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Stories That Teachers Tell: Exploring Culturally Responsive Science Teaching

Jamie Wallace , Elaine V. Howes , Arthur Funk, Sean Krepski, Maya Pincus, Susan Sylvester, Kin Tsoi, Caity Tully, Raghida Sharif and Samantha Swift

Education Department, American Museum of Natural History, New York, NY 10024, USA

* Correspondence: jwallace@amnh.org (J.W.); ehoves@amnh.org (E.V.H.)

Abstract: In this paper, we explore the stories teachers tell as they study and grapple with culturally responsive education in their science classrooms. This qualitative case study focuses primarily on “Stories from the Field”, a conversational routine at each professional learning group meeting where teachers shared observations, thoughts, and insights about their classroom, instruction, and school settings in the context of culturally responsive education. We found that teachers’ stories from the first year of the group surfaced themes of navigating systemic constraints and supports, connecting through science, and sensemaking and learning from developing and analyzing strategies for culturally responsive science teaching. This helped to shine a light on a critical aspect of our work exploring culturally responsive education and what that might look like in science classrooms through the stories that teachers tell. Our findings suggest that storytelling is a rich, descriptive vehicle for exploration and sensemaking amongst teachers in a professional learning group and an underused resource in studying culturally responsive education, especially in science.

Keywords: teacher education; culturally responsive education; science education; stories; teacher professional learning; teacher storytelling



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1. Introduction

Some cultures have relied on the spoken word rather than the written word to convey, preserve, and reproduce knowledge . . . By telling stories and coding knowledge into songs, chants, proverbs, and poetry, groups with a strong oral tradition record and sustain their cultures and cultural identities by word of mouth. The oral tradition places a heavy emphasis on relationships because the process connects the speaker and listener in a communal experience([1], p. 28).

In this paper, teachers are the storytellers. We explore the stories teachers tell as they study and grapple with culturally responsive education in their science classrooms. These stories are personal and of a sensitive nature, representing lived experiences and personal insights that are specific to their contexts. Told in the setting of a professional learning group through a conversational routine called Stories from the Field, these teachers’ stories illustrate larger themes concerning learning about and implementing culturally responsive science teaching. Thus, in this empirical study we investigate the research questions: What are we learning from the stories in regards to teachers’ perspectives and experiences with culturally responsive science teaching in their individual settings? In what ways do stories shed light on teachers’ experiences and practice in the context of culturally responsive science education?

We explicitly operate through an assets-based model, “seeing participants’ perspectives and stories as opportunities for understanding reality and co-constructing knowledge” [2] (p. 404). The teachers in this study engage in challenging thinking and work that is extremely complex. As co-inquirers with the teachers, we entered this study with the assertion that all of the teachers are working deliberately and purposefully to make a

difference, centering their students' best interests. Each member of the group recognizes that we are all still learning and approaches this work with humility and care.

The purpose of Stories from the Field in the Culturally Responsive Education Professional Learning Group (CRE PLG) meetings was at least two-fold. It provided focus at the beginning of each meeting, as members were expected to situate their stories in the context of CRE. In turn, this provided communal accountability to the ongoing project of making connections between theory (represented by literature study) and actual classroom instruction and interactions with students. Therefore the routine functioned as more than a check-in, and turned out to be a core aspect of the power of the group, extending in time and importance as teachers learned about each others' settings, experiences, and implementations of culturally responsive approaches. In this context, the learning and application of CRE in stories was not linear but continuous, complex, and organic.

1.1. Situating within a Larger Context: Examining the Literature

Three areas of scholarship ground our work: culturally responsive education, teacher professional learning communities, and the role of stories in teacher education. Below, we summarize the literature in these areas and indicate how they inform our study of CRE PLG Stories from the Field.

1.1.1. Culturally Responsive Education

For decades, scholars have argued that CRE is critical for classroom teaching and learning for students who have traditionally been shut out of academic success [3,4]. This perspective has undergone multiple iterations and modifications since it was introduced by Ladson-Billings [5] as culturally relevant pedagogy. A plethora of derivations continue to weave through the research base, such as culturally relevant teaching [6,7], culturally responsive teaching [1,8,9], culturally sustaining pedagogies [10–12], culturally responsive education [3], and culturally responsive-sustaining education [4]. Throughout these interpretations of CRE, several criteria remain central: students' academic success, cultural competence, and development of critical consciousness [5], and the integration of students' lived experiences and cultural and language assets into instruction [3,13,14].

This study adopts the language of culturally responsive education for consistency and shared terminology within the city in which our teachers worked during the time of the research. With a focus on teaching practice, Geneva Gay defined culturally responsive teaching as:

Using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively. It is based on the assumption that when academic knowledge and skills are situated within the lived experiences and frames of reference of students, they are more personally meaningful, have higher interest appeal, and are learned more easily and thoroughly. [8] (p. 106)

We use the language of 'education' to encompass teaching practices, teacher and student learning, and social-environmental components and contexts.

Culturally responsive pedagogy has been a focus of dialogue in education for quite some time, and studies are beginning to empirically examine its effects [14–16]. While research findings indicate that CRE is crucial for supporting effective teaching in high-needs schools [17,18], much of this research is rooted in literacy [19–23] and social studies [23–27], along with mathematics [28–31]. However, what culturally responsive science classrooms look like requires further exploration [15,32,33]. Furthermore, applying the tenets of CRE into classroom practice can be elusive, partly because CRE conceptualizes teaching as shaped to meet the strengths, needs, and localities of the particular students with whom teachers are working. This work is challenging as there cannot be a "one size fits all" approach, and demonstrates a clear need for more research. We advocate, however, that this should not be a barrier to using the CRE tenets, as they are fundamental to productively engaging all students in accessible and rigorous science learning [1,15,34,35]. Drawing

from research on the criteria central throughout the various interpretations of CRE, we argue that culturally responsive science teaching exhibits the following fundamental tenets, in that the teacher:

- 1 values what students bