixth year of teaching who could identify where in the Middle East her students came from based on their accents. Her school was classified as low-income (92% free and reduced lunch) and had a high population of English language learners (87%). Many students were bilingual or emergent bilingual in Arabic and English, and Hoba was also bilingual in Arabic and English. Hoba had a leadership role in her district, creating maps for *NGSS* adoption and sharing her *NGSS* expertise with her colleagues.

My second teacher collaborator was Karen, a first-grade teacher at Independence Charter School (ICS), a bilingual (Spanish and English) charter school serving a largely Latinx population in a post-industrial upper Midwestern city (also emergent urban, according to Milner, 2012). She was a White monolingual woman in her fifth year of teaching, and she did not teach in the bilingual program. Independence Charter School had a high population of English-language learners (90%) and was classified as low-income (98% free and reduced lunch). Karen was one of the founding teachers of this school, and she remained passionate about the school and its mission. Karen took on leadership roles among her colleagues, leading team meetings and mentoring new teachers.

While not a focus of my study, it is noteworthy that students in both schools struggled to pass the state science tests every year (as low as 0% at one school, single digits in another school). The administration in each school was working with teachers to make structural, curricular, and/or instructional changes to improve students' science achievement, as measured by their state tests.

Table 3.1

Teacher Participants

Teacher Pseudonym	Grade	Type of School	School Demographics	Teacher Demographics	Years of Experience
Hoba	K-5 Science	Traditional Public	Arab Muslim, ELL, low-income	Lebanese-American	6
Karen	First Grade	Bilingual Charter	Latinx, ELL, low-income	White	5

As distinct cases, these teachers presented rich diversity for this study. With both schools serving predominantly immigrant student populations from different parts of the world, this study presented interesting opportunities and challenges for teacher participants' responsiveness because their students had a range of resources available to them for science sense-making.

Further, the case of Hoba, whose racialized and cultural background was more closely aligned with many of her students—an unfortunate anomaly in U.S. schools (U.S. Department of Education, 2016)—presented interesting analytical implications. Finally, the schools themselves represented a cross section of urban school structures (traditional public and public charter). These school structures are controversial in U.S. politics today, and they provided interesting contexts for this dissertation.

This dissertation assumes a theoretical replication model in which the researcher predicts different results across cases for particular reasons (Yin, 2014). In particular, for the cases within this work, one might expect Hoba to more readily pick up and/or enact disciplinary aspects of responsiveness because of her position as a science enrichment teacher. One might reasonably expect that Hoba has had more professional development in science teaching pedagogy than Karen. As another example, one might expect Hoba to more readily pick up and/or enact equitable aspects of responsiveness because of her intersecting identities as Lebanese-American, Muslim, and bilingual in Arabic. One might predict that these identities which more closely match her students' than Karen's would better position her to be responsive to students' varied repertoires of practice. Therefore, the two cases in this study provided interesting contexts for investigating the embedded phenomenon of teachers' responsive teaching practices.

Positionality

I am a White bilingual (Spanish/English) researcher interested in equity issues. Karen is White and monolingual, and Hoba is Lebanese-American and bilingual (Arabic/English). All of us are middle-class, cis-gendered, heterosexual, able-bodied women. In this project, I grappled with my own positionality in how I identified and responded to problematic enactments of Whiteness enacted by Karen with whom I worked hard to develop a positive relationship. I also

struggled with how I raced Hoba, whose Lebanese-American ethnicity affords her the classification of White according to the U.S. census, who identified as White growing up in Lebanon, yet she is not perceived as racially White in U.S. society. Hoba no longer self-identifies as White, but rather self-identifies as Arab- or Lebanese-American. The power I have to tell their stories is palpable, and I take great care to tell them with dignity and truth.

I was both an insider and outsider in this project. I was an insider in my work with both teachers because of my past experiences teaching elementary school, and specifically elementary science. I was both an insider and outsider because of my familiarity with their schools. On the one hand, I have taught in traditional public and charter schools, and I have taught similar populations of students to Karen's. On the other hand, I was an outsider because I was not a teacher in their buildings—I was a guest. I was invited in, which required a certain level of trust that the work that we did would be meaningful and purposeful. With Karen, I was an insider as far as understanding what it means to be a White teacher of predominantly students of Color or from lower-income families. Additionally, I am steeped in the same White cultural norms that shape the language and ways of thinking we have about people of Color that we must disrupt. With Hoba, I was an outsider since I did not share a cultural background or history with her or her students. Instead, Hoba patiently worked with me to help me better understand her experiences in this country and in her school.

Prior to engaging in this dissertation study, I worked for three years researching equitable sense-making and teacher responsiveness. Thus, I brought particular experiences, expertise, and a theoretical lens to the project with a broad goal of shifting science instructional practices towards being more rigorous and responsive. However, I did not enter this study with a singular vision of what responsive teaching might look like. In fact, I remain critical of some of my

former teaching practices and the ways in which my deficit perspectives as a White teacher of predominantly students of Color inevitably harmed some of my students as a result of unexamined micro-aggressions or biased decisions. For example, I wrote too many office referrals for students in my science classes who I interpreted as distracting their peers from learning without taking time to develop a depth of understanding of their histories and experiences in schooling which prompted the disturbances in the first place. While I know that some of my students developed an interest in science and science-related careers, I remain critical of my teaching practices for not being consistently responsive to students' contributions in science class and wonder how many students were turned off to science as a result. Therefore, my study aimed to translate theory into practice, rather than replicating my own past teaching practices. Thus, I entered the study prepared to learn alongside my teacher participants as we explored what responsiveness might look like.

Later in this chapter, I explore how the work unfolded with each teacher participant. First, I turn to the data I gathered across cases.

Data Collection and Analysis

In this section, I describe my data collection and analysis process. I begin by describing the central features of the study design, including the pre- and post- interviews, and lesson observations and debriefs. I then profile each case study teacher, describing how we entered into partnership together and the data I gathered from each one. Finally, I describe my process of analyzing data for this study.

Pre-and Post-Interviews

I conducted and audio-recorded two semi-structured interviews (Glesne, 2011) with each participant prior to and after participation in the study (Appendix A). Prior to the study, I asked

questions about the teachers' students and their familiarity with the study's constructs in order to learn more about the teachers' contexts and determine a baseline of their knowledge about the study. These questions included:

- What do you appreciate about your students?
- What do you know about some of your students' families?
- What is unique or special about your school?
- What are 3-5 words that describe your teaching?
- How would you describe your approach to teaching science? Examples?
- What do you do when a student says something that you think is completely wrong?
- How do you think about being responsive in a disciplinary way, that is, to students' science ideas?

With this set of questions, I learned more about how each teacher approached science and science teaching, how they engaged with students in their class, and what ideas they had about responsiveness before beginning the study.

Following the pre-interview, I engaged each teacher in conversations about the study constructs and logistics. In these audio-recorded conversations, we talked through our ideas about student sense-making, responsive teaching, and issues of equity. I organized these conversations by beginning with definitions and examples that I had been working with, and then I offered opportunities to each teacher to respond with how they think about these constructs in their own classrooms or from their worldviews. Finally, we talked through study logistics, including writing down our research goals for the project, our responsibilities in completing the work, and putting dates on the calendar for my classroom visits and debriefs.

After the study, I prompted teachers to reflect on their learning experiences from this work, what aspects of the experience supported their teaching and why, and what remained challenging to them. These questions included:

- Did you meet your goals for this study?
- What is important to you about your science teaching?
- How do you see science as valuable or relevant to your students' lives right now?

With these questions, I gained a sense of how each teacher benefitted from participating in this research project and their reflections on their responsiveness at the culmination of the project. The post-interview was also audio-recorded.

Lesson Observations and Debriefs

I balanced a participant-observer role in the field (Glesne, 2011) when I visited the teachers' classrooms. My primary engagement with each teacher was to observe her science lessons and debrief about the lesson afterwards. With Karen, I additionally co-planned the unit that she taught through the course of this study (per her request). I audio-recorded the co-planning conversations for analysis. In these initial conversations, Karen's responsiveness looked like embedding opportunities for students to share and revise their ideas throughout the unit, and her knowledge of equity issues as expressed in response to topics such as meritocracy.

Table 3.2

Timeline for Data Collection

Timeline	Data Collected
Before Classroom Observations	Audio-recorded semi-structured interview Audio-recorded conversation about study construct Audio-recorded conversation about study logistics
Before and During Classroom Observations	Audio-recorded conversation to co-plan science unit (with Karen)

Table 3.2 (cont'd)

During Classroom Observations	Video-recorded science lessons Audio-recorded debriefing sessions Student work samples
Daily	Field notes
After Classroom Observations	Audio-recorded semi-structured interview

Lesson observations. I video-recorded teachers' science lessons over several weeks. I occasionally intervened to model disciplinary or equitable responsiveness, at other times I circulated through student groups as they engaged in science activities, and at other times I recorded field notes (Emerson, Fretz, & Shaw, 1995). I compiled notes for future coding as I worked to understand how teachers enacted disciplinary and equitable responsiveness. Responsiveness in the video-recordings sometimes looked like teachers noticing and responding to student sense-making in a way that both centered student thinking and disrupted normative power structures privileging particular voices.

Lesson debriefs. The teachers and I met after science lessons to debrief. We used a Reflection Tool to guide our conversation (Appendix B). The Reflection Tool prompts for what students were working on in their thinking and what the teacher did to support sense-making. We referred to the classroom video and student work samples during these conversations. In preparation for the debriefing conversations, I selected segments of video to watch. Teachers sometimes selected which student work samples to focus on. In addition to learning from teachers about their perspectives on the science lessons, I also provided feedback to teachers on their disciplinary and equitable responsiveness. We also talked about what teachers might do next with their science instruction. I acted as a thought partner as we deliberated possible next steps and role played possible teaching scenarios. I analyzed recordings of the debriefing sessions in order to better understand how teachers talked about their enactment of

responsiveness. Additionally, I digitally collected student work samples as evidence of student sense-making (see Appendix C for my protocols for the debriefing conversations). Responsiveness in the debriefs sometimes looked like the teacher deciding whose model to spotlight the next day based not only on the ideas presented on the model, but also on the frequency with which the student is positioned as having expertise in the classroom.

In the following two sections, I provide more specific information on each teacher. I share how I entered into a partnership with each teacher and what data I gathered from each case.

Background Information and Data from Hoba's Case

Hoba and I began working together in the fall of 2016 after she reached out for support in her new position as science enrichment teacher. Hoba and I met multiple times throughout 2016-2017 as we got to know one another. I learned that she wanted more curricular materials as well as more manipulatives for teaching science. So, I used funding from a small grant to put together a shopping list with Hoba of materials for her science classroom (including items such as a small weather station and a small stream table). I also met with her to co-plan a science unit, using an inquiry-based instructional model and colorful sticky notes to organize and rearrange our ideas. She referred back to the sticky notes a year later in one of our conversations for this study:

> **Hoba**: I'm going to use stickies. Because somebody taught me how to use stickies, remember?
> **Christa**: Oh, did somebody teach that to you? [laughing]
> **Hoba**: Remember that? [laughing]
> **Christa**: I do remember that. That's perfect.

This brief preview of findings illustrates the familiarity that Hoba and I had upon entering into this project together. This familiarity was indicative of the strength of our partnership after a year of collaborating.

In addition to material resources, I also connected Hoba to Jessica Thompson's research group at the University of Washington to participate in their K-2 Modeling Lab. Hoba recruited several K-2 teacher colleagues at her school, and she and I co-facilitated Thompson's 10-week professional development (PD) in the fall and winter of 2017-2018. This PD walked teachers through a 4-day mini-unit with their students during which they engaged students in creating and revising scientific models explaining the disappearance of a puddle. During the PD, teachers debriefed their experiences of engaging with students' sense-making through scientific modeling. Since Hoba's school is a long drive from my home, I mostly took care of the online portions of the modules while Hoba led the weekly meetings with teachers in her classroom.

Once the Modeling Lab completed, Hoba and I began this study together, already having a sense of each other personally and professionally. We decided that I would follow three of her third-grade classes: Ms. Flores's, Ms. Bilko's, and Ms. Vaughn's. During the first few weeks of our time together (see Table 3.3), we were unexpectedly waiting on Hoba's school district to grant us IRB approval. While waiting, I visited Hoba's classroom informally and began getting to know her students without a video recorder or notebook in front of me. After receiving approval, we rescheduled two debriefing conversations to occur later in the study since I did not yet have consent or assent from students to begin classroom observations.

Table 3.3

Hoba's Project Schedule

2018	Monday	Tues	Wednesday	Thursday	Fri
Week 1 Feb 26- Mar 2	~~Lesson Observation (Ms. Vaughn's Class)~~ Informal Visit – pre-district approval		~~Lesson Observation (Ms. Flores & Ms. Bilko's Classes)~~ Informal Visit – pre-district approval		
Mar 5-9	University Spring Break				

Table 3.3 (cont'd)

Mar 12-16	NARST/NSTA			Received Notice of District IRB Approval	
Week 2 Mar 19-23	~~Lesson Observation (Ms. Vaughn's Class)~~ Informal Visit – pre-consent/assent ~~Lesson Debrief (Vaughn)~~ Rescheduled due to lack of consent/assent		~~Lesson Observation (Ms. Flores & Ms. Bilko's Classes)~~ Informal Visit – pre-consent/assent ~~Lesson Debrief (Flores & Bilko)~~ Rescheduled due to lack of consent/assent		
Week 3 Mar 26-30	~~Lesson Observation (Ms. Vaughn's Class)~~ Informal Visit – pre-consent/assent		Lesson Observations (Ms. Flores & Ms. Bilko's Classes)		
Apr 2-6	Dawson Spring Break				
Week 4 Apr 9-13	Lesson Observation & Debrief (Ms. Vaughn's Class)		Lesson Observation & Debrief (Ms. Flores' Class) ~~Lesson Observation & Debrief (Ms. Bilko's Class)~~ Cancelled due to testing		
Apr 16-20	AERA				
Week 5 Apr 23-27	Lesson Observation & Debrief (Ms. Vaughn's Class)		Lesson Observations & Debrief (Ms. Flores & Ms. Bilko's Classes)		
Week 6 Apr 30-May 4	Lesson Observation & Debrief (Ms. Vaughn's Class)		Lesson Observations (Ms. Flores & Ms. Bilko's Classes)	Lesson Debrief (Flores & Bilko)	
Week 7 May 7-11	Lesson Observation (Ms. Vaughn's Class)		Lesson Observation (Ms. Bilko's Class) ~~Lesson Observation (Ms. Flores' Class)~~ Cancelled due to testing		

Note. Items in black font were originally scheduled. Yellow highlighted text shows cancellations. Blue highlighted text shows the modified schedule due to delayed district IRB approval. Bold outline shows complete lesson observations and debriefs.

My initial goal was to debrief after nine science lessons, approximately every other week, for a total of about three of our seven weeks. This was cut down to six debriefs instead because I observed two third grade lessons each Wednesday, and it made more sense to debrief after both of them rather than debrief after each one. Table 3.4 displays the data I gathered from Hoba's case.

Background Information and Data from Karen's Case

Karen and I began working together in the fall of 2016. Similarly to Hoba, we did some co-planning, I secured some science teaching materials for her classroom with a small grant, and I connected her with the same professional development on teaching with scientific models for K-2 teachers.

Karen and I began our work together on this project as I wrapped up with Hoba, taking advantage of Karen's extended school year, and working into ICS's second to last week of school (Table 3.4). We had several unplanned events occur during our time together which are indicated in green highlighting in Table 3.4. Karen was interested in using me as a resource to help plan her final unit on space science, so we added additional recorded conversations early in our work together as we co-planned for future lessons. By the end of our work together, we decided to write a *Science and Children* article on formative assessments, so we added in time to plan for that. Additionally, Scott (Karen's principal) wanted Karen to lead a professional development with her colleagues over the summer, so we also scheduled an additional meeting at the end of our time together to plan for her PD. Finally, during our last week together, Karen was planning on starting a mini engineering unit on bubbles, but I was unable to observe it because of excessive heat and end-of-year activities.

Table 3.4

Karen's Project Schedule

2018	Monday	Tuesday	Wednesday	Thurs	Friday
Week 1 May 7-11	Lesson Observation	~~Lesson Observation~~ Cancelled due to last-minute meeting	Lesson Observation		No School
Week 2 May 14-18	Lesson Observation & Co-Planning Meeting	Lesson Observation & Co-Planning Meeting	Lesson Observation & Co-Planning Meeting		
Week 3 May 21-25	Lesson Observation, Debrief, & Co-Planning	Lesson Observation, Debrief, & Co-Planning	Lesson Observation, Debrief, & Co-Planning		
Week 4 May 28-June 1	No School	Lesson Observation, Debrief, & Co-Planning	Lesson Observation, Debrief, & Co-Planning		
Week 5 June 4-8	Lesson Observation, Debrief, & Co-Planning	Lesson Observation, Debrief, & Co-Planning	Lesson Observation, Debrief, & Co-Planning		
Week 6 June 11-15	Lesson Observation & Article Planning Meeting (not audio-recorded)	Lesson Observation & PD Planning Meeting	Lesson Observation		
Week 7 June 18-22	~~Lesson Observation~~ Cancelled due to heat day	Lesson Observation No science taught	~~Lesson Observation~~ Cancelled due to power outage		

Note. Items in black font were originally scheduled. Yellow highlighted text shows cancellations. Green highlighted text shows additions. Bold outline shows complete lesson observations and debriefs.

As with Hoba, my initial goal was to debrief after nine science lessons. We scheduled eight debriefs because of a school holiday. However, as I described above, we had other recorded conversations in addition to the planned debriefings. Table 3.4 displays the data I gathered from Karen's case.

Data Analysis

In this section, I describe the stages of data analysis I used as I worked through my corpus of data to answer my research questions.

I analyzed data by first conducting open coding on my field notes while asking questions of my data, in order to identify initial themes and patterns (Emerson et al., 1995). For example:

- When did I note moments of disciplinary responsiveness, and when did I note moments of equitable responsiveness?
- In what ways did these notations surface in my field notes? As references to teacher moves? To instructional events? To relational events? To dialogue between the teacher and me?

While engaging in this process, I wrote memos about each teacher and about particular events (Emerson et al., 1995). From the initial descriptive codes (Saldaña, 2016), I began developing a codebook which I organized according to themes related to my conceptual framework. I clustered the codes according to patterns within the themes. These themes and codes included items such as those in Table 3.5 (see Appendix D for a more detailed version of salient codes from the codebook).

Table 3.5

Initial Codebook

Themes	Parent Codes	Child Codes
Teacher Characteristics	Others' perceptions	
	Values	Perceptions/stances of/around Equity
		Perceptions of Science
		Perceptions of own teaching
	Life Outside of School	Family/Home Circumstances
		Personal Health
	Logistical Info	
Teacher-Student Relationships	Moves by T or S affecting their relationship	Building
		Damaging
	Knowledge of Students	Assumptions
		Familiarity
		Expectations
	Values around relationships	
	Feelings towards students	Caring
		Disdain

Table 3.5 (cont'd)

Teaching Pedagogy	Voice/Choice or Student Talk	
	Responsiveness	Disciplinary
		Equitable
		Both
		Neither
	Sense-Making Opportunities	Missed
		Landed
Teaching Context	Colleagues	Teachers
		Administrators
		Staff
	Other school obligations	
	Social Capital	Empowerment
		Social Network
		Positioning
	School culture/climate	

Next I used MaxQDA software to code transcriptions of audio files and my field notes. I used a combination of codes from my codebook to capture patterns across cases as well as in vivo codes (Saldaña, 2016) to capture patterns within cases. Two examples of in vivo codes were "no more spoon feeding" and "tight-knit group." These in vivo codes were useful indicators of teachers' goals and values because they were phrases they repeated frequently in the transcripts.

During this stage of analysis, I also created data displays (Miles & Huberman, 1994) to visually organize data for each teacher into a timeline. I organized data about when I observed science lessons and what content was covered in each lesson, when I debriefed lessons with teachers, when meetings were cancelled or rescheduled and for what reasons, and so on. I used these data displays to track teachers' progress over time and to account for the data I gathered.

I also used this stage of coding to consider which moments from classroom instruction in each case would be valuable for pursuing a close analysis. One set of codes from my codebook was to identify disciplinary and/or equitable responsiveness (or neither). In my field notes and transcripts, I coded moments of reflection or discourse around classroom instruction that could

be coded with one of the responsiveness codes. I used text assigned with these codes to identify moments to analyze in the videos. These video moments were illustrative examples of disciplinary and/or equitable responsiveness.

I transcribed these moments of science lessons and engaged in analytic inductive analysis, considering the nature of the interactions visible in the dialogue and videos (Saldaña, 2016). From the videos, I identified patterns of teacher moves as evidence of disciplinary or equitable responsiveness. I determined this based on the ways in which opportunities were presented to students to engage in sense-making, teachers fostered relationships with students, or curriculum was designed with students' lived experiences in mind. I developed narratives around these moments which are shared in the findings chapters with each case study.

Finally, I began writing a report of each case study. This was an iterative process of moving back and forth between transcripts, secondary data sources (student work samples, anchor charts, videos), codes, memos, literature in the field, and my writing. This process continuously shaped and revised my understanding of each case. I then distilled the content of each report into what appeared to me to be the most salient aspects of each case in order to investigate the central phenomenon of this study: the nature of each teacher's responsive science teaching.

Limitation

A primary limitation of this study design is the absence of students' experiences in and perspectives on this work. I collected some data about students' sense-making that was visible in their science talk in classroom videos as well as in their student work artifacts. However, in-depth student interviews to learn more about their lived experiences both in and outside of school, as well as their perceptions of their teachers' science teaching, were not a focus of my

study. Instead, I relied on participating teachers' understanding of their students' lived experiences, which is not fully reliable, and on my informal interactions and conversations with students, which was not well documented outside of my field notes. I believe the collection of student data and incorporation of students' voice will be important additions to this kind of research in the future, by me or other scholars.

CHAPTER FOUR:

Hoba’s Case Study

Elementary science teaching and learning are often activity-based and do not engage students in rich sense-making. Elementary science is not always equitable either—in part due to the lack of students' scientific sense-making and in part due to other factors, such as oppressive relationships with students. Engaging students in disciplinary and equitable sense-making is critical, especially for students from historically marginalized backgrounds who are less often positioned as knowers and doers of science.

In this first of two findings chapters, I profile Hoba's case. Despite the sheer quantity of K-5 students that Hoba taught each week, she strove to develop equitable, anti-oppressive relationships with as many students as possible. She also worked hard to design science lessons that were responsive to students' lived experiences and sense-making. I use this chapter to consider *why* Hoba foregrounded building relationships with students, and *how* she designed responsive science lessons.

I organize Hoba's chapter as follows. First, I introduce Hoba and her students. Next, I present findings on Hoba's disciplinary responsiveness by sharing a narrative from her classroom teaching. Finally, I present findings on Hoba's equitable responsiveness by sharing additional narratives from her teaching as well as data demonstrating her knowledge of issues of equity.

Introducing Hoba

During our time working and getting to know each other, Hoba shared a lot of information with me about her story, her students' stories, and the geo-political dynamics impacting her and her students' community. The information and data I share here and throughout this chapter represent Hoba's telling of these stories to the best of my ability to capture her words, ideas, and experiences. In this section, I introduce Hoba and her teaching context.

Hoba grew up in Lebanon, moved with her family to the United Kingdom for secondary school, and then moved to the United States to pursue higher education, right around the time of 9/11. Here in the United States, Hoba met her Lebanese-American husband who was born in the United States, and she settled down to raise her family of three young boys. Hoba was the K-5 science enrichment teacher at her school. She saw every class in the building (there are about four classes per grade level) once each week for 45 minutes. Hoba had her own science classroom, and teachers brought their classes to her, just like they brought students to art and music. The difference was that these teachers also taught science in the classroom. Hoba's instruction was meant to be an enrichment to provide students with extra science instruction in an effort to increase their science literacy and achievement. This was in part a response to students' test scores in 2016 showing only 6% of students meeting the state science standards, compared to 20% state-wide.

After receiving her teaching certificate, Hoba spent the first two years of her career teaching elementary school at a private concept-based teaching school. Concept-based teaching emphasizes teaching big ideas to students in an interdisciplinary way, allowing students opportunities to figure out concepts through hands-on authentic experiences and discussions, rather than learning out of textbooks and worksheets. However, "it was very mentally draining because there wasn't curriculum for it or materials. It was all on the teacher. Not enough training. I felt like, I don't want to quit teaching, but I needed to find a place that had better resources."

Even though Hoba left this school after just two years, this method of teaching had an impact on Hoba's teaching pedagogy. She saw the "sheltered strategies" she was trained in for ELL students as well as the shifts with the *Next Generation Science Standards* as fitting well

with this kind of pedagogical approach towards teaching concepts. After her time at the private school, Hoba entered the Dawson Public School system first as a long-term substitute teacher in middle-school science, and then as a second grade teacher in her current school, Warren Elementary School. Then, the principal created a science enrichment teacher position, and he asked Hoba to fill that role. Hoba accepted, and during the time of this study, she was in her second year in that position, and she was finishing her master's degree in English for Speakers of Other Languages.

The majority of students in Hoba's school are emergent bilingual students who speak Arabic at home and whose families are from throughout the Middle East—including Syria, Iraq, and Sudan. The majority of students in Hoba's school are also Muslim, like Hoba, with many recent refugees from the conflicts in Syria and Yemen, as well as many students whose families emigrated from other places in the Middle East and/or immigrated to the U.S. decades ago.

While around half of the teachers in Hoba's school are Arab American and half are White non-Arabs, Hoba's story is different from the majority of the teachers in the United States who are White, non-Arab, monolingual women. Hoba's background in some ways more closely aligned with the backgrounds of many of her students. This similarity seemed to help Hoba better relate to her students than her White colleagues were able to relate to students, a point I return to in greater detail later in the chapter. First, I present findings on Hoba's disciplinary responsiveness.

Hoba's Disciplinary Responsiveness

In order to illustrate Hoba's disciplinary responsiveness, I begin with a classroom narrative called Squirrel Graphs which took place over two lessons in two weeks. I use this

narrative to highlight moves that Hoba made to be responsive to students' sense-making about bar graphs.

Squirrel Graphs: A Classroom Narrative

In the following narrative, it is important to attend to the moves that Hoba made as she worked towards centering students' ideas in discussions about graphing. I chose this story to share as a narrative because at first Hoba exercised more epistemic authority than she needed to as she funneled students' ideas towards particular ideas. Then, after she and I debriefed the lesson, Hoba changed her original plans for the lesson in order to be responsive to students' sense-making. In so doing, Hoba managed to share more epistemic authority with her students and co-construct the science storyline. Thus, this narrative not only shows evidence of Hoba's responsiveness through a disciplinary lens, it also shows contrasting evidence of moves that were not disciplinarily responsive.

Students began their Animal Adaptations unit by sorting different types of animals into their different habitats, and they were introduced to the concept of adaptations. Next, Hoba introduced the concept of camouflage as an example of an adaptation, based on conversations her students were having about their video games "and how they camouflaged so they wouldn't get killed. And so I wanted to bring camouflage in in a different way." Finally, students conducted an investigation at home in which they tracked how many black, brown, and gray squirrels they saw around their homes and whether the squirrels were in the shade or the sun. Students were asked to consider whether there is "a correlation between the animal color (black squirrels and gray squirrels) and the environment that they live in."

Back in class, on April 25, students were tasked with graphing their data with a partner. With Ms. Bilko's class, one of the three third grade classes I followed with this research, Hoba

began by modeling for students how to set up their graphs, combine their data, and draw the bars. She paired up with a student named AJ, asking him to help her teach the class about what they were going to do with their graphs, positioning him as her "co-teacher." I am highlighting Hoba's relationship with AJ in this narrative in order to draw conclusions later in this chapter about Hoba's interactions with students. AJ is a student whom teachers had deemed a "troublemaker" (Shalaby, 2017); or rather, a student who did not follow the norms and routines of school and whom Shalaby would argue is a canary in the coal mine of the oppressive nature of schooling for children. I argue that Hoba's interactions with AJ are different in important ways from how teachers might more typically interact with their troublemakers.

As AJ and Hoba graphed their data on the digital document projector (the "Elmo"), they got to a data point (14 brown squirrels) that would have extended beyond the limits of the graph (which was 10 on the y-axis; see sample graph in Figure 4.1).

Number of Squirrels

10						
9						
8						
7						
6						
5						
4						
3						
2						
1						
	Gray	Black	Brown			

Figure 4.1. A reproduction of the graph that Hoba and AJ were constructing.

> **Hoba**: Oh, we have a problem. Show me how you're going to graph that now. [AJ looks down at data sheet and bar graph.]
> **AJ**: Uh oh....
> **Hoba**: Uh oh, what's uh oh for?

AJ: How are we gonna do it? We don't even have 14 boxes. Oh! You can do it here! [pointing to the column to the right of the Brown column] You can do it here on the empty one. You can do it on the empty one.
Hoba: Do you think it will work?

Hoba was skeptical about AJ's idea to use the empty boxes next to the Brown column for the extra data, so she asked the class if they thought it would work. Students responded with a mix of "yes" and "no." Then a student called out to make extra boxes, and Hoba responded, "Here, I heard a solution. Let's make extra boxes." To AJ, she asked, "What do you think?" AJ shrugged his shoulders, said "okay," and got to work filling in the column from the top.

Hoba: [AJ starts graphing, holding the marker at the top of the graph] Nooo.... So, start from the bottom, and then we can work our way up. How does that sound? So- oh, no, no, no. Start- no. No. Hold on. [turns to face class] Who in this class thinks starting from the bottom is better?
Students: No! The top!
Hoba: Are our numbers going up or going down?
Students: Up!
AJ: Yeah, you told me to go down.
Hoba: No, I- this is what I meant. I said start shading here. Let's see 1, 2, 3. So you see how I have those lines? Yeah, that's what I want you to do.

As this moment was proceeding, I wrote in my field notes that students were sense-making about graphing, and how interesting it would be to probe students' thinking about how this graph was making sense to them. As soon as I finished writing down that thought, Hoba picked up a similar train of thought:

Hoba: So I have a question for you guys. Do we add our boxes on the bottom?
Students: [Mostly "no" some "yes"]
Hoba: No. Why?
Student: Because we won't- oh, I forgot what I was going to say.
Hoba: Ok, I'll come back to you. Nabila.
Nabila: Because you're not even adding, you're just subtracting.
Hoba: Because under the bar the numbers are going down. And above, the numbers are going up.
Student: So it's going to be negative one if you go down!
Hoba: It's like negative one. All right.
AJ: I'm the teacher, so I want $100 for work!

The final comment made by AJ received laughter from his classmates and from Hoba, as it appeared was his goal. Over the weeks I observed this class, I frequently observed AJ behaving in similar ways to get others to laugh with him. His light-heartedness was often endearing, though I imagine for teachers it could also be frustrating sometimes. Later in this chapter, I return to AJ's story. For now, I focus on how students were trying to make sense of how the numbers were working in the bar graph, and how they represented data. AJ wanted to start shading from the top, because he had heard Hoba and a classmate suggest adding boxes to the top. As AJ started shading from the bottom, Hoba began probing students' reasoning to ask what it would mean to add boxes to the bottom. Two students reasoned that this would mean subtracting, or getting into negative numbers. Even though Hoba asked students for their reasoning, which was a move that was responsive to students' sense-making, she also made definitive moves during the lesson to indicate which ideas she agreed with and were correct. After this point in the lesson, students went to tables with their partners and graphed their data (Figure 4.2).

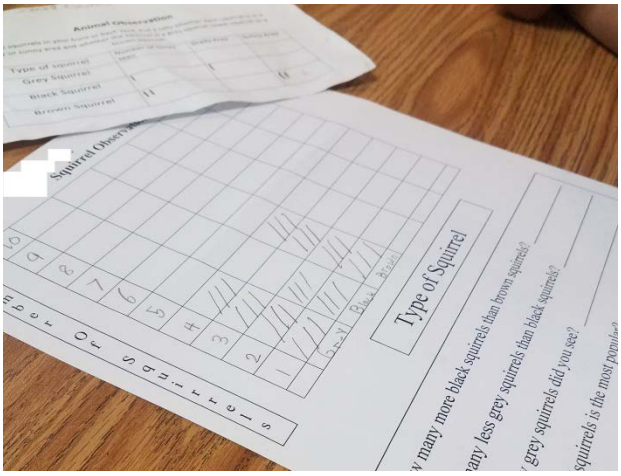


Figure 4.2. One group's graphing worksheet.

Right after this class, Hoba taught this same lesson to her next third-grade class, and those students shared similar ideas about bar graphs. In our debriefing after both lessons, Hoba

and I chatted about students' sense-making, and we agreed that next week, instead of moving on to interpret the data, it might be interesting to have students dig into their sense-making about the graphs themselves some more. We both agreed that, in Hoba's words, "students had different ideas about the ways to make a bar graph" and we wanted to do more to support their thinking about graphing. So, we co-planned a lesson that would present students with graphs depicting the same data, but were filled in differently (some with the "empty" columns filled in, some with data filled in below the bottom, and some completed correctly). We wanted students to consider how the data was displayed differently in each of these cases and which one seemed the clearest to them, rather than simply believing Hoba about what the right way was. In other words, we wanted to redistribute epistemic authority away from primarily Hoba in order to allow students to take up some authority in the classroom as science knowers and doers.

The next week on May 2, in their small groups, students compared and contrasted three different graphs created by their peers, and then they came together to talk about how the data was displayed in each one. The conversation sparked by the second graph that Hoba discussed with the whole class (Figure 4.3) engaged the class in rich sense-making.

As students sat on the carpet (Figure 4.4), AJ took his position as "co-teacher" again behind Hoba's desk. Hoba did not invite him to do so again like she did the week prior, but she went along with it. Hoba asked the class, "What do you guys see here?" The first student suggested that the extra bar on the right side of the graph was wrong and should be on top of the brown squirrel bar. When Hoba asked how many students agreed with her, most students raised their hands, but a handful of students had a different opinion.

Number of Squirrels

11						
10						
9						
8						
7						
6						
5						
4						
3						
2						
1						

Below this graph, on the Elmo, Hoba had the following data displayed:

Grey	Black	Brown
3	5	12

Figure 4.3. A reproduction of the graph projected on the screen.

Figure 4.4. A screenshot from the video during the class discussion.

The first student with a different opinion pointed out that the number 1 should not be on the bottom of the graph like it was. He pointed to the second row in the graph and started counting from there along the y-axis, 1 to 10. Hoba revoiced his idea as all the students followed

along on the board. Then, another student Zack said, “I have a different opinion.” Hoba replied, “Okay, what do you think?”

> **Zack**: [approaches board] They shouldn't have put it here [pointing to what the first student said was the extra bar] because that's where you put the name, and then they won't know if it's for brown, or if it's for black, or if it's for gray. And then they (indecipherable) the whole thing and get zero.
> **Hoba**: So this here on the bottom should only be for putting the names? (**Student**: Yeah) Can I put a zero in there?
> **Students**: [Students call out, “Yeah,” “no,” “maybe,” several students start talking]

Here Zack reasoned that without labels at the base of the bars in the graph, it was not clear what each bar was supposed to represent. Before he finished his comment, though, he introduced an idea about zero, which launched a five-minute discussion about whether to put a zero on the graph, and where it would belong.

Hoba went back and forth with multiple students to try to figure this out. For instance, when Zack motioned on the board where to draw a box and said, “Yeah, chik, chik, chik, and put a zero,” Hoba responded, “Okay, chik, chik, chik here?” She also asked clarifying questions like “on the bottom or on the top?” She voiced confusion in the interest of gaining clarity by saying, “Okay, I’m a little confused. I’m confused by telling me to put these boxes on the bottom. So you told me to….” Zack continued trying to explain before Hoba extended the discussion to the whole class:

> **Hoba**: So, hold on. Zero on the bottom here. How many of you agree? [a few hands up] No? No? Okay, why shouldn't? It's okay [Zack is pretending to be upset about students disagreeing with him.] Why I shouldn't put a zero down here?
> **Student**: Because it won't make sense.
> **Student**: [stands up and point to graph] Because you don't have to do, just do 1, 2, 3, all the way to 11. You don't have to do with the zero like what Aamin said.
> **Hoba**: So, I don't need to put the zero down here? (**Student**: No) Okay.

In this way, Hoba brought in more students to the discussion to sense-make together around Zack’s idea.

AJ was still standing behind Hoba's desk, but this week he was not as actively engaged in the lesson. At one point, he picked up Hoba's phone, jokingly pretending to dial. Hoba responded with laughter in her voice, "Okay, if you try to do that, it will ring to Mr. Harrison's office. Stop doing that." Next AJ started looking at Hoba's email which was open on her computer monitor on her desk. Again, Hoba responded with laughter in her voice:

> **Hoba**: What are you doing in my emails? Get out of there!
> **AJ**: Please!
> **Hoba**: What are you reading? Ha!

After these interruptions, Hoba brought the class's attention back to the topic for a new student's voice to be heard.

> **Asia**: I think that- I disagree because then that's supposed to be for there [pointing to the lowest bar] And this should be for zero, 1, 2, 3, 4, 5, 6, 7, 8, 9, and then- I mean 8, 9, 10, and then here [pointing to smallest bar to the right] 11 and then 12.

Asia suggested a solution for counting along the y-axis starting with zero, and then she returned to the original idea that the 11 and 12 should go to the right to capture the extra data for brown squirrels. Hoba asked students if they agreed or disagreed, and while there were mixed opinions, most students disagreed. One student suggested that it would look like it was another set of data (for "brown chickens" as a second student suggested), while a third student suggested it would "look like you messed up."

At this point in the lesson, AJ was increasing his efforts at making his classmates laugh, saying "I wanna learn some education!...Why are you guys laughing?...I wanna say one thing! Guys! I wanna ask you a question!" Hoba decided this was enough, and knowing he still considered himself her co-teacher, she played along and said, "AJ? You're fired. Go sit down, right now." The class enjoyed some back and forth trying to figure out who would be selected as the next co-teacher as Hoba put her head on her hands with a smile on her face which suggested

she was repressing a laugh. Then, after Asia's contribution, as students were deliberating their ideas, Zack pointed to a classmate and told him that he agreed with him but didn't want to "because I don't like you to get smart." Most of the class giggled at this comment, including the student at whom Zack was pointing, but Hoba decided to wrap up two minutes early to talk about the class's behavior before dismissing them from science. The class did not get to a point of resolution on their ideas about where to put the zero, if anywhere, or what to do about the extra data.

Characterizing Hoba's Disciplinary Responsiveness

Hoba made several moves during the Squirrel Graphs narrative that are evidence of being responsive to students' disciplinary ideas. In this section, I describe those moves while also drawing on literature that is supportive of identifying them as responsive. I synthesize these moves into two main categories: being flexible with her plans and sharing epistemic authority with students.

Hoba elicited and responded meaningfully to students' science ideas, especially during the second part of the Squirrel Graphs narrative. In doing so, she positioned students' ideas and thinking as central to the sense-making discussion in the classroom. Traditionally, epistemic authority—that is, "the degree to which the participant is evaluated, acts, or is treated as a credible source of" what counts as knowing (Engle, Langer-Osuna, & de Royston, 2014, p. 252)—lies in the teacher or a textbook wherein correct answers can be found (Thompson et al., 2016). When students' ideas and thinking become central to sense-making discussions, the storyline of the lesson or unit can become co-constructed, and some amount of epistemic authority moves from the teacher to students who collectively work on figuring something out about science (Haverly et al., 2018). In the first lesson described in the Squirrel Graphs narrative,

as Hoba and AJ constructed their initial graph, Hoba maintained epistemic authority for herself. While there was some class discussion about what to do, and while Hoba leveraged ideas from a few students, she did not provide students with many opportunities to work through those ideas before determining which idea to move ahead with (adding more boxes to the top) and the proper way of completing the graph (from the bottom). She did, however, circle back to students' ideas and spent a little time probing student thinking about how best to complete the graph and why.

It turned out that students in her other third-grade classes had similar ideas and disagreements about graphs. So, Hoba and I decided to, in Hoba's words, "kind of move it away a little bit from, 'why do squirrels have different color fur?' to just helping them better understand what the graphing process is." Hoba felt that her job as the science enrichment teacher was to find ways of enriching, or adding onto, teachers' regular instruction rather than taking the place of it. Since two of the NGSS Science and Engineering Practices are related to math and graphing, Hoba and I decided that spending more time the next week sense-making about graphs would be time well spent on these science practices as well as a way to enrich instruction that was already happening in classrooms.

As a result of this decision, several important interactions happened during the 10-minute whole-group discussion at the end of the second Squirrel Graphs lesson. Students worked through their ideas about where to put extra data, where to start the bars at the bottom of the graphs, and whether or not (and where) to put a zero along the y-axis. In doing so, they considered such factors as audience (who is reading and interpreting the graph? How are they making sense of it?), number sense (if data is plotted below the x-axis, is that a negative number? How does the placement of the zero complicate how we understand the location of negative numbers?), and clarity of data presentation (extending data above the graph looks wrong, but so

does putting the extra data to the side). These moves made by students were their attempts at making sense of science data they and their peers had gathered and graphed; in other words, they were engaged in sense-making about graphing scientific data. Hoba made several moves throughout the discussion to foster this kind of sense-making, including asking who agreed or had different opinions, marking students' ideas on the paper which was projected on the Elmo, revoicing students' ideas to be sure she understood, and allowing many students in the class opportunities to voice their ideas and express their agreement or disagreement with reasoning.

To summarize, Hoba (1) decided (with guidance from me) to modify her plans and revisit students' ideas about graphs, and (2) shared epistemic authority with students as they collectively grappled with figuring out how to best represent their data on the bar graphs. These moves (Table 4.1) are illustrative of disciplinary responsiveness in that Hoba repeatedly centered students' ideas and voices, providing students with multiple opportunities to work with and on their own ideas, and thereby sharing epistemic authority with students.

Table 4.1

Hoba's Disciplinary Responsiveness Moves

Responsive Moves	Examples from Narratives
Deviating from plans	Hoba shifted focus from squirrel fur color to representing data on bar graphs.
Sharing epistemic authority	Hoba gave students opportunities to grapple with their ideas about how best to represent data in the bar graphs and why.

Hoba's Equitable Responsiveness

Arguably, Hoba's practices described above as disciplinary are also equitable practices. Her sharing of epistemic authority with students, and her ability—with guidance—to be flexible with her plans in order to do so, were important moves towards expansive equitable responsiveness. This is because traditional science teaching maintains authority with the teacher

or texts, and students do not typically have opportunities to engage in more authentic inquiry as they move along with a teacher's plans. Traditional science teaching reifies existing inequitable hierarchies as students with opportunities outside of school to engage in authentic science learning experiences are more likely to identify as knowers and doers of science, and those students are more likely to be members of non-marginalized groups. Therefore, it is important for students—particularly students who are historically marginalized—to have these kinds of science learning opportunities in school. In this way, Hoba's disciplinary responsiveness was also equitable by expanding traditional boundaries of who is positioned as knowers and doers of science.

There are other aspects of Hoba's teaching that are worth consideration when describing her equitable responsiveness: her choice to integrate place in her curriculum, and moves she made to foreground and foster relationships with students. These practices highlight Hoba's orientations, habits, and perspectives which informed and were intricately connected to her science teaching. In this section, I describe these practices by highlighting two more examples of classroom discourse. I then share additional data about Hoba's knowledge of issues of equity which informed her responsive teaching practices.

Integration of Place

Hoba's choice of curriculum with the Squirrel Graphs narrative is one example I present as equitably responsive in her practice. I argue that this was equitably responsive because of her intentional move towards integrating place into students' science learning. This move was informed by Hoba's knowledge of her students, and illuminates a particular perspective she brought to her science teaching for engaging students in authentic science learning experiences

that were also culturally relevant to her students. In the following paragraphs, I present data to support this claim for why this was responsive to Hoba's students in particular.

As part of a broader unit on adaptations, Hoba's mini-unit on squirrels tasked students with gathering data from their neighborhoods on the types of squirrels they encountered and where they observed them. This was important to Hoba because she felt "that's something that they can relate to and learn about because that's where they live." Additionally, the activities connected students to this place in Dawson. Hoba believed many of her students did not have a firm sense of place or belonging in Dawson because of their immigration experiences. Moreover her refugee students first immigrated to refugee camps before coming to the United States, creating for them a deeper disconnection. Hoba imagined herself saying to students:

> "This is where you're living now. This is home." And making [students] feel safe and trust where they're at. Because they really lost trust. For example, with Yemen, they feel like that was their place, but they had to leave. So this is their place now, but will they have to leave?

Hoba believed that many of her students lacked trust or a sense of stability with their lives in Dawson ("this is their place now, but will they have to leave?"). Therefore, it was all the more important to Hoba to ground her science teaching in a sense of place in order to increase students' sense of belonging despite ongoing uncertainty in their lives (Gruenewald & Smith, 2008). For Hoba, integrating place into her curriculum was more than simply good pedagogical practice for making abstract learning concrete. She felt like it was important for these particular students based on their life experiences. Indeed Ehret and Hollett (2016) suggest that the affective dimensions for students of integrating place into instruction may increase their sense of belonging. I consider this an expansive and equitably responsive move made by Hoba because she made space through her curriculum for a different way of engaging in science learning which was tailored to the needs of the lived experiences of many of her students.

Students' engagement in this learning activity showed evidence of their interest in and appreciation for Hoba's responsive decision to integrate place into her science curriculum. One of Hoba's third grade classes was behind with their data collection, so when they came to class to graph their data, they first needed to gather the data. Hoba decided in-the-moment to take the class on a walk through the school neighborhood to gather squirrel fur color data. As she was getting ready to tell them "about what we are going to be looking for," students became excited to go outside, and one by one, they began sharing stories related to squirrels. Hoba spent the first seven minutes of class listening to students' stories. In our debrief after the lesson, I gave Hoba feedback that those seven minutes may have been better spent setting the purpose for students' neighborhood walk:

> They spent about five minutes, a little over five minutes, sharing stories about their experiences with squirrels, which was really sweet. And they had cute stories. But that time also could have been spent with, "Here's a problem we're trying to solve. What do you think? What might we find when we go outside based on what experiences you've had?" So those stories would have served a sense-making purpose, rather than just kind of like, yeah, I've had experiences with that too, kind of purpose.

My suggestion was essentially to re-frame students' stories to help set a purpose for what they might find when they went outside on their neighborhood walk. My focus in that moment was on a disciplinary frame of responsiveness, but Hoba made space for a more equitable frame of responsiveness as she passed from one student to the next, listening to their personal stories. In hindsight, I recognize the importance of her decision to make time and space for students' stories in order to broaden opportunities for participation and to foster relationships with students. My lens of looking for Hoba's responsiveness to students' sense-making initially made it difficult for me to appreciate her responsiveness in this conversation to students' story-telling.

The moves Hoba made in these first seven minutes allowed for students to author a sense of place through their stories in ways that went beyond simply being "cute." These included

students (a) expressing a sense of physical connection to neighborhood wildlife through touch, (b) expressing a sense of caring for neighborhood wildlife, (c) imagining a reciprocal relationship with wildlife, and (d) sharing community knowledge about wildlife. In each of these ways, students communicated how they positioned themselves in relation to their place. In the following paragraphs, I provide excerpts from students' contributions to this class conversation as evidence of each of the above.

Physical connection. As one student was sharing about a squirrel he saw digging yesterday, he commented that "I- I- petted it." Hoba responded, "And it let you pet it?" Another student said, "Oh man." Hoba shared a related story about a squirrel on her family's back deck which did not scurry away when she opened her sliding glass door. She cited this as evidence that neighborhood squirrels are getting much more familiar with and uninhibited around people. Hoba circled back to the student who pet a squirrel and teased him saying, "Are you sure you were petting a squirrel?" The student replied, "Yeah!" Hoba continued, "Not some other random animal?" Hoba had laughed through her own story and was playful in her tone as she teased the student about petting the squirrel. This student's expression of petting the squirrel suggests a physical connection he was making in this place, in his neighborhood.

Sense of caring. Students expressed care for animals in multiple ways. In one example, a student named Violet shared that,

> After we went to a birthday party, we went back. We saw my sister on the couch. She was like, "a squirrel got in by the window!" And she's like feeding it. That's the thing, she's deadly allergic to nuts, and she had like a glove on.

Hoba responded, "Oh! And she was still trying to feed the squirrel? That is really sweet." Violet's story highlights an example of caring for a squirrel by trying to feed it. A wildlife expert

may or may not agree that this was a good idea, but for the purpose of this analysis, feeding the squirrel demonstrated an act of care for the animal.

In another example, a student shared a story about going to her grandparents' house, "and the squirrel was stuck on the fence. It got stuck, so I went closer." The student briefly described what she did for the squirrel, and Hoba responded, "So you helped the squirrel?" Helping the squirrel get unstuck from the fence was another demonstration of care for wildlife.

In a third example, a student named Moe shared a story about seeing a squirrel in his backyard. He started by describing some new construction in his backyard:

> They're digging in my backyard. So like- so like they're gonna make new stuff in it. And yesterday, I saw this squirrel, just looking at its- uh, the backyard. And I felt so bad. Because it only used to bury its stuff there.

Moe's expression of feeling badly about the impact of humans on the squirrel's backyard habitat was another expression of care. These three examples of expressions of care for wildlife, specifically squirrels, is another way students demonstrated a relationship with their place. The caring was happening in a shared place; in other words, the students and the squirrels belonged in the same place together, and the students were showing care.

Reciprocal relationships. After the student referenced above shared her story about helping the squirrel that was stuck on the fence, another student wondered aloud: "Imagine a squirrel helping you." Hoba replied, "You never know. We've heard that in fables." The student replied, "Yup." In this case, the student was imagining a reciprocal relationship between humans and squirrels—where humans help squirrels and squirrels help humans. Hoba's move validated the student's contribution rather than dismissing it as a joke or as irrelevant. This student was afforded the opportunity to imagine the possibilities of how he might be in relationship with the squirrels in his neighborhood.

Community knowledge. After Moe shared his story about the new construction in his backyard taking over the squirrel's space, he shared more information about the squirrel:

> **Moe**: And last year it was pregnant. So it might have babies.
> **Hoba**: It might have babies? How do you know?
> **Moe**: Because last year my mom looked at it, and she's like, "It's pregnant."
> **Hoba**: Oh!

Moe brought in his family's knowledge about the squirrels as he shared his story about the squirrel in his backyard. His family, or community, knowledge informed his relationship to the wildlife in his place. Hoba's move to inquire as to how Moe knew this information is an example of her sharing epistemic authority with students, and in this case, Moe drew on his funds of knowledge as he connected to his place through this story.

To summarize, across examples, Hoba continuously made space for students to share their stories. Hoba made space by calling on or responding to 13 students who shared their own stories about squirrels they had encountered. She also made space by repeating students' contributions ("It might have babies?"), asking follow-on questions of students' stories ("And it let you pet it?"), and providing validating comments in response to students' stories ("You never know"). Students used these opportunities to author their relationships to squirrels in their neighborhoods. Her interpretation of students' stories as valuable to the science lesson was one way Hoba's responsiveness here was equitable. Gay (2010) describes story-telling as a topic-associative, or topic-chaining form of communication which is often devalued by classroom teachers expecting topic-centered communication. Hoba recognized her students' storytelling to be a valid and worthy way of engaging in science learning, thereby expanding notions of what counts as doing science. Furthermore, the ensuing walk through the neighborhood provided additional opportunities to students to connect with their place and develop a sense of belonging.

The Art Class Incident: A Classroom Narrative

I chose the following narrative to share as an example of equitable responsiveness because it demonstrates Hoba foregrounding relationships with students over her science instructional time. While developing caring and anti-oppressive relationships with students does not neatly align with my working definition of expansive equity in this study, as I argued in Chapter 2, these relationships are a foundation on which equitable responsiveness happens. Hoba's case shows compelling evidence for its importance. This narrative illustrates Hoba's intent to work towards developing caring, anti-oppressive relationships with students which was an integral part of her identity as their science teacher.

Hoba's third graders had just entered the classroom and were waiting on the carpet for Hoba to begin the science lesson, as per their routine. As she began the lesson, Hoba noticed a girl crying on the carpet. She interrupted herself and asked, "Are you okay?" The girl did not respond, but several others spoke up, blaming one particular student as the culprit, referencing an event that happened in art class right before coming to science, with the blamed student accusing the crying student of throwing scissors. Hoba responded, saying: "Would you like somebody to talk about you and kind of like hurt your feelings?"

Again, several students spoke up, including for the first time the student whom the art teacher had determined was the offender. He denied any wrongdoing. So, Hoba spoke up over other student voices who were all talking about the event and said to him, "So, you're upset because everybody's saying it was you?...And it was not you?" In the video-recording of this moment, it is hard to hear the boy's response, but with regards to the scissors, he said, "I'm saying that I just—I said—maybe you didn't need two."

After he spoke, Hoba directed her attention to the crying girl: “And you’re crying because he said maybe it was you?” Again, it is difficult to hear the girl’s response, but she confirmed what Hoba suggested.

Hoba wrapped up by saying in a compassionate yet firm tone of voice to the boy, “I don’t want you talking about it like that. Or even pointing to a friend like that.” And in a similarly compassionate tone, she said to the crying student: “Um, will you go wash your face? Cuz I don’t want to see you cry.” At this point, the girl stood up to go to the restroom, located just behind them inside Hoba’s classroom, and washed her face. The students had said their piece. And Hoba moved on with introducing the science lesson.

This moment is somewhat difficult to piece together, even for me as an observer who was in the classroom as it unfolded. In the video-recording, enough students are talking at once that it is difficult to hear exactly what was being said. From what I have figured out from my classroom observation, repeated viewings of the video recording, and my conversation about this moment with Hoba, there was an incident in art class immediately preceding science class where a pair of scissors was thrown. Perhaps the boy had accused the girl of having too many scissors. Perhaps in frustration, she threw one of her pairs of scissors. The boy was blamed for throwing scissors, but according to Hoba, “he was a behavior problem student last year, and we had to work with him. Now this year he’s trying to prove himself that, ‘No, I’m changing. I’m different.’” Inevitably pieces of this story are missing.

Like me, Hoba was also confused about what had happened in art, saying, “he got upset because he was blamed for something that he did not do, I guess.” However, she worried that if she tried too much to “try to solve a problem that happened in a different class, the art teacher will try to take it personal. That, ‘hey, are you trying to say I’m not able to handle my things?’”

Ultimately, Hoba "didn't want them to be mean to each other, and I wanted them to just resolve it now." So, she spent time listening to the two students, and then responded with a compassionate tone to each student in an attempt to find resolution.

Earlier, during their art class, I was sitting in the staff lounge, which is right next door to the art classroom. While there, I heard the art teacher yelling loudly at a group of children, which turned out to be this group. This was uncharacteristic of the culture of the building, in which I rarely heard teachers raising their voices, and the halls and classrooms I passed through always appeared calm. I could not imagine what might have prompted this kind of reaction from an adult. Hoba later described the art teacher to me as "not so well with our population."

Hoba made attempts in her teaching to develop anti-oppressive and authentic relationships with students despite her complicated context of teaching hundreds of students each week. The Art Class Incident demonstrates an attempt of Hoba's towards this end. She took time out of her science instruction to let students' voices be heard who felt they had been wronged. This legitimized their feelings and their interpretations of the event in important ways. Hoba also did not make assumptions about what had happened, but repeated what students were saying to assure she understood their intended meanings ("You're upset because everyone was saying it was you?"). Hoba's tone in her final response was compassionate, but some may interpret her response to the youth as gendered—to the boy, she communicated a reprimand ("I don't want you talking about it like that") and to the girl, she communicated for her to stop crying ("Will you go wash your face?").

In my interpretation, it was a chaotic scene with many students talking at once and concerned, and Hoba's overall response was to compassionately listen to her students (Table 4.2). Perhaps Hoba could in the future be more mindful about gendered responses, for instance

by allowing more time for students to express their emotions in class, but importantly, Hoba did make time to and express an interest in figuring out what happened. These types of moves to legitimize students' feelings and give space for them to voice their feelings are important for building relationships with students. While they are absent of disciplinary responsiveness, they nonetheless are moves towards equitable responsiveness, creating a foundation on which more expansive science learning can progress more smoothly.

Hoba did not take her relationships with her students for granted. "Having those relationships really helps. Because if I'm always being like, 'you've got to do this, you've got to do that,' and I'm not understanding their chemistry and how they interact with each other, it's hard." She pushed back against a former principal's insistence on jumping into academics right away from the beginning of the school year, saying, "No, I have to get to know them first." Hoba developed these relationships by taking a stance of caring for her students. Noddings (2010) described caring as involving "attention, empathic response, and a commitment to respond to legitimate needs" (p. 28). In the Art Class Incident narrative, Hoba made time before launching her science lesson to attend to an emotional need of a student in the classroom. The moves she made to listen to students, to give them opportunities to share, and to respond firmly yet with compassion, served to build relationships not just with the two main students involved in this event, but with the whole class. These responses stood in stark contrast with what we know about how the art teacher handled the incident in her classroom. Hoba's care and concern for her students' well-being was central to her philosophy of teaching and therefore to the choices she made when foregrounding relational aspects of her work.

Previously, I argued that Hoba's integration of place into her teaching, and her interpretation of students' stories as valuable, were two ways in which her science teaching was

equitably responsive. In this section, I have argued that her making time to listen to students' concerns and emotions is another reason why I consider her science teaching equitably responsive. This is because she spent time developing a foundation on which to teach science in more expansive ways. In the next section, I examine one of her relationships more closely—her relationship with AJ.

Hoba's Relationship with AJ

AJ was a central figure in the Squirrel Graphs narrative. On the first day of the lesson, Hoba noticed AJ was struggling to sit still, and in order to set him up for success, she decided to ask him if he wanted to be her partner to model how students were going to complete their graphs. He quickly accepted, and when he went up to her desk and jokingly said he was smart, Hoba looked him in the eyes and said, "You are smart." AJ was engaged in the task, and while he prompted some laughs from Hoba and his classmates, he got right to work constructing the graph. On the second day of the lesson, AJ took the position of "co-teacher" once again. This time, he was less engaged in the lesson discussion, distracting himself by picking up Hoba's phone and looking at her computer.

I chose AJ to focus on in this chapter as an example of a student with whom Hoba worked to build a relationship because he was a student with whom other teachers felt exasperated. On one occasion, Hoba stopped AJ in the hallway while she and I were walking together. He was on his way back to his classroom after lunch and recess, having lost his recess from getting in trouble. Hoba gave him a brief pep talk before we parted ways. It was clear Hoba cared for AJ, and she felt upset that he repeatedly got in trouble in his class. In science, Hoba responded to AJ's distractions with humor, trying to coax him back to the classroom discussion

before playing along and "firing" him while directing him to sit down with his peers. When I asked Hoba more about AJ, she shared with me,

> AJ is such a sweetheart, and I guess he does have behavior issues. We just found out recently that him and his mom, and his two other siblings were taken by social services, I think they were abused in the house. And that got me thinking that that explains it all, why AJ is the way he is. AJ is not an ELL student, he was born here; he grew up here. They do speak Arabic in the house, but he does understand English.

The first thing Hoba said about AJ was that he was a "sweetheart," foregrounding a positive statement before acknowledging that he can be difficult in class. However, she did not linger on this point, but rather pivoted to share information she and her colleagues recently learned about AJ, reflecting on how this information helped her to better understand AJ and his choices in school. Her foregrounding of his personal assets (his sweetness), and her developing knowledge of his home situation, invariably influenced the kinds of empathic choices she made in her interactions with AJ.

Empathy is the combination of an emotional response (one of sympathy) and a cognitive response (one of understanding or perspective-taking) (Noddings, 2012; Warren, 2017). In practice, empathy is "the piece of the student-teacher interaction puzzle that connects what a teacher knows or thinks about students…to what he or she actually *does* when negotiating appropriate responses to students' needs" (Warren, 2017, p. 3). While empathic relationships are bidirectional (empathy expressed by both students and teachers), I focus here on Hoba's moves to foster empathic relationships. Even during class the second week, when AJ started picking up Hoba's phone and looking at her email on her computer, Hoba was not quick to anger; in fact, she smiled and appreciated his humor as just that—humor—while also working to focus his attention back on the lesson. As Delpit (2012) says, "we must learn *who* the children are and not focus on *what* we assume them to be—at risk, learning disabled, unmotivated, defiant, behavior

disordered, etc." (p. 38). Who children are can be described as a youth genre, which may include "playfulness, affect, intensity, sense making, reciprocity, experimentation, and argumentative stance" (Varelas, Becker, Luster, & Wenzel, 2002, p. 581). Hoba's responses to AJ—informed by her empathy—were to be appreciative of his humor and playfulness, to acknowledge his epistemic contributions to the discussion, to consistently and compassionately redirect his attention back to the task, and to respond to his humor in kind.

AJ is a helpful example of one of many caring relationships Hoba fostered in her position as the science teacher. Hoba taught over 600 students every week. She could not foster this depth of relationship with each of those students. However, she was committed to doing her best with as many students as possible, including AJ. For this reason, his story is another helpful example of her equitable responsiveness—or rather, an example of moves she made which were foundational to her being able to teach science in equitably responsive ways.

Characterizing Hoba's Equitable Responsiveness

The sections above provide evidence of moves Hoba made towards equitable responsiveness (separate from those which I already categorized as disciplinarily responsive): integrating place, interpreting students' stories as valuable, listening to students' concerns and expressions of emotion, and responding to students' humor with humor (Table 4.2). The first one in this list refers specifically to Hoba's design of curriculum, with intention to be responsive to students' lived experiences and needs. The second item in the list categorizes the ways Hoba interpreted students' stories as valuable as a pedagogical move Hoba used to not only broaden students' participation in science, but also to develop relationships with students. The last two items on the list are both examples specifically of how Hoba foregrounded and fostered relationships with students, laying groundwork for equitable and expansive science teaching and

learning. Listening to students' concerns and expressions of emotion happened in place of beginning science instruction at the start of class and took up instructional time. However, Hoba knew taking that time was important and foundational to her teaching practice. Finally, responding to AJ's humor with humor, rather than strictly disciplining him as off-task or insubordinate, fostered an anti-oppressive relationship with AJ. All of these are moves towards being equitably responsive in her science teaching practice.

Table 4.2

Hoba's Equitable Responsiveness Moves

Responsive Moves	Examples from Narratives
Integrating Place	Hoba intentionally integrated place into her curriculum to help give her students a sense of belonging to their community.
Interpreting Students' Stories as Valuable	Hoba made time to listen to students' stories about squirrels in their neighborhoods.
Listening to Students' Concerns and Expressions of Emotion	Hoba made time and space to listen to students' concerns after art class.
Responding to Students' Humor with Humor	Hoba responded to AJ's humorous distractions with humor.

In the following section, I provide findings that demonstrate Hoba's knowledge of issues of equity affecting her community—specifically, I share evidence of the ways in which she recognized cultural similarities and differences between herself and her students. These perspectives Hoba brought to her work informed the types of responsive instructional moves she made in her science teaching.

Hoba on Cultural Similarities and Differences

Hoba's choice to integrate place in her curriculum and her foregrounding of building relationships with students were informed by her knowledge of her students and their cultural backgrounds. I present the following data as my understanding of Hoba's perspectives on the Middle East, Arab Americans, and her students' experiences, recognizing that others may have different perspectives on the region's politics, conflicts, and people. I share this data to provide

an additional perspective which can explain why integrating place and foregrounding relationships were important to Hoba.

In some ways, Hoba shared cultural practices, histories, and values with her students who were predominantly Muslim and from the Middle East. For example, Hoba spoke Arabic and could translate for students: “Students that are brand, brand new - I actually translate for them. Because I want them to understand what's going on.” She could also code switch with students when she needed their attention more urgently: “Sometimes I do code switch with certain students just because I feel it might work better with them. I know sometimes they see, ‘that's how my mom at home's going to talk to me,’ so they are more responsive….” Even though there are dialect differences in Arabic depending on where a person is from—as Hoba shared with me one time when she identified a parent who was speaking Arabic as being from Syria—when I observed Hoba speaking in Arabic to students, they seemed to understand her.

Hoba also celebrated some of the same holidays as her students, including Ramadan, Eid-ul-Adha, and Eid-ul-Fitr, even though they do not always start on the same day. (According to Hoba, “Saudis- I don't know if they do it purposely, but they do announce Eid at a totally different time than everyone else. Several days different!”) For example, Hoba shared the following story with me:

> Did I tell you about the beginning of Ramadan? I started Wednesday; some kids started Thursday. Someone in [one of my classes] came and told me, ‘Do you know today is the Lebanese Ramadan?’ I was like, ‘Why?’ She goes, ‘We start tomorrow.’ I was like, ‘Okay, I’ll start with you tomorrow!’

This student made a connection with Hoba, noticing that she started fasting a day early for Ramadan, and Hoba made a connection back, offering to start fasting together. Sharing language, holidays, and fasting with students were some ways in which Hoba was able to connect with her students.

There were other more nuanced ways in which Hoba culturally connected with her students as well. For example, when students were upset, Hoba knew expressing empathy must be demonstrated in a way that was not simply an apology (i.e., "I'm sorry to hear that"). Rather, students expected empathy to be demonstrated by saying:

> 'Oh, come here and tell me what happened. So what happened? How did you solve it? Are you feeling better about it now?' They want to hear more of that then, 'I'm sorry.' Just kind of blowing that off. They don't consider that empathy. At all. In the back of their mind, I know they're like, 'She doesn't care.'

This way of understanding how to demonstrate empathy as asking students about "what happened" sheds light on her approach to responding to her students in the Art Class Incident narrative wherein she spent time trying to figure out what had happened to made students so upset. In other words, Hoba had a cultural understanding not only of language and religion, but of cultural expectations around communication and interactions which helped her to build relationships with students.

These cultural characteristics which Hoba shared with students set her apart from her White, non-Arab teacher colleagues in important ways. Recall that in Hoba's youth, she considered herself White in Lebanon; however, as an adult in the U.S., Hoba no longer identifies as White. When she refers to White teachers, she is referring to the non-Arab White teachers in the building. In addition to Hoba expressing that her White colleagues were more likely to respond to students by saying, "Oh, I'm sorry to hear that," Hoba shared stories with me of her White colleagues whose interactions with students were quite different. One example of this is the way the art teacher responded to students in the Art Class Incident narrative. Hoba shared other examples with me, including that sometimes her White colleagues expressed disapproval when students fasted ("I have students that are fasting right now, for example, and they're looked down upon"). Another example Hoba shared was that in classrooms with a White teacher, she

noticed that students who were more fluent with the English language were less likely to want to help their peers who were more recent immigrants and less familiar with English.

> I don't want to point, but I think some of the White teachers make them [their students] feel uncomfortable, and that makes them feel like, 'Oh, now I speak the language so I don't need to go back and be that way.' You don't see it with a lot of students, but you'll see it with students from specific classrooms, and you know where it's coming from….That all depends on the classroom teacher. Who the classroom teacher is.

In other words, Hoba's conjecture was that as a result of White teachers insisting students speak English in class, this resulted in a class culture of not wanting to stand out as an Arabic speaker, even in the interest of helping others.

Finally, Hoba shared with me that one White fifth-grade teacher who was new to her building was telling jokes to her students in an effort to connect with them. When one of her students in particular was not amused (according to Hoba, responding with an attitude of, "these jokes are not even"), this teacher complained in the faculty lounge in front of Hoba about not being able to connect with the student. Hoba explained to her and to me that this student "wants to become a doctor. Academically she's excelling; socially she's an introvert….So, I was trying to explain to her, and she was like, 'I don't know. I feel that's weird. I don't know if I can handle another year.'" In this interaction, where Hoba was able to understand this student through her personal knowledge of her, the classroom teacher was so frustrated and confused that she was thinking of leaving the school the next year. Hoba's ability to connect with her students was different from the experiences of at least some of her White colleagues, and her understanding of students' culture was a key factor.

While there were many ways in which Hoba shared cultural assets with her students, there were countless other ways in which she felt culturally different from her students. For example, Hoba had more experiences in her youth with people from diverse cultural

backgrounds than many of her students. As she described it, Lebanon is a place "where the culture is very much merged. It's mixed. Religious-wise, it's not considered a Muslim country like most of the countries where [my students] come from. It's very diverse." In contrast, most of her students came "from areas where 90% are Muslims, so they don't see much [religious] diversity. Coming to the United States can be a shock, from celebrating Christmas—I don't think they see Christmas [where they come from]. I've seen it in Lebanon."

Another difference is that Hoba immigrated to the United States as a young adult to pursue higher education, while many of her students immigrated to the United States as young children under duress as refugees. Hoba had a choice in deciding to leave, already knew English before coming, and came with economic resources—these are important differences in experiences between Hoba and many of her students.

Hoba also described to me how norms of dressing for women are different, with many students' mothers covering their faces (with a niqab) and wearing long, loose cloaks which also cover the head (called jilbabs or abayas). However, Hoba covers her head with a scarf (called a hijab) without her face covered. Hoba's students "observe it, and they see and they ask." These differences in clothing signal to Muslims religious differences in how individuals practice Islam. They can also signal differences in which parts of the Middle East a person may come from, or to which parts a person may feel allegiance or alliance. Students who have only experienced, for example, women dressed with niqabs or abayas may be curious or even distrustful about their teacher who wears a hijab instead.

In addition to these differences of experiences and dress, Hoba also explained to me important differences related to politics and power. These differences at times manifested

themselves personally towards Hoba when she had students and families who distrusted her because she was Lebanese and practiced Islam differently. As Hoba shared:

> Sometimes it's a challenge being of the same religion but appearing differently and practicing differently. In their head they might judge that. You're actually not like them. Or one of the comments, I heard it once, someone telling her child, 'You shouldn't be like her. She's not a practicing Muslim.' Or, 'she does not practice religion like us.'…So I do get criticized sometimes badly, in that sense. Like I had—that was in second grade—I had a parent tell her child that she shouldn't listen to me….Discipline-wise. Because I'm different. And she also told her that she shouldn't be going outside to play with Lebanese kids because they're different, and that her child is going to- they're going to ruin her child.

Here in this school community, Hoba and most school families were Muslim. However, because Hoba came from Lebanon and practiced Islam differently, some families vocalized their disapproval, saying "she's not a practicing Muslim" and warning their kids from playing "with Lebanese kids." So, to the extent that Hoba recognized cultural differences between her and her students, so too did students' parents.

Hoba also shared with me the ways politics and power caused division among her students. Over multiple conversations, Hoba explained how she understood the role Saudi Arabia played in her students' and their families' lives. In Yemen, Saudi Arabia is largely seen as a government that is killing Yemeni people, and some of Hoba's students are refugees from the war in Yemen. According to Hoba, "the ones that are coming straight from [Yemen], they're recognizing that extremism, that Saudi influence, so at their mosque, they are kind of moving away from that." However, for other Arab Americans who have been in the United States since before this conflict started in 2015, they, like many other Americans, see Saudi Arabia as an ally, "so that causes a division, a big division." Hoba went on to describe this division as not "based on color or gender or whatever. It's more based on practice. And kids can tell you, 'oh, you

didn't have Eid with us,' 'we had Eid at a different day,' or 'your family is different.'" Hoba noticed differences among her students,

> with the way they dress or the way they're talking to each other….I start picking up on things from students. I don't see it as a racial division in that sense, but it is a power division. Because if you are basically supportive of—Saudi basically have the power, and 'you're unrighteously killing people in Yemen.' That's how they feel about it. So they kind of hold grudges in that sense.

Across these conversations, Hoba described Yemeni people seeing Saudi Arabia as the enemy—as "unrighteously killing people in Yemen," while immigrants who arrived in the United States before the conflict in Yemen are more likely to "see Saudi Arabia as an ally." These differences could be kept private, except Saudi Arabia announces holidays such as Eid on different days, which made these alliances more public when Arab Muslisms celebrate shared holidays at different times. These alliances then were noticed by students, and Hoba watched as students recognized differences among their families.

Hoba's attentiveness to her students and their conversations, who they sat next to, how they dressed, when they fasted, gave her insight into how politics and power were playing out in their everyday lives. Despite immigrating to the United States, almost all of Hoba's students had families who still lived in the Middle East, and their lives were interconnected to those places and politics in ways that crossed over to the new lives they and their families had begun here in the United States. In this section, I have provided evidence of Hoba's sociocultural awareness. As described by Wallace and Brand (2012), a teacher's sociocultural awareness influences their beliefs and practices in their science teaching. For example, Hoba's understanding of her students, their communities, and their lived experiences provided her with a critical awareness of how inequities were playing out for her students on a global and local scale, the impact of this on

her own philosophy of teaching, and her understanding of students' needs and behaviors in the classroom.

As I demonstrated earlier, Hoba did not take her relationships with students for granted: "Having those relationships really helps." "No, I have to get to know them first." Hoba learned about her students through her interactions with them and with one another. As Milner (2011) proposed, fostering authentic relationships with students has this effect of positioning the teacher to learn both with and from their students.

Hoba's similarities to her students, and her recognition of their differences, positioned Hoba with sociocultural awareness and empathy in her relationships with students. These perspectives compelled her to be responsive in her science teaching to their lived experiences and to their sense-making.

Conclusion

In conclusion, moves Hoba made that I categorized as disciplinarily responsive to students' scientific sense-making were to be flexible with her plans and to share epistemic authority with her students. Hoba enacted these moves as a result of work she and I did together, and I do not know whether she would have enacted them without my support. Nonetheless, they serve as useful examples of moves towards disciplinary responsiveness. These moves were also part of her enactment of equitable responsiveness as she positioned students who are traditionally marginalized in school science as knowers and doers of science. Hoba demonstrated other moves that were further evidence of equitable responsiveness. For example, Hoba additionally intentionally integrated place into her curriculum in response to students' immigration experiences, and she foregrounded developing relationships with students in her science teaching practice. The foregrounding of relationships does not neatly align with my definition of

expansive equity in this dissertation; however, it was foundational work on which Hoba developed her teaching moves towards equitable responsiveness. I argued in this chapter that Hoba's teaching practices seemed to be largely influenced by her knowledge of equity issues impacting her students and their families. Hoba's knowledge was largely informed by her own identity and life experiences, which were both similar to and different from those of many of her students.

In the next chapter, I present data from my second case study—Karen. Karen's case is different from Hoba's, and it problematizes what it means to teach responsively and equitably.

CHAPTER FIVE:

Karen’s Case Study

Hoba's case study provided an image of elementary science teaching that was responsive. Hoba was flexible with her plans based on students' sense-making, and she shared epistemic authority with students during her lessons. She also worked towards equitable responsiveness through her foregrounding of developing anti-oppressive relationships with students and her intentional integration of place into her curriculum in response to her students' lived experiences. These two groups of moves are categorized distinctly, and yet Hoba's enactment of the disciplinary responsive moves were also equitably responsive. Furthermore, Hoba's knowledge of issues of equity as demonstrated in how she talked about her cultural similarities and differences with her students informed how she noticed and responded to students equitably. Disciplinary and equitable responsiveness are important approaches to science teaching and learning, especially for students from minoritized groups who are systemically disadvantaged in the United States and whose epistemologies are largely absent in science and school science. In this second findings chapter, I profile Karen's case.

Karen's case was difficult for me to write, for reasons that should become apparent while reading this chapter. Karen's disciplinary responsiveness was strong. In many ways it mirrored Hoba's, and in some ways I would argue it was stronger. However, Karen was not equitably responsive. Despite the fact that some of her moves towards disciplinary responsiveness appeared to also be equitably responsive, I argue in this chapter that Karen's color-blind racism, White fragility, and White emotionality betrayed troubling orientations to her work which manifested in her treatment of two students: Jose and Julia.

I organize this chapter similarly to Hoba's. In this chapter, I begin by introducing Karen and her students. Next, I present findings on Karen's disciplinary responsiveness by sharing two narratives from her classroom teaching. Finally, I present findings on Karen's equitable

responsiveness by sharing one story about her relationship with two students, and insights into conversations she and I had that exposed a racist worldview. I use these findings to argue that while her science teaching practices were strong with regards to her disciplinary responsiveness, her orientations to her students and their communities negatively impacted her relationships with students and were therefore not equitably responsive.

Introducing Karen

Karen shared openly with me throughout our time working together about her life experiences, her views of her students and their families, and her passions and frustrations with her school and colleagues. At times information she shared was contradictory, but I did not seek external validation to confirm which pieces of information were "true." Rather, I took Karen's words as her truth, and I have worked to understand Karen's truth within the sociopolitical context of her school, city, country, and history and with the help of Critical Whiteness Studies scholars who offer useful constructs for understanding Karen's case. In this section, I introduce Karen and her teaching context.

Karen was a White woman, born and raised in a suburb of Hatton she considered diverse. Karen knew early on that she wanted to be a teacher. About a year after she graduated from Midwest University with her teaching degree she was hired at Independence Charter School (ICS), a new charter school in Hatton with a bilingual (Spanish/English) program and an expeditionary learning instructional model which focused on authentic, real-world learning experiences.

Karen started in fourth grade for one year before moving to the first grade, and she loved it. This was her fourth year teaching first grade, her fifth year in the school, and she felt a strong sense of ownership over the school since she had been there since its inception.

> It's definitely developed over time. Our first year was really, really rough. We didn't have photocopiers until December or January, so every weekend I'd go to Office Depot and pay for my copies and my paper.…And as time has gone on, there has been a lot of change in leadership and with change comes, you know, one person coming in and saying, "We're going to redo everything." It's just been a lot of rebuilding. So finally now seeing that we're on a trajectory where every year we build on top of what we already have and we're growing – I'm just very passionate about the families and the kids that we're servicing in this area…. I guess just being a part of something that I've helped to build makes me very protective over it. I've had a lot of opportunities here that I wouldn't necessarily have had at other schools. I've been able to have a voice because from the get-go it was, "We can't just build a school with one person making all the choices." It was always a team effort. That's what I've always liked about it. We're a family here.

Karen's optimism and sense of ownership in her school was palpable ("It was always a team effort"). She exuded enthusiasm for her school ("I'm just very passionate about the families and the kids that we're servicing"), was fiercely protective of it ("being a part of something that I've helped to build makes me very protective of it"), and had historical knowledge of ICS ("we didn't have photocopiers until December or January") which gained her credibility among her colleagues.

However, this positivity co-existed with tension and frustration between her and some of her administrators. She repeatedly expressed to me frustration with the way in which her school's former founder, Jessica, who remained deeply engaged with the school's management as its CEO, repeatedly made decisions about cases of student misbehavior which Karen felt undermined her authority. These experiences, and others I describe in greater detail later in this chapter, were disorienting to Karen, and she shared her frustrations with me with tears in her eyes.

A friend of Karen's from high school recruited Karen to come work at ICS, but Karen had never imagined she might teach in an urban school.

> I never once thought I'd want to be urban. Never once. Growing up in metro Hatton and hearing all the things that you hear about Hatton schools. Just being an adult woman

> coming down to Hatton scared me when I was younger. Hatton has changed a lot now, though. It's a city that I feel like I've grown with and I want to stick with it. I feel like a lot of people here have a lot of grit and a lot of passion, and I feel like I fit right in.

Hatton has a reputation in the U.S. for its crime, crumbling schools and infrastructure, and post-industrial economic struggles. White flight combined with industry job losses affected Hatton, like many other cities of its size, decreasing the population from over 1.6 million in 1960, with a Black/White composition of 29%/71%, to just over 700,000 in 2010, with a Black/White composition of 83%/11% (according to U.S. Census reports from 1960 and 2010). The city in turn saw disinvestment from public and private sectors. Recently, however, White young professionals have begun re-inhabiting neighborhoods in Hatton—part of a move towards gentrification, a shared phenomenon with other post-industrial U.S. cities. According to the 2017 U.S. Census, today Hatton's population is 79% Black, 14% White, 2% two or more races, and 1.5% Asian, with 8% identifying as Hispanic or Latino. The increase of Whiteness, wealth, and investment into the city is rife with tensions as downtown businesses seem to have much-needed economic activity, while questions of who is left out (or pushed out) of this upswing raise concerns about racist and "selective" reinvestment (Lipman, 2008). Karen felt like she fit in because there were more White young professionals moving to the city, with complicated consequences for people of Color who never left the city. Her statement did not account for those consequences, but rather it belied a fear of people of Color in Hatton.

Karen had 24 students in her first-grade class. She identified 20 of them as Latinx, two as Black, and two as White. Karen identified 13 of her students as bilingual in English and Spanish and seven students as emergent bilingual, or limited English. She had high concern about the attendance of seven of her students, four of whom she also identified as far below reading level. From my observations, Karen's students could sometimes be silly, sometimes quiet, sometimes

insightful. According to Karen, “They’re willing to try. They like school, they like learning, they’re willing to follow directions, and they can see the error in their ways when they hurt others.” Each day when I entered the room, I was greeted by hugs; students quickly warmed up to me as I worked with them on their scientific modeling; and as I packed up my equipment each day, students engaged me in conversation as they too prepared for dismissal (“it’s my birthday today and we’re having cake when I get home!” “Do you know what 24 plus 32 equals?”). The class felt warm and inviting, with soft lighting, norms and routines for requesting think time as needed, and flexible spaces in the classroom for the very occasional cool-off when students needed it. This feeling I had in her room contrasted with what I came to learn about Karen’s orientations to her work. Later in the chapter, I unpack these orientations in greater depth. First, I present findings on Karen’s disciplinary responsiveness.

Karen’s Disciplinary Responsiveness

To illustrate Karen’s disciplinary responsiveness, I share two narratives from Karen’s classroom which I use to illustrate some of her responsive teaching practices—namely, Karen provided multiple opportunities to students to engage in sense-making, she made space for multiple ways of knowing and doing science, she shared some epistemic authority with students, and she was willing to deviate from her lesson plans to follow students’ sense-making. These moves represent a distinct departure from traditional elementary science teaching, and I offer these narratives as illustrative examples of what this kind of responsive teaching can look like.

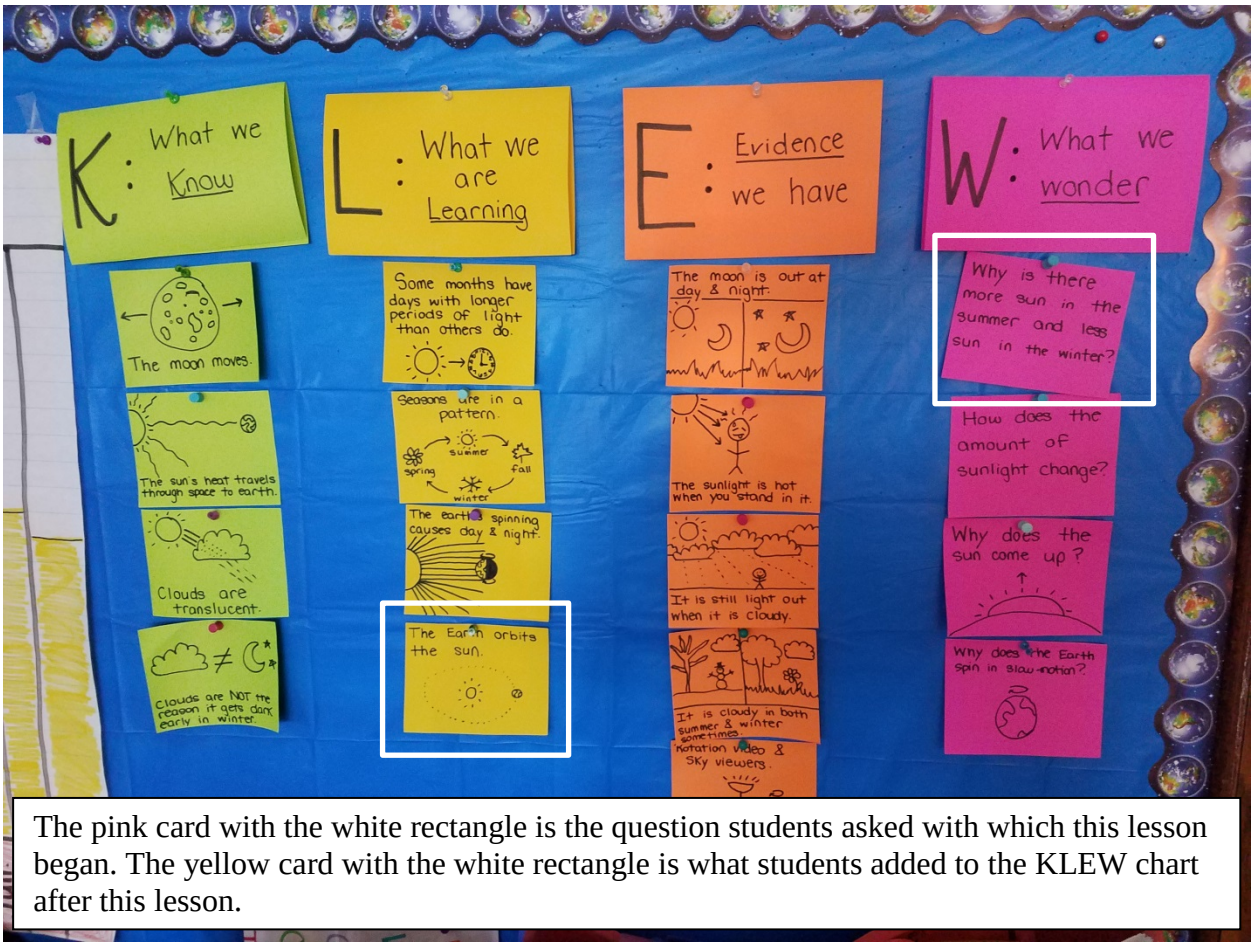
The Moon Sat on the Tree: A Classroom Narrative

In the following narrative, Karen was responsive to a student’s story which could easily have been interpreted as unrelated to the science discussion. I chose this story to share because

Karen made space for the student's story-telling, and she worked with him and other students to connect it to their sense-making about the day/night phenomenon.

It was the second day of extreme heat on May 30, and for the second day in a row, Hatton Public Schools had closed early due to heat, but Karen's charter school remained open. Karen's non-air-conditioned classroom felt oppressive, and many parents had kept their kids home, leaving Karen with 14 out of 24 first graders. Karen started her science lesson by having students turn and talk to share their ideas about why there is more sunlight in the summer than in the winter. In the NGSS Performance Expectation (1-ESS1-2), students are supposed to "Make observations at different times of year to relate the amount of daylight to the time of year." At this point in the unit, students already figured this out. But some students had been asking questions about *why* this was the case, and Karen had recorded this question on their KLEW(S) chart (Know, Learned, Evidence, Wonderings; Figure 5.1): "Why is there more sun in the summer and less sun in the winter?"

After their turn and talk, Karen shared a YouTube video (Crash Course Kids, 2015) designed for older students, but which had some ideas to begin to help students with their question. Karen planned multiple stopping points throughout the video to engage students in sense-making along the way. With this video, Karen and I hoped that students could gather evidence from the various models that not only does Earth rotate, causing the day/night cycle, but Earth also orbits the sun, which is part of what causes our seasons.

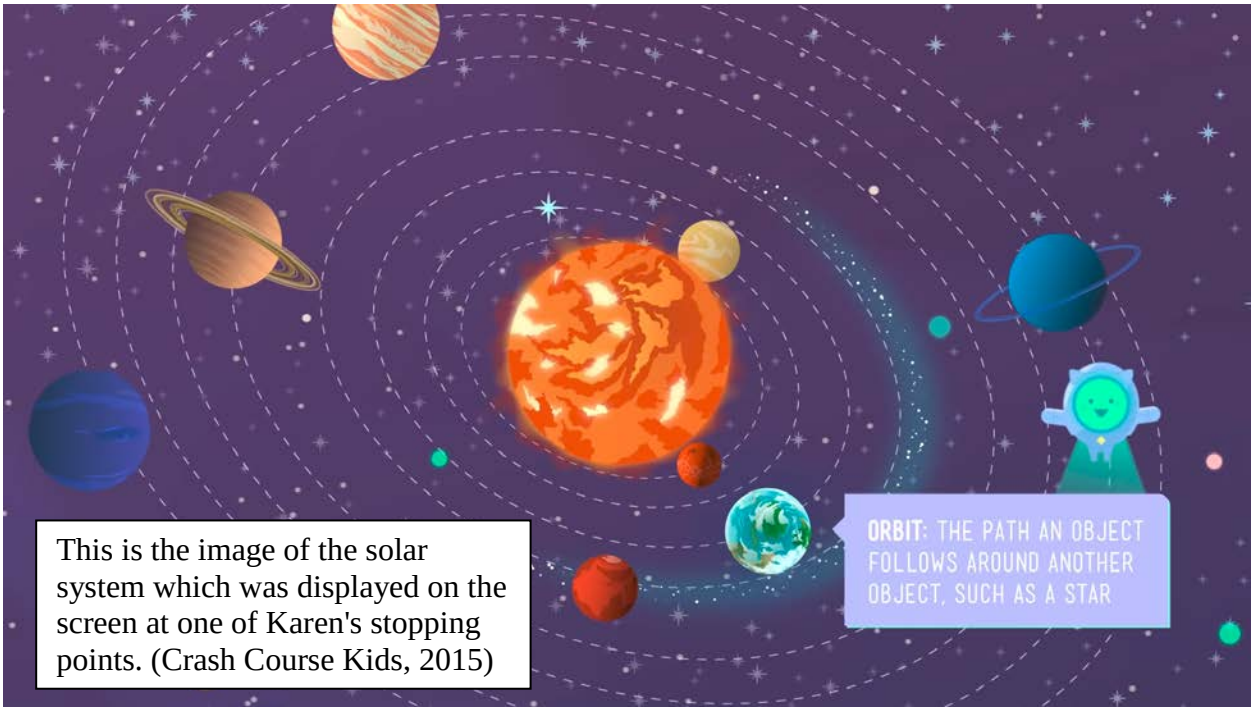


The pink card with the white rectangle is the question students asked with which this lesson began. The yellow card with the white rectangle is what students added to the KLEW chart after this lesson.

Figure 5.1. Karen's KLEWS chart part-way through the unit.

One of Karen's stopping points was on a model of the solar system showing the orbital paths of the planets around the sun (Figure 5.2). Some students in their own models of the phenomenon were already drawing Earth in an orbital path around the sun, but most were not yet. This was their first time seeing this model during class. As they talked about it, Karen motioned with her finger along an orbital path, explaining the circles show the path of the planets, "almost like the path a street goes in." One student exclaimed, "I did that in my model!" Another student described that she thought the planets were "doing their little circles" but not touching the Earth because "if that would happen, something would happen to the earth." She seemed to be noticing the pathways in the model were positioned too close to one another. After

a couple more students voiced their noticings about the model, Alonso raised his hand to share a story.



This is the image of the solar system which was displayed on the screen at one of Karen's stopping points. (Crash Course Kids, 2015)

Figure 5.2. Solar system screenshot.

> **Alonso**: Yesterday, me and Samuel, we were staying at another person's house. And we watched the moon (inaudible), and then I watched the moon on the front, and the moon was in the tree.
> **Karen**: So the moon was moving?
> **Alonso**: And another way it was not in the tree.
> **Karen**: And then when you looked again it was somewhere else? [Alonso neither shook his head yes nor no.] So the moon moved.

Alonso's comment about the moon was unexpected. Karen later shared, "I know the nature of those two kids [Alonso and Samuel], and it's horrible to assume, but when we have a time crunch and it's hot, I know that they'll tell stories that are kind of about what we're talking about, but not really." It was unclear how Alonso's story related to the solar system model, Karen's learning goal about recognizing another way the Earth moves (orbiting), or to the last student's comment about the yellow planet being too close the sun. However, Karen entertained

the idea. She made some clarifying statements to make sure she understood what Alonso was describing.

Alonso was an emergent bilingual student whose native language was Spanish. According to Karen, his English was usually pretty good, “but this is such big concepts.” In other words, because Alonso was trying to communicate an idea that was so big, Karen suspected it became harder for him to communicate his ideas in English. Sometimes Alonso was attentive during whole group discussions, but at other times, he would be “rolling around and he’ll hear something that draws his attention and [it] suck(s) him into participating.” For example, on more than one occasion, I noticed Alonso turning his eyelids inside out on the carpet to get his classmates’ attention during a turn-and-talk. After Karen gave Alonso space in the classroom to share his story, she made a move to try to help the class make sense of what he had observed:

> **Karen**: And then when you looked again it was somewhere else? [Alonso neither shook his head yes nor no.] So the moon moved. I wonder how the moon is moving.
> **Sofía**: It might be orbiting. [She traced a circle with her finger in the air.]
> **Karen**: <Gasp!> Say that louder, it might be what? [leaning towards Sofía with her hand by her ear]
> **Sofía**: Orbiting. [She traced another circle with her finger in the air.]
> **Karen**: It might be orbiting! What do you think it's orbiting Sofía?
> **Sofía**: I think it's orbiting about the planet.
> **Karen**: It's orbiting our planet! I think Sofía might be onto something.

In this exchange, Sofia volunteered her response without waiting to be called on. While it is more typical in Karen’s classroom for students to be called on, Karen frequently allowed space for organic opportunities like this for students to share their ideas without being called on. Like Alonso, Sofia was an emergent bilingual student whose home language was Spanish. Earlier in the school year, Sofía was having serious attendance issues which were affecting her academic progress. After Karen sat down with Sofía’s mom, laid out her concerns, and suggested Sofia might need to be held back in first grade if her attendance and academics did not improve, Sofía

started attending school more regularly, and her academics began to improve. Karen was particularly impressed with Sofia's engagement in this space science unit. Sofia readily engaged in the activities, including constructing her own models, even though she continued to only reluctantly complete her work at other times during the day.

In this discussion, Sofía was carefully tracking Alonso's story and Karen's think-aloud to begin to make a connection between what was displayed on the model in the video with what seemed to be the phenomenon Alonso was describing. Karen was excited by Sofía's response not just because of her use of academic vocabulary, but because of Sofía's academic history. As Karen put it in our debrief after school,

> Sofía blew me away today. She just kept picking up on everything, which—it's kind of mean for me to say—is kind of out of character for her. It usually takes her a while. And she even said, "I was practicing at home." She's so excited about this!

However, Alonso was not satisfied with this interpretation of his story, and Samuel jumped in to help him out.

> **Karen**: It's orbiting our planet! I think Sofía might be onto something.
> **Alonso**: It was not moving.
> **Karen**: If we're- It wasn't moving? [Alonso shook his head no.] But I thought you said it was by the tree, and then when you looked it wasn't by the tree anymore.
> **Samuel**: No, instead- it, it, it would just go [gesturing to his right], then when we went again the other side [moving his arm to the left], (indecipherable) on a jar, and then it was right there [pointing up]. And then, we go right there [gesturing to his right] and then we looked at it before, and it was there [pointing to a different place above].
> **Alonso**: [moved from looking at Samuel to looking at Karen] It was on the tree.
> **Samuel**: It was on the tree.
> **Karen**: Ah, okay.
> **Alonso**: And I saw it [pointing up].
> **Karen**: So you moved and it looked like it was somewhere else?
> **Samuel**: Yeah, it looked like it was sitting on the tree.
> **Karen**: It looked like it was sitting on the tree. Cuz you walked somewhere and it made it- Kind of like when we were turning with our skyviewers. We were the ones moving [Karen rotated her body in a circle], but it looked like everyone around us was moving, didn't it?

Alonso's friend Samuel was also an emergent bilingual student, fluent in Spanish as his native language. Alonso and Samuel were sitting nearby each other on the carpet, and they were both listening closely to one another, to Karen, and to Sofía. According to Karen, Samuel "might not volunteer and participate as much, but I think it's because he's focusing so much on the inner translating and keeping up that he doesn't think to step outside of that." To the extent Karen and I may have been struggling to understand the details of their story, it was clear Alonso and Samuel understood one another, and they worked to help each other communicate. This time, Samuel's gesturing brought some clarity: it was not that the two boys had thought the moon was moving, but rather, they noticed that when they moved from one place to another, the moon appeared in a different place in the sky.

As Karen made more moves to further clarify her understanding, she then connected the boys' experience back to a previous activity the class did with "skyviewers." In this activity, students peered through an opening in a sheet of paper towards a center lamp in the room which represented the sun. Extending from the opening in the paper, parallel to the ground, was a paper cityscape. As they rotated their bodies, the "sun" appeared to be over different parts of the cityscape, rising and setting, but students concluded it was not the sun that was moving, but rather their bodies were moving. Of course, their bodies represented the earth in this model. Similar to their current attempts on May 30 to understand why there were seasonal differences in daylight, this attempt to understand why the sun appeared in different places in the sky stretched the students beyond the required NGSS performance expectation (1-ESS1-1: "Use observations of the sun, moon, and stars to describe patterns that can be predicted"). However, students were curious about why the sun was moving across the sky, and Karen thought this activity might help to make an otherwise abstract concept more concrete for her students' developing understanding.

So, Karen tried to help the boys connect their story to what they previously figured out about the sun's apparent motion being caused by the earth's movement. After this, Karen moved on to return to the video.

In our debrief that day, despite the heat, we were excited about the sense-making students had done in the lesson, and Karen did not feel like she had needed to spoon feed as much to students as the day before.

In the Moon Sat on the Tree, Karen made space for students to take up space in the classroom and engage in science in an unorthodox way for school science—through story-telling. In the next narrative, Karen displayed additional moves that were responsive to students' scientific sense-making.

The Nighttime Moon: A Classroom Narrative

In the following narrative, Karen displayed moves that map onto the moves Hoba displayed in the Squirrel Graphs narrative. I chose this story to share because of those similarities in order to identify patterns of practice that are responsive to students' sense-making across both cases.

Towards the end of their 6-week unit on space systems, on June 11 Karen reviewed with her first graders the content they had learned about the day/night cycle in advance of their summative assessment. Previously, they had discovered that the spinning motion of the Earth causes the day and night patterns we experience every 24 hours. They had also explored the idea that the orbit of the Earth around the sun (along with the tilt of the Earth) has to do with seasonal changes we experience on Earth. Throughout the unit, students had constructed, shared, and revised their own scientific models to explain these phenomena. In this particular lesson, students were returning to their day/night class consensus model (Figure 5.3), critiquing it, and

then revising it as a whole group. It became clear some students felt like the moon needed to be included on the model. This was not part of Karen's plan.

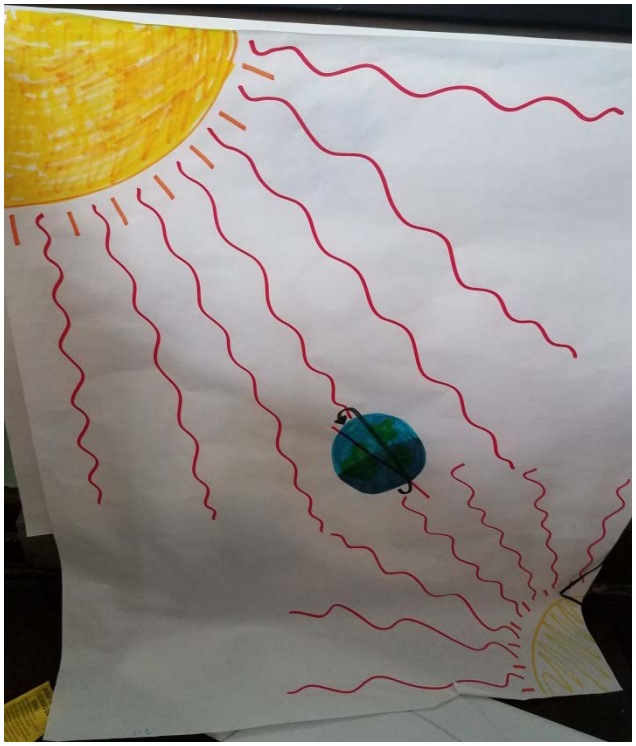


Figure 5.3. Initial class consensus model for day and night

In the following transcript, students were seated on the front carpet together in their assigned spots, discussing what on their model needed to be changed. They agreed there should not be two suns, and one student, Nadia, suggested changing one of the suns—which was pointing at the dark side of the Earth—to a Moon.

> **Nadia**: [walked to board] Put the moon over here, and take off that [pointing to the sun facing the moon].
> **Karen**: So does the moon make nighttime happen? [Nadia nodded head yes.] Raise your hand if you agree with Nadia. [Nadia sat back down on the carpet.] Put a thumb up if you agree with Nadia. In order to have nighttime, the Moon has to be out. Put a thumb down if you disagree. [All hands up, mix of thumbs]

Nadia was a student who typically did well in school. She was often on task, regularly volunteered to participate, and her contributions often aligned well with what Karen was hoping her students would say or do. In this case, Nadia's response was unexpected. Previously in the

unit, the class had a conversation about the moon, and they agreed they had all seen the moon in the sky during the daytime. Since Karen had not planned ahead to have her students keep moon journals, in the absence of actual data to use as evidence of moon patterns, Karen hoped this awareness of the moon in the sky during the daytime would help her students disassociate the moon as related to the day/night cycle. As evidenced in this brief interaction, it did not.

So, Karen walked to the back of the room to draw students' attention to the KLEW(S) chart (Figure 5.4). In the following exchange, Karen practiced her facilitation of students using evidence to support their claims.

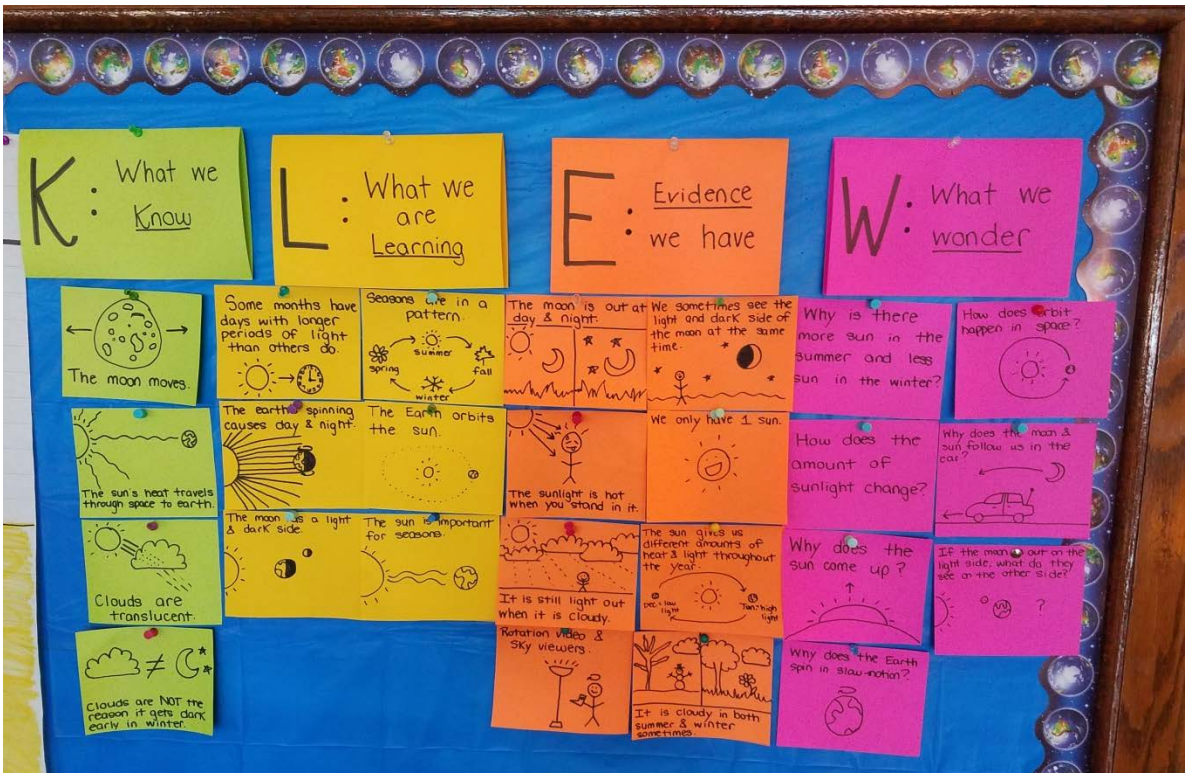


Figure 5.4. The class KLEWS Chart at the end of the unit.

> **Karen**: Well let's review our KLEWS chart. We have some evidence [walked to back of classroom]. I see right there on our evidence that the Moon is out at both day and night. [Walked back to front of room] Because remember we've seen it. We've talked about it. Alonso said he saw it outside, and then you guys all said you saw it outside too.
> **Student**: I've seen it!
> **Karen**: So, does the moon have to be out for it to be nighttime?
> Some students: No

> **Karen**: It can be out in the daytime too, which means sometimes the moon's over here. Sometimes the moon's here, sometimes it's here, sometimes it's here. [pointing to different spots on the model around the Earth]

Karen did a lot of the talking and heavy lifting in this part of the transcript. She was the one to refer back to students' evidence to make a counter-argument to Nadia's claim. For instance, when Nadia made her initial claim about the moon belonging on the dark side of the Earth on the model, the student who just above said "I've seen it!" did not raise his hand to protest Nadia's claim. This reliance on student-gathered evidence for supporting one another's science claims was new to Karen as a teacher, and also new to students. They were still learning this skill, and in the above passage, Karen was modeling the skill for students, to make sure they were still remembering and using their evidence as they continued to engage in scientific sense-making.

From this point in the lesson, Karen pressed further. She asked her students:

> **Karen**: What might be making that happen? What might be making the moon be in different spots? Sometimes it's on the dark side and we see it at night. Sometimes it's on the light. What is making that happen? Malia?
> **Malia**: It's making a circle around the Earth.
> **Karen**: It is! The Moon is orbiting us.

Here, Malia observed the pattern of the moon's positioning around the Earth as looking like a circle, and as she revoiced Malia's observation, Karen referred back to the vocabulary word "orbit" which was previously learned in relation to the Earth's movement around the sun. Next, Karen engaged students to think critically about the moon's placement on the model, asking students to think about the purpose of the model in relation to making this decision.

> **Karen**: So if we put the moon just over here, what might someone think if they saw our model? What might they think? Yoana, what might they be thinking?
> **Yoana**: Well, maybe they'd be thinking, "Ah! The Earth does- the moon goes to the dark side."
> **Karen**: And is that true?
> **Some students**: No
> **Karen**: Could we maybe draw something to show that the moon is moving around the Earth?

Some students: Yes
Karen: That way, whoever looks at our model to learn about day and night will be able to learn that, "Hmm, the Moon goes around [gesturing]. It could be out at day or night."

Some, but not all students participated in these exchanges. Karen was particularly exhausted this day as she had been helping her boyfriend with his sailing race over the weekend, and had not had enough time to recover before coming in to teach this Monday. So, students may have been picking up on Karen's exhaustion and getting tired by the end of the day. Or, perhaps students were really unsure about what they thought about the moon and its relation to the day/night cycle. Or, perhaps they were not sure what Karen *wanted* them to say, so they did not take the risk of saying anything. Either way, it is noteworthy that Yoana was closely following Karen's line of reasoning and responded about how someone might interpret the model, considering Yoana is a student Karen repeatedly referred to as "confused" and disengaged, including later that day when we met after school.

At this point in the lesson, another student chimed in to share something relevant he had learned before.

Zachary: I read in the book that the Earth rotates around the- [gesturing] the Earth.
Karen: The Earth goes around the Earth?
Student: The sun!
Zachary: No, the *moon* goes around.
Karen: The *moon* goes around the Earth. So, do you think that's an important piece? Should we draw that on our day and night model?
Students: [A mix of yes/no responses]

Here, students had been presented with three forms of evidence: their own observations of the moon being in the sky during the daytime, their observations of different places the moon can be in relation to the Earth on their model, and a report from a peer that he read about the moon's orbit in a book. Still, students were not in agreement about whether the moon should be on their model. It would have been interesting to learn why some students were saying no, and other

students were saying yes. However, in the interest of finding closure, Karen attempted to wrap up.

> **Karen**: Yes, because let's think about it. A lot of us were still thinking that the moon was only out at night. And a lot of us were thinking that when the moon comes, it brings nighttime. Is that true?
> **Students**: Yes, No
> **Karen**: Does the moon bring the night?
> **Some students**: No [some nodding head yes]
> **Karen**: But what happens when the moon is out during the day Malia?
> **Malia**: Uh, it's....
> **Karen**: Does it switch to night really fast?
> **Student**: No
> **Karen**: No, so the moon is going around the Earth. It might be out during the day, it might be out at night. Is there anything else that we should change? I know we mentioned we don't want the sun on the dark side. We want to show that the moon is going around the Earth, so it could really be anywhere. Anything else that's wrong with this model that we should maybe change?

Karen's plan was to "review and edit Class Model of day and night" (according to her lesson plan). The goal was to have students recognize there should not be two suns in their model, and to find another way to represent that the sun could be visible from other parts of the Earth. Then she was going to have students compare and contrast their revised model of the day/night cycle and their model of the seasonal cycle. She did not have time to do the comparison after all. Nadia's idea to include the moon was represented on the final model (Figure 5.5).

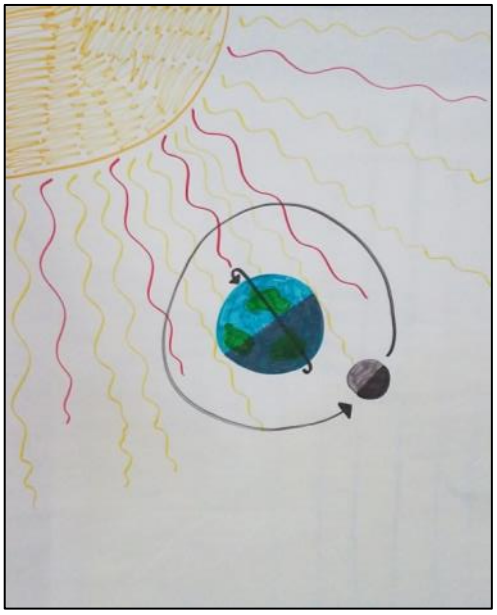


Figure 5.5. The final class consensus model of the day/night cycle.

Characterizing Karen's Disciplinary Responsiveness

Karen made several moves across both narratives that were responsive in disciplinary ways. In this section, I argue that those moves are disciplinarily responsive with the support of literature from science education. I categorize these moves as: providing opportunities for sense-making through modeling, interpreting students' story-telling as valuable, sharing epistemic authority with students, and being flexible with her plans. Note these last two items overlap with two from Hoba's case.

Karen's use of scientific modeling with students throughout the space systems unit provided them with repeated opportunities—often multiple times per week—to construct, critique, and revise their models of the day and night cycle and the seasons. Having students construct models can be a productive entry point for young students to engage in and communicate scientific sense-making (Passmore, Schwarz, & Mankowski, 2017). There are two central features that make a scientific model: (1) "they are sense-making tools that help us predict and explain the world," and (2) "they represent sets of ideas for how a system is put

together for the purpose of understanding how those parts and relationships interact to account for the phenomena we see in the world" (Passmore et al., 2017, p. 114 & 116). In other words, scientific models are tools for sense-making about how and why science phenomena occur. Models can take multiple forms: they can be physical and three-dimensional, which students build or act out; they can be two-dimensional and drawn, which students construct on paper; they can be verbal or numerical; etc. The models Karen's students constructed were primarily drawn models of their ideas about how the day and night cycle works.

Through developing and refining models, Karen's students constructed their own explanations for the scientific phenomena over time, drawing on their ideas and experiences, and increasingly on evidence from classroom experiences to account for how and why the phenomena occur (Windschitl, Thompson, & Braaten, 2018). For Karen's students, this process fostered both individual sense-making as students worked to express their own ideas through their models (not visible in either narrative presented in this chapter), as well as collective sense-making as they used each other's models to refine their own thinking (e.g., their development of the class model in the Nighttime Moon narrative). Modeling is an accessible entry point for first graders, and particularly emergent bilinguals, because of its openness to multiple means of expression. For instance, sometimes Karen's students drew out their ideas on paper, sometimes they labeled their ideas, sometimes they physically acted out what they thought was happening with the sky patterns they were noticing. This enabled them to communicate their current understandings in a variety of ways.

Throughout her space science unit, as students shared their ideas and experiences, Karen responded in ways that indicated she found value in them. The Moon Sat on the Tree narrative is an example of this. In the context of a conversation in which students were making sense of a

model displaying the orbital paths of planets around the sun, Alonso volunteered a story about a strange phenomenon he observed with the moon. Rather than dismiss the story as unrelated, Karen worked to make sense of Alonso's story within the context of their conversation, first working with Sofía's idea that perhaps the moon is orbiting the Earth which explained what Alonso observed, and then suggesting the spinning of the Earth might explain Alonso's story. This ability to consider on the fly how to incorporate students' stories into the science lesson can be challenging, but it is crucial for students to begin to understand how to participate in scientific discourse, as well as to believe they can (National Research Council, 2007). Additionally, Alonso's story was rooted in an experience he had which fascinated him. He knew it was related to what he was learning in science, but he had not yet figured out how or why this experience had occurred. As Gallas (1995) reminds us, scientists often have "initial fascination with a problem [that] originates in childhood wonder," and that circuitously leads towards inquiry and discovery over time. Creating space in science lessons for children to express wonderment and curiosity through story-telling may be central to their ongoing development towards emerging identities as scientists.

Furthermore, Karen repeatedly responded to students' unexpected ideas flexibly. In the Nighttime Moon narrative, Karen included the moon in the final class consensus model for day and night, even though she did not plan to. It was clear students still understood some relationship between nighttime and the moon. More typically teachers continue with their lesson plans when unexpected ideas arise, so "students systematically experience the flow of thought in science class as a predetermined set, and they learn a kind of epistemic activity that is in several ways at odds with scientific inquiry" (Hammer et al., 2012, p. 54). Yet, in Karen's case, she decided to be responsive to students' ideas about the moon. By finding a way, with students, to

include a representation of the moon on their model, Karen facilitated a more authentic version of scientific inquiry which followed students' ways of thinking about the phenomenon rather than her own.

Finally, Karen made space in her teaching by sharing epistemic authority with students (Haverly et al., 2018). When Karen decided to depict the moon orbiting the Earth, this was based on evidence provided by students—they could see the moon during the day sometimes, and a peer had read about this movement in a book. By doing so, Karen positioned students with epistemic authority and as knowers and doers of science.

To summarize, the above narratives highlight disciplinarily responsive moves Karen made throughout our time working together (Table 5.1): (1) she provided multiple and ongoing opportunities for students to express their ideas and engage in sense-making about science phenomena through modeling, (2) she noticed students' stories as valuable to moving the discussions forward thus affording them varied ways to know and do science, (3) she responded flexibly by making space for students' ideas that were not part of her plan but were nevertheless significant to students' sense-making processes, and (4) she shared some epistemic authority with students.

Table 5.1

Karen's Disciplinary Responsiveness Moves

Responsive Moves	**Examples from Narratives**
Providing opportunities for sense-making through modeling	Karen's students constructing and revising scientific models throughout their unit (Nighttime Moon)
Interpreting students' story-telling as valuable	Karen's engagement with Alonso's story about the moon (The Moon Sat on the Tree)
Deviating from plans	Karen's inclusion of the moon in the final class consensus model was not part of her plan (Nighttime Moon)
Sharing epistemic authority	Karen's inclusion of the moon in the final class consensus model was at the insistence of students (Nighttime Moon)

Karen's Equitable Responsiveness

Karen's moves to be disciplinarily responsive to students during science differ from traditional science teaching in important ways. Traditional school science is activity-based and focused on students learning facts and vocabulary (Clegg & Kolodner, 2014; Varelas, Martin, & Kane, 2013). It is laudable that Karen's science pedagogy instead focused on students' sense-making and broadened participation for many students in her classroom.

Traditional science teaching reifies existing hegemonic inequities by forcing students to rely primarily on opportunities outside of school to critically and authentically engage in science. Such informal science education opportunities are more prevalently available to students not living in poverty, which in this country often corresponds to students who are White (Bevan et al., 2018). Furthermore, those outside opportunities often show science as a male-dominated field. All students benefit from the kind of science teaching enacted by Karen, but especially students of Color, girls, emergent bilingual students, and others from marginalized groups to whom out-of-school opportunities to engage in informal science education are less often available.

Karen's science instructional methods engaged students in more authentic experiences with science inquiry which provided them with multiple and varied opportunities for sense-making and being knowers and doers of science. However, this opportunity was not extended to all of Karen's students.

In the remainder of this section, I unpack findings that complicate an understanding of Karen's teaching understood merely through disciplinary responsiveness lens. I begin by presenting a story of Jose and Julia—two twins in Karen's class whom Karen gave up on and decided to retain in first grade. I then present evidence of Karen's color-blind racism, White

fragility, and White emotionality. These orientations of Karen's necessarily inform how we must understand Karen's science teaching practices through an equitable responsiveness lens.

Jose & Julia's Trip to Mexico

Jose and Julia's story stands out among all of my observations of Karen's interactions with students as the most troubling. Therefore, it is worth taking a close look at what happened in this story in order to better understand why these children went through this experience. As in Hoba's chapter, teachers' relationships with students do not fall directly within the definition of expansive equity I articulate in this research, and yet they are foundational to doing the kind of equitable responsiveness I seek to characterize.

In Karen's class there was a set of twins, Jose and Julia. Early in our work together, their family took them and their siblings to Mexico, where they are from, for three weeks. As it happens, Jose and Julia were also struggling academically. Here is how Karen described it to me one day, specifically referring to Jose:

> **Karen:** I hate to say it but he's scoring lower than most of our kindergartners. That's what happens when you do your kid's homework for them and then go on three week vacations to Mexico every year.
> **Christa:** Do you know why they went to Mexico?
> **Karen:** They lied and said it was an emergency. But they go every year and I'm friends with mom on Facebook. There was no emergency. And older brother even said, "It's just a vacation. We go every year." I saw on Facebook they were just having a grand old time – which is fine, but not during the school year!

I do not have data from Jose and Julia's family directly about their trip to Mexico; all I know is what Karen shared with me. However, Karen shared another story with me that may shed a little more light on the matter.

In her first year teaching, Karen must have confronted a similar issue with a family leaving for Mexico for several weeks. When Karen contested their absence to her CEO,

> she told me that that type of mindset comes from the perspective of privilege. Like, "That is a cultural thing for them." Basically my first year saying, "It's illegal to take your kids out of school for a month and go on a vacation to Mexico. I don't care what color you are or what language you speak. It doesn't matter. That's what the rules are here." And she was like, "Well, it's a cultural thing. We spend our Mother's Day with our mothers. Our Mother's Day is different from yours." And I'm like, "It's a cultural thing to not value school?" We need to shake that and say, "No, no, stop using your culture as a crutch for that."

Here a third hypothesis was proposed that may have explained Jose and Julia's family's departure to Mexico—to celebrate Mother's Day. Mother's Day in 2018 was on May 10 in Mexico, and Jose and Julia's family left for Mexico on May 5, so this hypothesis could be valid. Also noteworthy in this excerpt, Karen revealed a color-blind racist frame of cultural racism (Bonilla-Silva, 2018) wherein Karen relied on a culturally-based argument ("stop using your culture as a crutch for that") couched in colorblind racism ("I don't care what color you are") to explain her Mexican students' academic challenges. After sharing Juan and Julia's story, I dig deeper into Karen's racist biases.

I do not know what the purpose of the family trip was. It could have been for an emergency, as stated by the family, and despite happy Facebook posts, they could have had more serious matters to attend to while on the trip as well. It could have been for a vacation, as shared by an older brother in the fifth grade and believed by Karen, which resulted in a prolonged absence from school—a luxury perhaps more commonly afforded to their White affluent peers. It could have been to celebrate Mother's Day with family, as suggested by Karen's CEO several years back, and as would seem to align with the dates over which they left.

On his last day of school before the Mexico trip, Jose and Julia's older brother told his teacher they were leaving for Mexico in two days and did not know when they were coming back. The teacher and principal rushed to make sure he took his state standardized test before leaving. However, they forgot about the younger twins. According to Karen:

> They're not going to NWEA test now, and if you're out for three weeks, I think we're dropping them from enrollment and reporting them to the state because we can't not NWEA these kids. I wish we would have known.

The Northwest Evaluation Association (NWEA; https://www.nwea.org/) administers standardized tests on which the questions get more or less challenging depending on how well the student is answering them. The results provide a measure of student proficiency in math, reading, and/or science. Many schools across the U.S., including ICS, administer the NWEA test three times during the school year in order to measure student growth. Karen felt anxiety related to testing accountability and liability ("we can't not NWEA these kids") which seemed to prompt her decision to advocate for Jose and Julia to be unenrolled from school ("I think we're dropping them from enrollment").

Karen also felt anxiety upon their return to the classroom. Here is an excerpt from my field notes the day they returned (May 29):

> Jose and Julia were back from Mexico today. Karen was really concerned because they spent over an hour in her classroom without being officially enrolled. She was worried about liability if one of them were to choke on food, she would be the one to go to jail.

I am a researcher and an educator, not a lawyer. However, I have a hard time imagining a scenario in which Karen would go to jail if Jose or Julia choked on food in her classroom. So, where did Karen's anxiety come from? A significant percentage of Karen's evaluation, which was tied to her salary, was based on her students' NWEA scores. Inevitably, some of Karen's anxiety came from pressures placed on teachers for being highly accountable for students' academic achievement.

Additionally, Karen's anxiety was associated with feelings of disgust towards Jose and Julia's family for choosing this trip over time in school. Karen sometimes masked this disgust with expressions of care, suggesting that she "wish[ed] we would have known." This presented

as a socially acceptable expression of care masking a socially unacceptable emotion of disgust (Matias & Zembylas, 2014). Karen's emotion of disgust may have been a driving factor in giving up on Jose and Julia, but in lieu of expressing it outright, she expressed care without a subsequent action needed to demonstrate *authentic care* (Matias, 2016; Valenzuela, 1999). Authentic care is predicated on the development of reciprocal relationships that are motivated by an "understanding of the socioeconomic, linguistic, sociocultural, and structural barriers that obstruct the mobility of Mexican youth" (Valenzuela, 1999, p. 109). However, Karen continued to blame Jose and Julia's academic struggles on individual rather than structural reasons. Karen ultimately determined they were too far behind in science to catch up, and she decided to retain them in the first grade because they were "far below grade level."

My responses to Karen's moves to dismiss the academic needs or progress of Jose and Julia were primarily to model what could be accomplished if we did not give up on them. During class, I made it a point to work with Jose and Julia and catch them up with what they had missed. My hope was that in doing so, Karen might recognize the flaw in her logic—that she might come to acknowledge they were capable of learning.

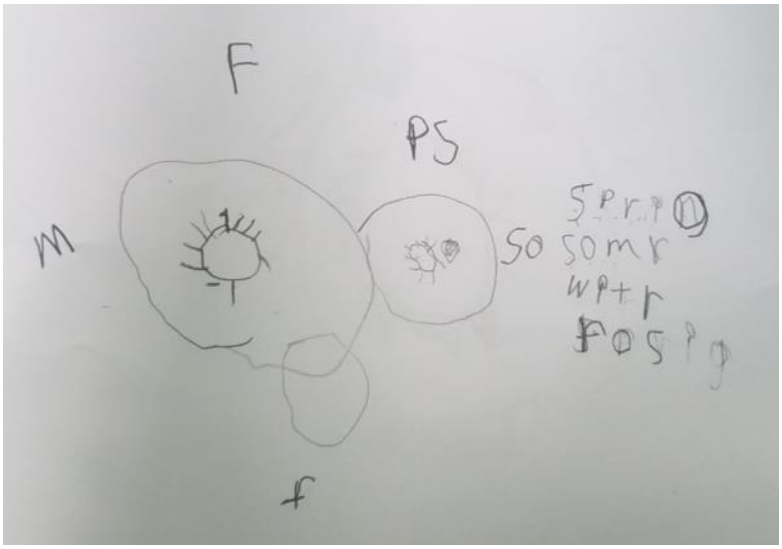


Figure 5.6. Jose's model.

There was one day when my strategy seemed to work. The week before, I spent time in class working with Jose on his model. On June 5, Karen and I were going through students' models from the day's lesson. Students had not had much time to work on their models that day, so we were curious, in their limited time, what they were able to do. Karen had just commented that even though another student's models did not often "say too much," she was impressed with what he accomplished that day. The following transcript picks up our dialogue from there:

> **Christa**: Yeah, so that worked for him even though there wasn't a lot of time. Even Jose got the seasons going around (Figure 5.6).
> **Karen**: He continues to surprise me randomly.
> **Christa**: Yeah, check that out. I thought it was interesting – I think that's the moon, right? So there's parts of it that are still unclear but he got the season –
> **Karen**: Yes, I'll take that! Spring, summer, winter, fall – and again, I don't think I emphasized the whole gaps enough. Or maybe it's because they're six and don't have spatial perception.
> **Christa**: That's very possible.

At this point, we did more co-thinking about why some students were not spacing the seasons or months evenly around Earth's orbital path. This acknowledgement of Karen that Jose was surprising her is what I hoped would happen. However, I missed an opportunity here to explicitly draw a connection I believed existed between the time I invested in him in class the week before to this surprise in our debrief. In other words, with some guidance from me, Jose was able to figure out how to construct a model of his current understanding of the phenomenon based on his everyday and classroom experiences. He was not a lost cause.

On June 6, we were flipping through models again. When we got to Julia's (Figure 5.7), Karen shared that she had noticed me working with her during class that day, and she said, "That was nice of you to work with her." I explained that I was working with Julia and questioning her about her model ("Was anything moving?" She said, "No."), reminding her about evidence she could refer to from our recent science lessons to help her sense-making about the movement of

Earth around the sun. Then Alonso—the student who saw the moon sitting on a tree and who sits at the same table as Julia—said "*pais*" (country, in Spanish) quietly to Julia. I thought he was trying to refer to Earth, so I worked with Alonso and Julia to come up with the word *planeta* since I could not remember the word for Earth (I knew *tierra* was soil, was it also "Earth"?). From that point, I used both Spanish and English to communicate with Julia about her model and the evidence she could use to support her thinking. During this conversation, Julia decided to add an arrow to her model. I then enlisted Alonso's help to continue working with Julia on her model as I walked away from the table.

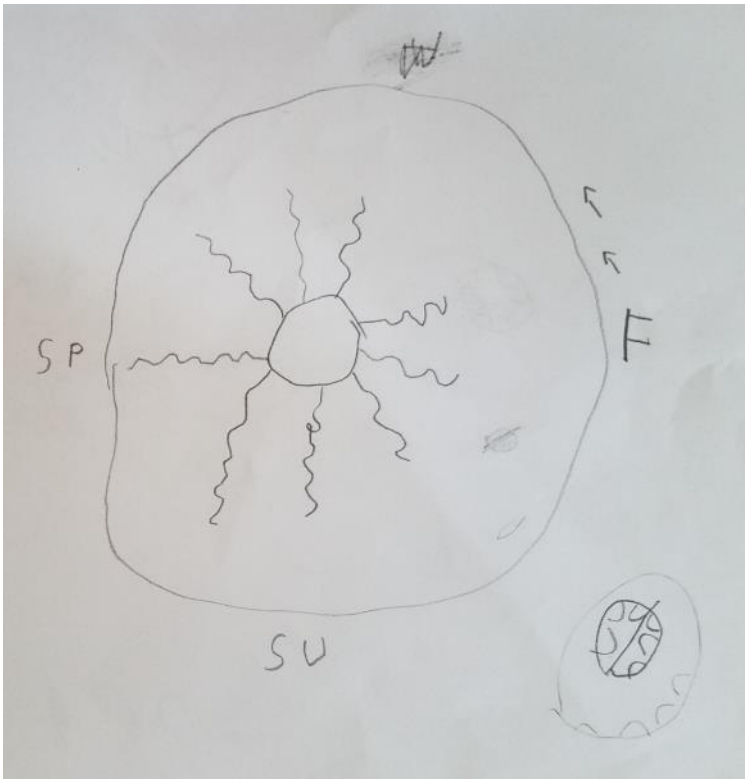


Figure 5.7. Julia's model.

At this point in the debrief, Karen complemented Julia's model, saying:

Karen: Hey, but her seasons are in the right order, and it's showing movement in this direction.
Christa: Yes, and I think that part she got from Alonso. So, after I walked away, then she came and she showed this to me afterwards, and she had the seasons. So, it was good, I

was glad that I had a chance to work with her. And it's nice that- I was glad that Alonso had a chance to help her instead of always being the one that's being helped.
Karen: I'm really glad that you did that, and I'm really kicking myself of not thinking of doing that sooner. Cuz he does well- again, it's hit or miss on the moon, it's on the day he's having. But lately his behavior's been a lot better. And he really does thrive when he's put in a leadership position. It's just- there are so many days I can't trust him in that.

This time I more explicitly connected Julia's achievement in her model to the time I spent working with her (i.e., we should not be giving up on these kids). Separately, Karen and I had been noticing throughout the unit that Alonso's models were often copies of Zachary's, another student at his table. On this day, when he helped Julia, he positioned himself as a leader rather than taking the position of follower. I noted in Karen's response that she was more excited about this learning opportunity for Alonso than for Julia, and my suspicions were confirmed when the following exchange occurred just a bit later in our debrief.

After reviewing everyone's models, I noticed Julia's Earth in her model was not placed on the orbital pathway she drew, and I noticed this in other students' models as well. It occurred to me that in the model Karen constructed with students that day, there was no Earth. It was an oversight on our part in planning for the lesson. So, I pointed it out as we were planning for the next day's lesson:

Christa: You know I'm wondering if for students like Julia, who are still not putting the Earth on the orbit, if you need an Earth? Something to represent Earth on your model.
Karen: Oh!
Christa: That just now occurred to me, I hadn't thought of it
Karen: I didn't think of it either. That would be good. Not necessarily for Julia's sake, but for students like Julia.

Karen's comment that this instructional move would be worthwhile for the sake of others but not Julia was indicative of the extent to which Karen had given up on Julia's (and Jose's) academic progress.

Karen went on to explain how she had checked to be sure, and Jose and Julia were not going to be making up the NWEA tests. Another student who was out on extended leave for medical reasons for about the same amount of time as Jose and Julia did make up the NWEA. However, the testing coordinator said “too bad” about Jose and Julia, and Karen was more relieved than anything since she was worried about their scores bringing down her averages. Here, Karen explained the underlying reason for her concern about Julia and Jose:

> Well, basically I'm having them retained. Their scores were so low in the winter, and showed such little growth to begin with, that my case is going to be very easy to- you know- and they were gone! They legally can't go to second grade anyways. They were gone. So, they're going to try to fight it and say that their kids are academically ready. I will say, "No, they are not. Have your kids write numbers 1-50 right now." That's not even first grade standard. They can't do it. They're not there. And, behaviorally, everything. They were retained in kindergarten too, because they leave all the time, go on vacations, so.…. It would bring my scores down. My averages down. So I don't want them to take it. Because I know their scores are going to be super low, super, super low. Lower than any of my other kids. It's not fair to me.

Karen was seriously concerned about test scores—a real concern, indeed, for many teachers. Bringing her class average down could have a direct impact on Karen’s end-of-year evaluation, and therefore on her salary. This complicates Karen’s story by situating her responses to Jose and Julia within a neoliberal testing system that constrains teachers’ abilities to be forgiving of families when the system is so unforgiving of the teachers. However, Karen’s responses were also influenced by her worldview which was heavily informed by White supremacist notions of good versus bad.

Karen’s read on Jose and Julia’s family was that they did not care about education since they took a 3-week trip to Mexico during the school year and they did their kids’ homework for them. Not caring about education is a common stereotype used against marginalized families (Valenzuela, 1999). Karen was motivated by this stereotype as she used it to make sense of what was happening, and it exposed her cultural racism (Bonilla-Silva, 2018).

Additionally, Karen sometimes expressed her colorblind racism masked in caring. Her caring was expressed as an aesthetic caring, "in appearance only" (Matias, 2016, p. 38). Authentic caring requires action, but Karen's actions were not caring. Karen portrayed her actions as though they were natural outcomes of events which were out of her control—that she held Jose and Julia back in first grade due to a lack of academic progress. However, this choice was motivated by her deficit-oriented stereotypes and sense of betrayal for being accountable for their vacation. It was not a natural outcome, nor an act of authentic caring.

Jose and Julia's story is one example of an oppressive student-teacher relationship. Though student-teacher relationships are not part of the definition of expansive equity, they are a foundation on which equitable responsiveness can happen, and this foundation was not strong. In order to more fully understand how Karen came to so easily dismiss Julia and Jose, it is helpful to better understand Karen's worldview. In the remainder of this section exploring Karen's science teaching practices through an equity lens, I present findings that illustrate Karen's deficit-based stereotypes and her viewpoints on affirmative action and assimilation.

Karen's Deficit Stereotypes

During her time at ICS, Karen was learning about Latinx culture—sort of. She had two Latinx friends in the building—a para professional from Puerto Rico named Eva and an office administrator from Mexico named Evelin—whom she considered confidantes. Karen often turned to Eva and Evelin for advice or input, particularly when she was frustrated by student behaviors or by accusations from her CEO of cultural insensitivity. Karen's takeaways from these conversations seemed to largely support what Karen wanted to hear—confirmation that undesired student behaviors were consequences of family or cultural deficits, or that she was not

being culturally insensitive. The following is an example of one of these conversations Karen shared with me:

> Well, this is something that Evelin pointed out. Eva and Evelin are like best friends. Evelin works in our front office right now and she told me that Puerto Ricans are very whiny. Evelin is not Puerto Rican, but I told Eva. I was like, "Eva, guess what Evelin said about Puerto Ricans?" And I told her and she was like, "What?" I said, "No, we were talking about [a student]." And she was like, "Oh yeah. Yeah, Puerto Ricans baby their children. They tolerate whining. They learn the whining from their parents." Eva even kind of agreed to it. So there are different cultural norms that I'm not aware of. Once I hear it from my colleagues, I do see it in some of my kids.

While Eva or Evelin may have been influenced by White-supremacist deficit perspectives on children and families from their communities, it is also possible Karen's interpretations of these conversations did not match the intended meanings. Karen's interpretations led her to reify her existing stereotypes of students' families which influenced how she interacted with students like Jose and Julia.

Jessica was the CEO of ICS and a Latinx woman; however, as I mentioned briefly early in this chapter, Karen did not trust Jessica's judgment as a leader or as a cultural broker. For example, in her first year teaching at ICS, Karen had a rule in her classroom that if students did not have their homework complete, they lost five minutes of recess. After a parent complaint, Jessica told her she could not do this anymore and gave her the book *No More Taking Away Recess* (Cassetta & Sawyer, 2013).

> I'm like, "I'm not reading this." That was the most insulting thing anyone had ever done to me. So what do I do every day? I take recess away for five minutes. And guess what? My kids don't cry about it and they get their homework done much more often than not. It works. None of them are damaged. They're all fine, they still all get their recess time except five minutes. And I was told that that was a cultural thing—that Latino parents, I get it, they baby their kids. Well maybe they need to stop. And then I have other Latino parents, like Eva who works here, who is like, "Yeah, Puerto Ricans don't do that." It's so weird what is and what isn't. Can't we just be like, "This is a school in Hatton. This is what we want for all of our kids no matter what color they are. This is how we're going to get there together." We're starting to get there.

Karen's CEO appeared to be sending her a message that, culturally, Latinx parents baby their kids, so students should not have recess taken away for not doing their homework. Previously, Karen had told me Eva had also said Puerto Rican parents baby their kids. Now Karen was telling me Eva told her they "don't do that." Again, I was not present for these conversations; I only know them through Karen's re-telling. It is possible Karen's colleagues (in particular, Eva) were sending different messages to Karen for different purposes—sometimes to contradict their CEO, and other times to agree with Karen. Or, it is possible Karen understood their messages in ways that supported her own cultural racism (Bonilla-Silva, 2018).

On multiple occasions Jessica accused Karen of being culturally insensitive. On these occasions, Karen went to her Latinx colleagues who, according to Karen, repeatedly assured her she was not being culturally insensitive in those moments.

> And then I talk to my Mexican colleagues and they're like, "That's not a cultural thing! Whoever told you that, don't let them make you think you're being racist." That's what the other first grade teacher has told me multiple times. She's like, "No, I'm Mexican, and that is not a cultural thing. She's trying to make you think those ideas are racist so you stop having them."

Karen understood from these trusted women that she correctly interpreted student and family behaviors, and this contributed to her lack of confidence in Jessica. It also contributed to her lack of understanding of Latinx culture and her deficit perspectives.

Karen on Affirmative Action

In one of our early conversations I was introducing Karen to equity constructs which informed my understanding of equity issues in education. One of these ideas was a critique of meritocracy. Karen quickly agreed that meritocracy is not a reality for everyone because, as she said, "if every single kid this year who is a senior in high school graduated with a 4.0 GPA, not every single one is getting into college because there's not enough room. It's just the way it is." I

proceeded to introduce the idea of racial bias as part of the problem, telling her about the bias studies which have concluded that the likelihood of being called for an interview decreases when one's resume shows a name that sounds more African American. Karen responded with the following story:

> It's actually the opposite because one of my best friends from high school—no AP classes, wasn't on the honor roll, a Black friend of mine, she got into University of Midwest. I was only allowed to go there if I double majored. They wanted more money from me. And she was offended! She's like, "You have a higher GPA than me. You took AP classes. You clearly are going to do better at University of Midwest than I'm going to." She was like, "Just because I'm Black they think that I need that extra boost." And I went to the same schools and had the same opportunities, and because I'm White they assume I have money. It was so weird. Affirmative action has kind of screwed me over and offended all my Black friends.

Karen felt it was unfair that her Black friend whom she (and supposedly the Black friend) perceived as less prepared to be successful at University of Midwest, a prestigious private university, was accepted, but Karen was only accepted provisionally. Here Karen is more concerned about equality than equity. In this way, Karen expressed a form of colorblind racism that Bonilla-Silva (2018) calls abstract liberalism—the use of liberal ideas like "equal opportunity" to negate the need to atone for historical disadvantages. Karen did not understand that affirmative action was intended to make up for historic inequalities.

I tried to point out to Karen that, "My way of understanding that is that what it's trying to do is take into account historical injustices—." However, to Karen, this was precisely the problem with affirmative action.

> Exactly. But for them [her Black friends] they're like, "That happened 200 years ago!" My family moved here after slavery! I feel like some of my Black friends want to move forward, whereas another one on the other day is like, "Bill Cosby just got arrested for his actions; should White people go to jail for slavery?" I'm like, "Are you kidding me? How could you even say that?" My family never owned slaves. We moved here at the turn of the century. What a dumb thing to say!

Again, Karen was more concerned about equality, or sameness, than equity because equity accounted for injustices which to Karen were ancient history and were not enacted by all White people—certainly not by her or her family nor to her Black friends. Therefore, it was unfair to think someone like her might be accountable now. What Karen described as fair was another expression of abstract liberalism—blind to the relatively recent history of African Americans and the social repercussions of White supremacy and slavery experienced by the African American community (Bonilla-Silva, 2018). Her sense of fairness was rooted in her own experiences as a White woman existing in this country, and her perception of the experiences of select friends of Color, with these personal stories superseding other evidence presented to her, for instance in well-cited research about racial bias.

Karen on Assimilation

When I asked Karen about what countries her students and their families immigrated from (mostly from Mexico), it spurred a conversation about culture, during which Karen mentioned she did not feel like she had much of a culture.

> **Karen:** I feel like I don't have any culture in my family. We don't embrace any traditions. I've got some German in me but I don't know anything about German traditions. Dutch-English? I don't even know what that means! I like food from everywhere, pretty much. And then you've got my boyfriend's family who are like, "We are Polish!" They sing in Polish every birthday. They celebrate that and embrace it. But they're not just Polish but they identify with that the most. It's so funny, I'm like, "We're American! We like cheeseburgers and hot dogs and we watch Friends and Seinfeld!"
> **Christa:** But I think that is culture, right? I totally get what you're saying. For me, the perspective I always take is like, "Okay, if I were to travel to another country, what do they do that is different from what I do?" And what's different is that's my culture, right?
> **Karen:** And that's what is so cool about America. We are a melting pot. We are pretty much the youngest country in terms of nationality and customs. In terms of traditions, we're so new; we came along so late that the rest of the world was already established in their traditions that we just kind of stole and borrowed and changed. And as a result, people like me are like, "We don't celebrate anything!"

Karen's cultural norms and traditions were not visible to her in spite of the efforts I made to share from my own experiences how I came to see my own culture. Karen's Whiteness was too normalized. This aligns with Bonilla-Silva's (2018) naturalization frame of color-blind racism, wherein White people see the current state of racial phenomena (in this case, the U.S. as a melting pot in which we "steal, borrow, and change traditions") as normal and natural.

At her core, Karen believed in the importance of assimilation, a belief that resulted in words and actions deemed culturally insensitive by Jessica.

> And when I'm told that I'm being culturally insensitive it's when I'm saying, "It doesn't matter what language you speak. It should not matter what color your skin is. We're all here now, we're all in this together, we all want success for our students. This is how you're used to things being done, now here are our laws." And that's the thing—some of the parents just don't know the laws because they just moved here. "These are what the laws are. These are the rules we have in school that are in support of those laws and we are here to help you transition into a new lifestyle. Any questions, concerns, comments you have, come to us." We're a very open school like that. But then it's like, let's talk about the attendance issue. That's not a cultural issue. We've got Malia, who is a Black student who had really horrible attendance. We've the Acosta family who is White and they have horrendous attendance. That's why when I step in I'm like, "You know what? Yes, race is a thing. Yes we have cultural backgrounds. Yes we have different tongues that we speak in and different belief systems. But we're all here right now and the goal is academic success." Some parents might not like what we're recommending but we've got data to back up everything we're doing here. We have the facts on our side. We have logic. It's like Calm Classroom; if you think that yoga is the devil and meditation is evil because it's not Christian, take your child elsewhere because this is what we're doing here.

This statement of Karen's exposed more color-blind abstract liberalism when Karen said, "We all want success for our students," and "take your child elsewhere because this is what we're doing here." This is both political liberalism of "equal opportunity" and economic liberalism around choice (Bonilla-Silva, 2018). Karen also expressed care ("we are here to help you transition into a new lifestyle") that thinly masked disgust ("if you think that yoga is the devil and meditation is evil") towards her students and their families (Matias & Zembylas, 2014)

Karen's commitment to assimilation compelled her towards decisions she made in her interactions with families, students, and colleagues. They informed how she understood the attendance problem she spoke about frequently. They informed how she thought about the kinds of lunches students brought in from home which needed to be refrigerated and re-heated at lunch time (i.e., "pack something else that's packed with love" because your children "don't have time to eat" and can get sick with food that's not adequately kept cold during the day). When she was accused of being culturally insensitive, she found comfort in the words of colleagues who she believed were supportive of her.

Taking together what we know about Karen's deficit stereotypes and beliefs about affirmative action and assimilation, it is easier to understand the decisions she made with Jose and Julia. In the following paragraphs, I unpack Karen's lack of equitably responsive teaching practices.

Karen's (Lack of) Equitable Responsiveness

As I stated previously, in many ways, Karen's enactment of moves that were disciplinarily responsive showed promise towards also being equitably responsive. However, a closer inspection of Karen's relationship with Jose and Julia, and her underlying racist worldview, suggests that overall her practice was not equitable.

Karen's motivations to retain Jose and Julia were driven by her color-blindness. Karen strongly believed all students deserve a good education and she must teach her best to all of her students regardless of their race, culture, linguistic background, or class. Karen equated "equality with sameness" (North, 2008, p. 1187), an abstract liberal notion of equality which Bonilla-Silva (2018) describes as color-blind racism. This abstract liberalism also surfaced in Karen's opposition to affirmative action because of her perceived unequal treatment from her Black

friend as well as in assimilation. Additionally, Karen's cultural racism (Bonilla-Silva, 2018) allowed her to believe negative stereotypes about her students. This included, for example, those apparently communicated by her Latinx colleagues about how her students' parents babied their children to the detriment of their academic growth. Karen's expressions that her students and their families needed to learn the rules of the school and country now that they were here were expressed without nuance for maintaining their cultural norms and practices.

Karen was also driven by her White emotionality and White fragility (DiAngelo, 2018; Matias, 2016). When Karen was confronted with accusations of being culturally insensitive, she responded with anger ("That was the most insulting thing that anyone had ever done to me")—a common response born out of a lack of emotional capacity for White people to confront our own racist beliefs and actions (DiAngelo, 2018). Furthermore, Karen masked her racist beliefs and actions with expressions of care ("Any questions, concerns, comments you have, come to us") despite more pernicious beliefs of superiority ("We have the facts on our side. We have logic."). These empty expressions of care were an enactment of White emotionality—expressions of care devoid of authenticity or action, but which rather mask forms of racism less socially acceptable to express (Matias, 2016).

Karen's beliefs about assimilation made it easier for her to take on deficit perspectives of her students. When students or families behaved differently from her expectations or worldview, her response was to view those behaviors as inferior, as not focusing enough on academic achievement, or as unfair. She rationalized these beliefs with color-blind racism, and she hid these beliefs (to some extent) with false expressions of empathy. This resulted in her oppressive relationships with Jose and Julia. When their family took a trip to Mexico for three weeks towards the end of the school year, Karen's color-blind racism was triggered. Karen's cultural

racism allowed her to believe stereotypes of the family's lack of care for their children's education. Karen's abstract liberalism allowed her to view the family's choice as counter-normative to U.S. customs. Karen briefly expressed some care ("I wish we had known") before un-enrolling them from school and later retaining them in the first grade. Within the context of ICS and standardized test pressures, Karen felt put upon that the family would do this *to her* and jeopardize her final evaluation due to their children's low test scores.

To summarize, on the surface, Karen's disciplinary responsiveness appeared to promote equity. Her pedagogy was strong, and she was teaching with strong pedagogy to emergent bilingual students, students of Color, and girls. In this way, Karen was providing students who are traditionally marginalized in science with access to disciplinary knowledge in varied ways that allowed them to be knowers and doers of science. However, this opportunity was not extended to all students. In particular, she considered Jose and Julia as lost causes. This decision can be explained by Karen's colorblind racist worldview which believed in deficit perspectives of her students' families (babying their kids, not caring about their education) and the importance of assimilating to the rules and norms of ICS in the United States. Jose and Julia's story is the strongest story I have in my data to show how Karen's worldviews permeated her teaching. Her worldview surfaced in other interactions with students, with students' families, and with her colleagues. These troubling stories, along with a recognition of the strength of Karen's science teaching pedagogy, tell a more complete picture of who Karen was as a teacher.

Conclusion

I want to end with a similar note that I began with: this chapter has been the most difficult for me to write in this entire manuscript. In my work with Karen, I developed what I considered to be a strong partnership rooted in trust. In fact, our work has extended past the seven weeks of

this study as we have continued writing a publication, designing curriculum, and planning professional learning experiences together. I value my opportunities to work with Karen despite her shortcomings. Knowing how sensitive White people are to being labeled racist (and at this point in my journey, I consider myself one of these), I have feared Karen might be offended by my words on these pages and thus feel betrayed by me. Yet it felt necessary to paint a holistic picture of my interpretation of Karen and her teaching practices based on what she shared with me during this time working together and my current understanding of the field of Critical Whiteness Studies. The purpose of my research and work with Karen, I hope, is to move the needle, if only slightly, in our understanding of the work cut out for us as researchers, professional developers, and teacher educators, in working with White teachers, and particularly White teachers of students of Color. Withholding pertinent information towards this end would be unethical, so I have been compelled to share some unflattering findings about Karen. I have also wondered through this process how much my own White fragility (DiAngelo, 2018) has factored in to my hesitations and grappling around analyzing and writing Karen's case.

For any White researcher entering into a partnership with a White teacher with whom you develop a strong relationship, but in whom you identify faults, this case shows how complicated navigating this terrain can be. Yet hopefully there are some takeaways about how to approach the work. For me, I have tried to paint a picture that truthfully depicts the rich terrain of Karen's practice: the strong pedagogical work she did with many of her students alongside the troubling stories that complicate her case. Both exist and are true for Karen, and both exist within White supremacist systems and structures which are largely invisible to her.

CHAPTER SIX:

Conclusion

In this research project, I worked with two urban elementary teachers for about seven weeks each. During that time, I studied their science teaching, looked for evidence of disciplinary and equitable responsiveness, investigated what they seemed to foreground in their responsive science teaching practices, and tried to understand why they did so. In this conclusion chapter, I summarize findings across the two cases and propose a framework and implications of this work for research and practice. I begin by proposing a theoretical framework for understanding the relationship between disciplinary and equitable responsiveness based on this study and my review of literature. As I explain each component of the framework, I suggest specific moves that surfaced in my two case studies that teachers can make towards being responsive in both disciplinary and equitable ways. In other words, I consider what this kind of teaching might look like practically in elementary science classrooms. I end with final thoughts on implications for research and practice.

Towards a Framework of Equitable Disciplinary Responsiveness

Disciplinary frameworks of responsiveness in math and science education often focus on teachers' noticing and responding (e.g., Kang & Anderson, 2015; Thompson et al., 2016). There are a myriad of things teachers may notice in any given moment of instruction. When teachers are able to tune in carefully to students' science ideas and find ways of responding that engage students in working with and on students' ideas in science class, this is being responsive in productive disciplinary ways (Hammer et al., 2012). In their review of literature on responsive science and mathematics teaching, Richards and Robertson (2016) noted that many scholars doing work in this field point to the possibility of responsiveness for increasing equitable participation in science learning. In other words, equity is about enabling participation of multiple voices and therefore equity is positioned as a by-product of disciplinarily-responsive

science teaching. Evidence from this dissertation and other research indicates there are opportunities for teachers to be more or less equitable when noticing and responding to students. Equitably responding depends on any number of factors, including the types of opportunities teachers provide students to share their ideas in the first place, whose ideas they tend to notice more frequently, how likely they are to interpret diverse representations of science as science, the manner in which they decide to respond, and so on. Therefore, there are robust opportunities to address equity within the Noticing and Responding framework given those factors. However, with some notable exceptions (including recent work by Hand, 2012, 2017), current emphases of the Noticing and Responding work leave out what it means to be responsive in equitable ways if the focus is simply on teachers' disciplinary Noticing and Responding practices.

As a result of analyses from this dissertation, I propose teachers' disciplinary noticing and responding is *one part of* equitable pedagogy, which in turn is *one component of* equitable responsiveness (Table 6.1). Recall from chapter 2 the conceptual frameworks I constructed on disciplinary and equitable responsiveness. Table 6.1 represents the merging of disciplinary responsiveness as one part of what it means to be equitably responsive—an enactment of equitable pedagogy. Thus, rather than equity being a by-product of disciplinary responsiveness, equitably responding to students throughout cycles of opportunities, noticing, interpreting, and responding is an enactment of equitable pedagogy, and therefore part of what it means to be equitably responsive.

Table 6.1

The Merging of Two Lenses on Responsiveness

Equitable Responsiveness		Disciplinary Responsiveness
Equitable Curriculum and Pedagogy	←	Opportunities
	←	Noticing
Equitable Interrelationships		Interpreting
Knowledge of Issues of Equity		Responding

Other researchers have also moved to consider both equitable and disciplinary aspects of teaching. For example, recent work by Thompson et al. (2016) substituted the word "rigor" for responsiveness (i.e., rigorous science instruction as responsive in disciplinary ways), and they used the word "responsiveness" more along the lines of how multicultural education scholars might think of being culturally responsive. In this way, Thompson's group began considering how both disciplinary and equitable aspects of science teaching (or responsiveness) are important and possibly (or at least analytically) distinct. Importantly, however, Thompson's work did not emphasize the role of relationships in equity which surfaced in this study as foundational to equitable science teaching.

Many multicultural education scholars center the importance of teacher-student and student-student relationships in their work (including Delpit, 2012; Gay, 2010; Ladson-Billings, 2009; Milner, 2010; Paris, 2012). There are some in science education who also pay close attention to the role of relationships in the science classroom, for example, in the work of Parsons (2005) and Kang (2018). In the framework I propose for Equitable Disciplinary Responsiveness (EDR), I place the role of relationships in a central position. Considering the central role relationships seemed to play in the cases presented in this research, and considering my review of literature, I am convinced this is an important analytical consideration of equitable science teaching.

Based on findings from my two cases, I created the model of Equitable Disciplinary Responsiveness (Figure 6.1) as a way to dig deeper into the components of Equitable Responsiveness as presented in chapter 2 and Table 6.1 with an understanding that Disciplinary Responsiveness is one part of what it can look like to enact equitable pedagogy. Below, I unpack the components of EDR.

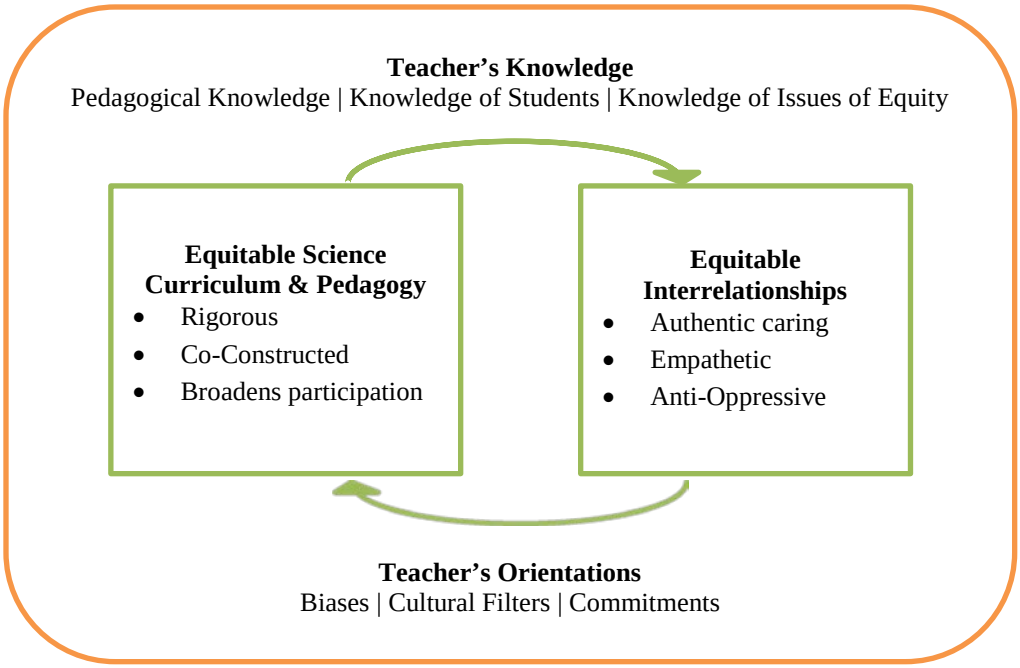


Figure 6.1. Model of Equitable Disciplinary Responsiveness (EDR)

In the EDR framework, the outer orange ring signifies the teachers' knowledge and orientations. This informs the center green boxes that are the visible enactments of responsiveness. Equitable science curriculum and equitable interrelationships (green boxes) interact with one another in practice—one informing or influencing the other—hence the arrows between them in the framework. Noticing and responding are integral components of equitable pedagogy to the extent that they have the potential to contribute to academic rigor and influence learning outcomes of co-constructed science storylines and broadened participation. In the following paragraphs, I unpack each part of the framework, leveraging both scholarly work in the field as well as findings from this dissertation.

Unpacking EDR: Planning and Enacting Equitable Science Curriculum and Pedagogy

Planning and enacting equitable curriculum and pedagogy is critical to students' academic success and political engagement (Figure 6.1, green box on the left). Equitable science curriculum must be academically rigorous in order to provide all students access to the culture of

power (Calabrese Barton & Yang, 2000; Delpit, 1988; Ladson-Billings, 2009; Thompson et al., 2016). In part, this may be done by providing students with opportunities for sense-making about phenomena (Kang & Anderson, 2015). Equitable science teaching (curriculum & pedagogy) must also broaden participation of traditionally marginalized students in STEM by valuing and leveraging students' diverse funds of knowledge as well as by expanding notions of what counts as science and science participation in schools and in the community (Bevan et al., 2018; Moje, 2007). This may be accomplished through integrating place (Gruenewald, 2003), teaching for equity literacy (Gorski, 2016), centering youth-oriented authentic experiences (Buxton, 2006), and so on. Finally, through noticing and responding to students' sense-making, teachers facilitate co-constructed science storylines by sharing epistemic authority with students (Haverly et al., 2018).

These enactments of curriculum and pedagogy are crucial for equitable science teaching because they engage learners as knowers and doers of science in ways which traditional science teaching does not. There is plenty of support for White, able-bodied, heterosexual males outside of school to pursue participation in science over the long-term despite traditional school science because they can more readily identify with and see themselves as belonging in the field of science. This is not the case for those students who do not identify with these normative ways of being (Bevan et al., 2018). Therefore, it is imperative for school science to continue to push for science instruction that provides support to students of Color, emergent bilinguals, girls, and other non-dominant groups to see themselves as participants in science.

Note this description of curriculum and pedagogy does not include a critique of hegemonic big ideas or norms in science and a leveraging of science learning towards fighting injustices relevant to students' lived experiences. These and other approaches to equitable

science curriculum and pedagogy should be incorporated into the model for use in future research. Because this project leveraged an expansive lens on equity, it focused on opportunities of curriculum and pedagogy to broaden participation by students as knowers and doers of science.

The cases in this dissertation provide some insight into what expansively equitable science curriculum and pedagogy could look like (Table 6.2). For example, in Hoba's Squirrel Graphs narrative, Hoba integrated place intentionally into her curriculum in order to be responsive to her students' sense of belonging in their community (Gruenewald, 2003; Thompson et al., 2016)—this move had the potential to broaden participation in science for her students. Hoba then deviated from her plans in order to follow students' sense-making and make space for students to figure out how best to represent their data, resulting in a co-constructed science storyline (Haverly et al., 2018). In Karen's Nighttime Moon narrative, Karen responded flexibly to students' ideas about including the moon in their class model, and through this and other modeling experiences, she gave students opportunities to be curious about the universe and to engage in rigorous sense-making, providing (some of) her marginalized students access to a culture of power (Delpit, 1988; Ladson-Billings, 2009). Karen and Hoba both made space for multiple modes of knowing and doing science through their curriculum and pedagogy.

Table 6.2

Teacher Moves Aligned with Equitable Science Curriculum or Pedagogy

Teacher Move	**Example(s) from Cases**	**Location in Framework**	**Support from Literature**
Providing opportunities for sense-making through modeling	Karen's Nighttime Moon Narrative	Curriculum > Rigorous	Passmore et al. (2017)
Integrating place	Hoba's Squirrel Graphs Narrative	Curriculum > Broadening Participation	Gruenewald (2003)

Table 6.2 (cont'd)

Interpreting students' story-telling as valuable	Karen's Moon Sat on the Tree Narrative Hoba's students' opportunity to share stories about squirrels	Pedagogy > Broadening Participation	Gay (2010)
Deviating from plans	Hoba's Squirrel Graphs Narrative Karen's Nighttime Moon Narrative	Pedagogy > Co-Constructed Science Storyline	Hammer et al. (2012)
Sharing epistemic authority	Hoba's Squirrel Graphs Narrative Karen's Nighttime Moon Narrative	Pedagogy > Co-Constructed Science Storyline	Haverly et al. (2018)

Unpacking EDR: Fostering Equitable Interrelationships

Fostering equitable interrelationships with students is essential to students' social-emotional growth and development (Figure 6.1, green box on the right). These relationships are predicated on caring, which is underneath everything teachers do (Noddings, 2012), including engaging in equitable science teaching practices. Authentic caring occurs when teachers have an understanding of the systemic structures that oppress students, and through their actions they empower students to transcend inequities (Ladson-Billings, 1995a; Parsons, 2005; Valenzuela, 1999). Through perspective-taking, teachers express empathy for students through an affective response of feeling what students are going through in addition to an intellectual response of understanding what they are going through (Noddings, 2010; Warren, 2017). Finally, "systemic inequities and inequalities are preserved and perpetuated by the teacher's actions" (Parsons, 2005, p. 26) unless they engage in anti-oppressive relationships which account for the racial and cultural contexts of the school (Milner, 2010).

To note once again, those who take a more critical justice perspective on equity may be additionally interested in teachers' relationships within the communities they serve and their

associated engagement in justice movements in and outside of the classroom. It is possible these relationships could be embedded within the equitable interrelationships part of my proposed model for future research endeavors in equitable science teaching and learning. In this project's focus on an expansive lens on equity, I pay closer attention to teachers' relationships with students in their classrooms.

Both teachers in this study said they cared about their students; however, they had different ways of expressing this care. Hoba cared deeply about her students and had knowledge of systemic, oppressive structures affecting her students. Hoba worked hard to develop anti-oppressive relationships with students, expressing both empathy towards students and culturally relevant caring (Table 6.3; Parsons, 2005; Warren, 2017). She felt this challenge more acutely with the sheer number of students she interacted with on a weekly basis. Karen expressed care for many of students, but this expression of care thinly veiled feelings of disgust for them and their families (Matias & Zembylas, 2014). As a result, she did not express empathy for all of her students, and she engaged in oppressive relationships with at least two of them (Milner, 2010; Warren, 2017).

Table 6.3

Teacher Moves Aligned with Equitable Interrelationships with Students

Teacher Move	**Example(s) from Cases**	**Location in Framework**	**Support from the Literature**
Listening to students' concerns and expressions of emotion	Hoba's Art Class Incident Narrative	Authentic Caring	Valenzuela (1999)
Responding to students' humor with humor	Hoba's Interactions with AJ	Empathetic Anti-Oppressive	Varelas et al. (2002)

Unpacking EDR: Teachers' Knowledge and Orientations

A teacher's enactment of equitable curriculum and pedagogy, as well as their fostering of equitable interrelationships is informed by both the teacher's knowledge (of pedagogy, students, and equity issues) and the teacher's orientations (their biases, cultural filters, and teaching commitments) which is included in the orange box in Figure 6.1 and Table 6.4. As exemplified in Hoba's narratives, Hoba took care to develop relationships with students, sometimes making time for relationships in place of science instructional time. Her caring nature also informed her curriculum and pedagogy as she worked to plan relevant and responsive science units and lessons for her students. Both her commitment to relationships and to culturally relevant instruction were informed heavily by her knowledge of her students and the issues they faced as predominantly Arab Americans. This knowledge was based on her own personal experiences as a member of the same community within which her students lived, and her understanding of the shared and different cultural practices, norms, and values she had with her students and their families.

Karen's science teaching included multiple examples of disciplinary responsiveness. During her science teaching, Karen valued students' funds of knowledge and allowed for multiple and varied ways of participating in knowing and doing science. There was potential for Karen's students to leave her classroom feeling inquisitive about science and its connections to their everyday lives, possibly beginning a pathway towards ongoing science participation. This is an important equity outcome. However, Karen's relationships with students, especially Jose and Julia, were troubling. Additionally, Karen's knowledge of students and of issues of equity were influenced by her Whiteness and reified White supremacy in ways that were harmful to her students. Karen's racist worldview likely permeated aspects of her teaching, interactions with

families, and conversations with colleagues in ways that were less visible to me while observing her science teaching. Karen's case points to the importance of coming to better understand teachers' knowledge and orientations in our research with them as it must inform how we think about their teaching and their opportunities for growth.

Table 6.4

Evidence of Teachers' Knowledge of Issues of Equity

Evidence	**Example(s) from Cases**	**Location in Framework**	**Support from the Literature**
Knowledge of cultural practices	Hoba's experiences talking with students about different fasting practices	Knowledge of Students	Wallace and Brand (2012)
Understanding of culturally appropriate expressions of care	Hoba's descriptions of how her students perceive expressions of care from teachers	Knowledge of Students	Parsons (2005)
Belief in foregrounding building relationships with students over academics	Hoba's description of how she pushed back on an administrator's insistence on starting academics right away in the school year	Commitments	Milner (2011)
Critical understanding of Whiteness and a critique of White supremacy	Karen's insistence on having logic on her side in disagreements with families demonstrated lack of criticality	Biases	DiAngelo (2018)
Reliance on broad and compelling evidence of inequities	Karen's reference to a personal story to determine that affirmative action is unfair to her and her Black friend instead of compelling research to the contrary	Knowledge of Issues of Equity	Bonilla-Silva (2018)

Implications for Future Work

Taken together, the proposed Framework of Equitable Disciplinary Responsiveness (Figure 6.1) can bring science educators and science education researchers closer to understanding what it takes to enact disciplinary responsiveness that is equitable—not merely as a by-product, but as an inherent part of the process. The EDR framework is not intended to be evaluative—i.e., as a checklist to determine whether a teacher is or is not equitably/disciplinarily

responsive. Rather, the EDR Framework can point researchers towards paying closer attention to teachers' relationships with students, and the interrelated nature of those relationships with teachers' equitable praxis. Doing so can illuminate areas of concern (as with Karen's case) or areas of promise (as with Hoba's case) where a more limited description of curriculum and pedagogy would be a less complete—and potentially misleading—picture of their equitable practices. This EDR Framework also has implications for teacher educators who are concerned about equitable science teaching—that is, it is not enough to prepare pre-service teachers with best practices for science teaching (such as being responsive to students' sense-making). Teachers like Karen, or like the international teachers in research by Dunn (2013), are capable of taking up best teaching practices that in many ways appear to be equitable. However, preparing pre-service teachers (or international teachers) to engage in authentic caring and to be knowledgeable about issues of equity impacting schools in the United States should be foregrounded as a critical concern in science teacher education. Finally, the moves and evidence compiled in Tables 6.2, 6.3, and 6.4 provide specific (though not exhaustive) examples from this dissertation of what this framework may look like in practice. These practical applications should continue to be further explored and refined with other elementary science teachers to confirm their utility across contexts and to add to them to paint a more comprehensive picture of what equitable disciplinary responsiveness can look like in elementary science teaching.

Final Thoughts

Scholars within the fields of science education and multicultural education have advocated for more responsive and equitable approaches to science teaching and learning. These changes are imperative considering the need for scientific literacy in systemically marginalized communities in order to self-advocate on behalf of issues such as clean drinking water,

preparations for and responses to climate change, and clean air. They are also imperative in order to broaden notions of participation in science to include perspectives, practices, and knowledges of non-Western epistemologies.

Results from this dissertation suggest disciplinarily responsive teaching moves, such as creating opportunities for sense-making and sharing epistemic authority with students, are one part of what it means to teach in equitable ways, but they are not sufficient. In addition, enacting equitable curriculum such as by integrating place and fostering equitable and anti-oppressive relationships with students through listening to their concerns and feelings, are integral components of *Disciplinary Equitable Responsiveness*.

While the cases in this dissertation did not provide evidence of the following, it is also possible to imagine a teacher might have equitable and anti-oppressive relationships with students but not provide disciplinary equitable responsiveness without rigorous curriculum or pedagogy. Scholars such as Ladson-Billings (2009) and Gay (2010) would agree that academic rigor is critical for moving towards expansive equity. Rigor supports students in constructing a sophisticated understanding of science which they can critique and contribute to with their own ways of knowing and doing science.

As I alluded to in the Introduction chapter, this dissertation does not empirically address the question of whether disciplinary responsiveness can ever be equitable considering the racist and colonialist history of the fields of science themselves. One way of addressing this concern is for teachers to use science learning as opportunities to support justice movements and social change in their communities (Philip & Azevedo, 2017) or to foster critical science agency in students (Schenkel et al., 2019). Through these experiences, teachers can facilitate opportunities for students to critique the disciplines of science for ways in which they are unjust and to re-

create ways of understanding the natural world that are just (such as in research by Bang & Marin, 2015). The science education community needs more guidance on how to do this given a focus, for example, on a first-grade classroom studying the moon and sun, or on a third-grade classroom studying animal adaptations such as the ones in this dissertation. If such work entails diverting these topics to others, is that justifiable? Is there an alternative role for science teaching to inspire wonder, awe, or curiosity in students, and is this the same thing as or different from inspiring agentic action against injustices? Instead of omitting some content, can that content be taught parallel to justice-centered science teaching in ways described in this dissertation? In what ways can science content be critiqued that are developmentally appropriate for first- and third-graders? These are outstanding questions from this work.

Importantly, results from this dissertation suggest that considering a teacher's practices alone, without accounting for her orientations or biases, provides an incomplete picture of that teacher's equitable responsiveness. Biases can surface in teachers' practices, interactions with students, and/or interactions with people outside of the classroom in ways that may be hard for some of us to see, thereby reifying Whiteness in schools despite seemingly strong pedagogical practices.

A challenge is thus presented of how to move forward. It is difficult enough to shift teachers' practices, but it is even more difficult to shift a predominantly White teaching force's orientations towards their students to be asset-based and liberatory. Part of the response to this challenge must be to recruit and retain more teachers of Color and teachers who share cultural backgrounds with their students. Another part of the answer to this challenge will require electing, appointing, and hiring people to positions of power (including as teachers) who are equipped with the needed resources and orientations to work with teachers towards more asset-

based orientations and pedagogies. Yet another part of the answer to this challenge is to create a culture change that de-settles hierarchical structures of power, privilege, and marginalization in schooling and science disciplines. The work of a responsive teacher is one small and critical piece of the puzzle given our current context for moving towards more equitable science teaching and learning in schools.

APPENDICES

APPENDIX A:

Interview Questions

Pre-Interview

The goal of this interview is to get to know you and your teaching context better, your initial ideas about some of the concepts I'm focusing on for my research, and your ideas about science teaching and learning.

Background Information about Teacher and Context

This first set of questions will be eliciting information about you and your teaching context.

1. What made you first want to be a teacher?
    a. Always this grade level/age group or other ages?
    b. Always in this community or elsewhere?
    c. Always with a particular interest in science/engineering or others?
    d. When a shift is indicated, what made you shift? Were there any key people or a key event important for that turning point?
2. Next I'll ask you to tell me about your students this year:
    a. What do you appreciate about them?
    b. What is challenging about them?
    c. What do you know about some of them individually?
    d. How are they similar and different from you?
3. Next I'll ask you to tell me about the parents of your students this year:
    a. What do you appreciate about them?
    b. What is challenging about them?
    c. What do you know about some of their families? The community?
    d. How are they similar and different from you?
4. Next I'll ask you about the kinds of professional learning experiences that work best for you:
    a. What has really helped you grow and learn best in your career so far? Can you tell me about a specific example?
    b. What are some professional learning experiences that keep being offered but that just don't seem to support your learning? Why do you think that is? What seems to be missing or misguided about those experiences for you?
    c. How have you interacted with mentors or coaches over the years?

d. What part of your science teaching practice is already really strong that you would like to continue to grow in the next several weeks?
    i. If you could design your own customized professional supports for [learning more about X] what would you want for support?
e. What part of your science teaching practice is really challenging or frustrating for you right now? What keeps you awake at night?
    i. If you could design your own customized professional support for [learning more about X] what would you want for support?

Finding Out More about Conceptions of Disciplinary and Equitable Responsiveness

This second set of questions will focus on your ideas about science, science teaching, and responsiveness.

5. Tell me what you know about science.
    a. What experiences have you had with science? How do you feel about science?
    b. What do scientists do?
    c. How would you describe your approach to teaching science? Examples?
    d. How do you think your students learn best? How do you maximize their learning?
    e. Tell me about a science unit or project that you've taught in the past where you felt really confident about the science concepts that you were teaching.
        i. Why do you think you felt so confident about [X]?
        ii. What steps did you take to build that confidence?
        iii. How do you think this influenced your overall teaching and students' overall learning experience?
    f. Tell me about a science unit or project that you've taught in the past where you felt really uncertain about the science concepts that you were teaching.
        i. Why do you think you felt uncertain about [X]?
        ii. What steps did you take to try to address the uncertainty?
        iii. How do you think this influenced your overall teaching and students' overall learning experience?
6. How often do you elicit students' ideas in science class?
    a. What do you do when students share their ideas? How do you respond?

    b. What if a student says something that you think is completely wrong?
    c. What if a student says something that sounds off-topic?
    d. Can you provide an example?
7. How do you see science as valuable or relevant to your students' lives right now?
    a. What modifications do you make to your science instruction based on your students' lives outside of school?
    b. Can you provide an example?
8. How would you define responsiveness as a teacher?
    a. How do you think about being responsive in a disciplinary way, that is to students' science ideas?
    b. How do you think about being responsive in an equitable way, that is to your students' cultural or racial identities and their lived experiences?
    c. Do you see these types of responsiveness as overlapping in any ways? Explain.
9. If you filmed your classroom for a typical week and then we played it back—sped up like a time-lapsed video—what are some of the typical kinds of interactions that we would see?
    a. Like, how is science similar to/different from teaching/learning in other subjects?
    b. When are you working in whole groups vs. small groups vs. one-on-one or other arrangements?
    c. When would we see students getting really excited about what they are doing and when would we see students tuned out or looking frustrated? Why does that happen?
    d. What about you? When would we see you looking really excited vs. looking tuned out or frustrated? Why does that happen?
10. Now let's imagine that we slowed the video down and listened in on the talk during a science learning experience:
    a. What are some typical patterns or routines that we might see and hear?
    b. How do you typically begin a lesson?
        i. Does that vary? How/what makes it vary?

c. How would we see students talking?
d. Would we see you up front posing a question to the whole group? If so, what does that sound like?
e. Or, would we see you moving around the room talking to smaller groups? What does that sound like?
f. When/why would you do one type of interaction vs. another kind of interaction?

11. Is there anything else that you think I should know about your teaching or about your school or classroom that would help me understand things better?

I tailored the post-interview questions to each teacher based on things that surfaced in our work together. There were many questions that were the same across teacher participants, and a few that were specific to each teacher. The following set of Post-Interview questions was tailored for Karen, as an example. I italicize the questions that were specifically targeted for Karen. The remaining questions represent questions I posed to each teacher participant.

Post-Interview

The goal of this interview is to hear teachers' reflections on their professional learning after the study, how they now conceptualize disciplinary and equitable responsiveness, what helped them learn, and what challenges they see as remaining.

Materials:

- Audio recorder
- Back-up audio recorder
- Multiple colored pens
- Scrap paper
- Note cards with words written down
- Blank note cards
- Model of Professional Learning

1) What was your purpose for participating in this study?

2) Your goals from the beginning were *to make abstract ideas concrete and to improve the flow of your science lessons.* Do you feel like you met these goals? Do you feel like you were able to meet other goals?
3) Of the work that we did together, what aspects of it, if any, helped you work towards these goals? Or helped you in other ways?
    a) Co-planning
    b) Co-teaching
    c) Watching video together
    d) Tool development
    e) Feedback
    f) Think-alouds
4) Part of what I'm doing with my work is trying to understand why professional learning experiences may or may not work with teachers (context part of model). Help me paint a picture of what you're paying attention to these days, what's on your mind. What are the things that are pulling you each day?
    a) Here are a few things that I've seen. Do you agree with these? Are there more?
    b) How would you map these in a concept map?
    c) What are the things that you're thinking about today?
    d) What were you wrestling with last week?
    e) What are the things that you'll still be thinking about next week?
    f) What are the things you'll be wrestling with still in June?
    g) Which are the top 3 for you? (in the morning, at end of day)
    h) If we had more time to debrief lessons or do anything else, what do you think could have come from that for your teaching? What else would have been helpful to you?
    i) What do you imagine might be helpful for a science resource teacher to implement?
5) Now let's think about your science teaching. Here are some things that I think are important to you. Are there any missing words?
    a) I have ideas about how you might categorize them, but I'm wondering if you can categorize them for yourself so I can check my thinking. Which ones are most important to you? Second priority? Think out loud as you're doing so, so I can follow your thinking.

b) I put these two together, what do you think? What if…?

c) What aspects of the K-2 Modeling Lab do you feel like you've been able to incorporate into your teaching practice?

6) *A central equity issue in education occurs when "the cultural knowledge and practices of some students—most often, students of color, English language learners and recent arrivals to the United States, or students from low-income homes and communities—are… unrecognized or dismissed in teaching practice" (Moje, 2007, p. 5). In other words, the ways of knowing and doing of the dominant White, middle-class, native English speakers are normalized and privileged, thus putting those who are not part of this group at a disadvantage to obtaining the same quality of education.* Can you talk a little about what this quote means to you and how you do or do not see it enacted in your own teaching?

   a) How do you see science as valuable or relevant to your students' lives right now?

      i) How do you think about making modifications to your science instruction based on your students' lives outside of school?

      ii) Can you provide an example?

   b) How do you see race or racism as relevant to your science instruction?

      i) How do you think that is? Can you give an example?

7) What have you taken out of this partnership? What was important to you about our work together?

   a) Were there things that you feel like I missed or did not understand based on my positionality (as an outside researcher, etc.)?

   b) What changed in your teaching practice as a result of your participation in this study?

      i) In what areas did you grow or not grow? Can you give an example?

      ii) One of the parts of our work that I was focusing on was with sense-making and responsiveness to students' sense-making. In what ways did you feel like grew or did not grow with respect to responsiveness to student sense-making? Can you give me an example of what you might do in the future?

      iii) Which aspects of our work with responsiveness influenced your choices?

      iv) What do you anticipate will remain different, if anything? or continue improving?

c) What do you anticipate will remain challenging in your teaching practice despite your participation in this study?
    i) What aspects of those things make it challenging?
    ii) Do you have ideas about what you might do to address those challenges?

d) Besides science teaching, we've also had some conversations about race, language, and culture. I am aware that we have some different ways of understanding issues around these topics. I'm wondering if you can reflect on what it has meant to you to be in a partnership with me, engaging in this work, while occasionally having disagreements.

APPENDIX B:

Reflection Tool

Reflecting on a Lesson for Sense-Making

Use this tool to help you consider how engaged your students were in thinking about and grappling with new ideas during a lesson.

Sometimes this sense-making happens for an individual student, and sometimes the class as a whole is engaged in collective sense-making. For this reason, there are two columns below to choose from. You may use one or both of them!

Sometimes students' sense-making seems to be headed in the direction you're hoping for, and sometimes it feels like it's still a ways off. Sense-making can be messy, and that's okay! Use the symbols below next to students' names to record the direction you see students' sense-making headed in.

△ Headed the desired way □ Headed in a different direction

TOPIC:

	Individual Sense-Making	Collective Sense-Making
Name(s) of student(s):		
Activity		
What were student(s) working on in their thinking?		
Evidence of sense-making:		
Teacher response(s) that promoted sense-making:		
Student response(s) that promoted sense-making:		
What do I do next to promote students' thinking?		

Table for Reflecting on Sense-Making in a Lesson

Place where sense-making happened	Activity that engaged sense-making	Evidence of sense-making	Teacher responses which promoted sense-making	Student responses which promoted sense-making	Challenges which hindered sense-making
Playground Schoolyard Science classroom Reading lesson Math lesson Art lesson Music lesson PE lesson Before/after school Field trip Videos Lunch Home (science backpacks; bringing artifacts to class)	Discussion Recitation Group Work Whole-Class Model/Demo Investigation Debriefing Exploration Journaling Four corners movement with persuasive explanations Foldables Sharing student work on a document camera Brainstorming Argumentation Problem solving	Asking and answering questions Making and revising predictions Students' errors Sharing ideas Making connections Explaining phenomena Shift in thinking Student work with materials Student movement Students listening to each other Students responding to each other Number of hands in the air Non-verbal cues (like waving to agree) Doing it at home Temperature of the room (facial/body expressions) Teacher's intuition Student's funds of knowledge Sharing experiences from home Student's words (spoken/ written) Scientific models Clickers and other electronic supports Gestures	Allow space for ambiguity Encourage students to change their ideas (hypotheses) based on new evidence Modeling own sense-making Recording students' ideas publicly Not being evaluative in responses Ask for further explanation Encourage consensus building Push questions to the class or small groups	"I agree with so and so because…" Active listening Body language Tone of voice Willingness to share (ideas, materials, answers) Feedback/questions to/of peers	Interruptions Opportunities to meet with all small groups Materials Time to set up materials Time to debrief at the end Time to present to whole group Oversee every group How to move kids through their sense-making Timing Classroom management Content knowledge Technology failure or lack of technology

This table is meant to help guide your thinking about the tool for evaluating a lesson for sense-making. The lists are not all-inclusive, but include the types of things you might think about for student sense-making.

APPENDIX C:

Discourse Routines

These discourse routines are adapted from literature on educative mentoring (Feiman-Nemser, 2001; Stanulis & Bell, 2017). The semi-structured debriefing conversations are designed to enact some of the discourse routines with two of the design cycles.

Types of Discourse Routines

- Probe teachers' thinking to elicit their ideas about their students and students' ideas
- Press teachers' thinking to articulate more about their ideas
- Ask clarifying questions
- Provide positive feedback
- Notice signs of growth
- Select a target for teacher practice
- Select a target for tool design and/or enactment
- Scaffold with steps towards the target goal
- Collect and analyze artifacts
- Model how to do something, for instance with a responsive teacher move
- Co-plan learning opportunities for students
- Focus on students and their sense-making
- Co-think with teacher to figure out what works for them and their professional identity and context
- Co-construct knowledge with teacher as we apply theory to practice
- Think-aloud either as a model for the teacher or to work through an idea out loud
- Use theory to inform practice

Semi-Structured Debriefing Conversations

- What was your favorite part of the science lesson? Why? What did you do to facilitate that? What did student(s) do to facilitate that?
- Did you notice any particular sense-making moments? What did you notice? How did you respond? Why?
    - Compare sense-making reflection sheets. What is similar? Different?
    - What are students grappling with in their sense-making? Individually? Collectively?
    - What are students learning?
    - What are your next steps?
- What stereotypes did you reinforce today? What did you do to disrupt those stereotypes?
- What power structures did you reinforce today? What did you do to disrupt those power structures?
- What support would you like from me? What support would I like from you?
- What adjustments do we want to make to future lessons in response to students and their sense-making today?
- What parts of the XYZ Tool are especially helpful? What should be changed or added?
    - Repeat for each tool
- Other feedback for teacher

APPENDIX D:

Codebook

Themes	Parent Codes	Child Codes	Code Descriptions	Examples
Teacher Charac-teristics	Others' Perceptions		Self-reporting of how others have described T	**Molly**: When I first started teaching I took over for a long term substitute who told all of the students that they should just switch schools because the teacher coming did not look like them at all. Which is true. So I've been the subject of some anti-racism - I don't even know what to call it - but it was like, "I get that but that means that I can't teach boys either. So you're saying I can teach little white girls." So those kind of things have happened to me in a very diverse district.
	Values	Perceptions/ stances of/around equity	Ts' interpretations of equity constructs	**Karen**: A couple of years ago I had a student who came to us at the beginning of third grade and spoke no English at all. By the end of third grade she was already reading at the end of second grade reading level. She just really stepped it up and at the end of her third grade year they were trying to deport her. We got involved and I actually signed off and wrote part of a letter explaining her test scores and that she's doing well here and she's going to be a productive, valued member of society. She's an asset to this country and by forcing her to leave is not only shooting ourselves in the foot but it's not good for her. And she was allowed to stay.
		Perceptions of Science	Ts' conceptions of nature of science	**Hoba**: [Scientists] question things a lot. One thing I like to tell my students all the time is that the experiment doesn't always work. It fails and you learn from it failing. It has to fail. And that's something that gets me, something we're implementing with our students, a growth mindset with the students. Mistakes are okay. We learn from mistakes.
		Perceptions of own teaching	What the T values (things she brings up repeatedly) & where T lays blame for shortcomings	**Molly**: We do a lot of small group work, and so we've been really working on- I actually have a strategy that I'll be teaching when we get back, about how do you talk to each other. How do you ask questions. If you disagree, how do you disagree. That kind of thing. I like to think that when I'm teaching science, I ask lots of questions, they ask lots of questions, we have this dialogue. I think, as far as instructional dialogue, we do pretty well on that.
	Life Outside of School	Family/ Home Circum-stances	Supports, stressors, obligations associated with home life	**Karen**: If all day every day I was told constantly by my friends, "You're not fat, you're skinny," but every day when I got home I wasn't allowed to do homework until I did crunches first for my mother. Even though it was her fault that I was overweight! She chose the food that went into my system. I wasn't allowed to leave the table until I not only cleaned my plate but drank all of my milk. She had control over my weight; I did not. And yet I was the one paying for it.
		Personal Health	Health of the T	**Christa**: Right. Your own personal health, which we've talked about a lot. **Hoba**: Yeah, I'm very conscious about my health to the point that I did a CAT scan. Did you know that you have to go and pick up the CD and take it to the doctor? **Christa**: Yeah, I've done that. **Hoba**: I've never had to do that before. They always send it to the doctor. **Christa**: Granted, I had to do it a while ago so it surprises me that they're still doing it that way. **Hoba**: And I've seen people there at the lab trying to X-rays and stuff – well, the whole point is I'm really curious about my health and I still did not pick it up. It's been two weeks.

	Logistical Info		Number of years teaching, schools, education background, etc.	**Molly**: In theory I get maybe one prep hour a month. Maybe two, but really?
	Moves by T or S affecting their relationship	Confronta-tions	Ways R or T do/do not push back and responses by other. Ways I reflect on pushing back or avoiding it.	**Hoba**: I didn't want to give too much, and I want to leave room for them to explore, and then maybe talk about it after. **Christa**: I think- **Hoba**: It was kind of hit or miss for me, like whether- **Christa**: I think if you're giving them a set data table, you know what I mean? Like if it was- no, I totally see what you're saying. I just think it would have been helpful for them to have a purpose.
		Building	When T or S says or does something that appears to strengthen the relationship	**Molly**: My kid that I had called about being disrespectful earlier on in the month, he was really upset about something that had happened. I said, "I understand that you're upset; that doesn't mean that you can just run from the building or run to the office. Come sit over here for a moment. I know Mom gets out of work at 1:30 so just sit over here and try to get it together." So then I called and I said, "He's just really upset; do you have a minute to just speak with him? He's upset at what happened on the playground. He was appropriate, he's not in trouble but he would just really like to talk to you."
		Damaging	When T or S says or does something that appears to damage the relationship	**Karen**: Her partner was Jose and he was more or less just helping to color stuff. He drew all these comets all over the place and I made him erase them because we had the conversation of, “Do comets make night and day happen? Those are decoration. Erase them!”
Teacher-Student Relation-ships	Values around relationships		How T talks about building relationships with Ss	**Hoba**: No, I agree. I think last year I had this challenge. I had six hundred some students that I saw. And my class was, teachers thought, “this is my prep, here, take my kids," so it was a challenge for me. Just knowing and memorizing the kids' names was a challenge, too. Some of my students kind of look alike, too! I start mixing their names! Which I still do, I’m not gonna lie. And then I resorted, okay, “I want you to share.” I mean, this is a challenge. But building relationships, I don't think I have struggled much with that with the students. Students always felt that they can come to me and say, "I don't understand this." I do allow them to ask questions and they feel like I'm open for them to ask me questions.
	Feelings towards students	Caring	How T expresses feelings such as compassion, empathy, or sympathy for Ss	**Molly**: This year's group, they're really pretty kind to each other. They're really supportive of each other. I have a really wide range of abilities and social emotional issues, and things like that. I think I came in this year being a little bit more firm with them on our procedures and how do you act, because last year's class was really a big challenge. And so, I just really appreciate their ideas. Fourth grade you get to talk a lot more, you get to hear what they have to say, and I think they have a lot to offer. I don't know that they always believe that, but we really work on our classroom community to encourage that.
		Disdain	How T expresses feelings such as disregard or disdain	**Karen**: I’m not trying to say that my kids don’t care at all, because that’s not true, but I don’t know – I’m going to say it’s a generational thing – this generation of children, I think, is lazier than when I was a kid. Everything is such a big deal to them if they have to go back

			for Ss	and do something or if they have to fix something. Whereas I have maybe one kid in the class who will make sure it's right the first time. That's the opposite of when I was a kid. There would be that one kid who just rush, rush, rush but that's half my class now. I'm going to say it's a generational thing.
Teaching Pedagogy	Responsive-ness	Disciplinary	Moments of disciplinary responsiveness	**Hoba**: I wanted to teach them, just to give them another example to add to their bucket with adaptations. So, last time on the chart, we came up with ideas. They started, they were so excited, the boys were so excited talking about camouflage and some game that they were playing. If I- I don't recall what was it. Some video game that they're playing and how they camouflaged so they wouldn't get killed. And so I want to bring camouflage in in a different way. And I don't want them to just think of camouflage in that context. It can be used in various, multiple positive ways as well. So that's where camouflage came.
		Equitable	Moments of equitable responsiveness	**Karen**: I used to think back on vocabulary it was like, "What is the scientific term and do they know the definition?" To myself, as bad as this sounds, I'm like, "Is it really that important that a six year old ESL student knows the difference between rotation and revolution?" No, they're both so similar in a language that is foreign to them and they're both so young that we can just call it spinning and going around. Because that's the point of the standard.
		Both	Moments of disciplinary and equitable responsiveness	**Hoba**: I was able to ask this question at the beginning because I thought it was helpful for them. So this tool was actually very helpful to guide my students into their critical thinking and to just deepen their thinking. Because when they're not questioned they just think it's out there…you just have to finish the sentence with whatever you think of the three options that were discussed in class. So they were not used to, "Oh, I can say my opinion and I could be wrong or right." I feel like because they're ELL, we're just dumbing them in that sense.
		Neither	Moments that are not responsive disciplinary or equitable	**Karen**: I really wish that I wasn't so hot and that I was able to focus more because I wish I could tell you what happened in my classroom today but I really can't. I felt like I had to spoon feed a lot to them because they just were not as they normally are. I did realize that they were being able to associate temperature with a season name. The color is where it got tricky but I feel like color coding is still kind of new for them. But for the most part they were able to associate that it's warm in the summer and cold in the winter and somewhere in between in the other ones.
	Sense-making opportuni-ties	Missed	Characterize what these moments are like	(from field notes) Molly began the science lesson with a read-aloud. The read-aloud was related to their unit topic on (matter and) energy, but it was not obviously related to the day's lesson (on building circuits). Molly did some intellectual work with the book, but the students largely did not.
		Landed	Characterize what these moments are like	**Hoba**: Okay, I kind of felt at the end I did not meet my lesson goal. But the students kind of took some learning from the process. There was like a lot of good discussion going on. Having them work in a group was interesting. And it was interesting to see the different ideas, and um, I noticed one of the group's at first did not even realize that these graphs were different. [laughing] They started like counting gray like on each- that the number of gray squirrels. On each one of these, grass, I don't- like "why did you do that?" And she goes,

				"because I see 3 here, 3 here, and 2 here," and then when I pointed out that they actually see two but there's number one that starts here on the bottom, and that's when they all like looked at it like, "Oh, like wait a minute. This is different and there's something wrong on this graph." And that's where that discussion started with them.
Teaching Context	Colleagues	Teachers	Memos, notes, conversations about other teachers	**Karen**: There's still some things that bothered me and I think it might just be this unit. Because both of the concepts that we're looking at are so similar yet so different so it's like, what one do you do first? I feel like it's just the unit so I'm going to chalk it up to that and maybe reassess later and ask for Deanna's opinion.
		Administrators	Memos, notes, conversations about administrators	**Karen**: Scott's mentor, Tom Sheilds – he's actually a pretty big name around the Hatton area – he consults for a lot of schools. He used to play for the Royals, which I thought was pretty cool. He observed me a few times and in my formal observation he was in the room with Scott. I guess a lot of teachers were really freaked out by his presence, like, "Why is he in my room? Who is this guy?" He even told me, "Nothing I say has anything to do with your formal Marzano evaluation." He was basically here just for a second opinion. And he sat down with me last week and he said some things that I have not heard in my five years of teaching that I really needed to hear – all positive. He was absolutely blown away. So I love feedback, even if it's negative.
		Staff	Memos, notes, conversations about staff	**Karen**: And also, it's not so much an issue anymore, but I was told on multiple occasions – now I know that it was wrong because I would ask Eva and Evelin, "Was I wrong?" I've been told that I was being culturally insensitive multiple times and then I would go and ask Latinos that work here, "Was that culturally insensitive?" And they were like, "No." So this kind of gives our crazy CEO a chip on her shoulder –
	Other school obligations		Intern, play, committees, structure of position	**Hoba**: Yeah, we have to have like an oral or a content objective. So, and those objectives are very direct. So I can't put, like okay, my objective is to get the students asking about bar graph. It has to be, by doing what. So I have to be very specific. These objectives.
	Social Capital	Empower-ment	Evidence of T empowerment (or not), control (or not)	**Karen**: I've had a lot of opportunities here that I wouldn't necessarily have had at other schools. I've been able to have a voice because from the get-go it was, "We can't just build a school with one person making all the choices." It was always a team effort. That's what I've always liked about it. We're a family here. You go to other schools and you ask for advice or help and you get shut out because everyone is competitive. Like, "I don't want to help that teacher because then they'll take my spot." That's not how it is here. We're very big on school culture here.
		Social Network	Ts' professional networks or communities in the school building or district or outside the district	**Molly**: The best learning experiences I have had are when I have a teaching partner. I'm sort of getting that going again at my current school, but the school I left before, which was hard for me to leave my teaching partner, not hard to leave the school, but we really worked well together and we would bounce ideas off each other, we'd just eat lunch together everyday and we would talk about, you know, what are we going to do here, what are we gonna do there?
		Position-ing	T's positioning by others in the	**Karen**: So I'm kind of mentoring them, which is different for me because in years past I have very heavily leaned on Jane. We together were always very much a 50/50. Learning

	building	last summer that she was leaving, I honestly cried. I was like, “What am I going to do? I can’t teach without you!” And you know, at the beginning of the year when I heard I was getting a first-year teacher I was like, “I need to step my game up. She’s going to need me a heck of a lot more than I’m going to need someone else.” And I think just putting that in my mind and going with it has really helped me.
School culture/ climate	Evidence of school culture/climate	**Molly**: I just have one big one right now and that's behavior. I feel like behaviors are filtering over into my class because they're like, "Well geez, they get to run up and down the hallway." And it's a struggle when you have an intern and different expectations, different voice levels.

Note. My study design initially included three teachers: Molly, Hoba, and Karen. I omitted Molly’s case from this dissertation as I was able to construct my central arguments without her data set. However, she remains in this codebook as I constructed the codebook while analyzing her data alongside Hoba’s and Karen’s.

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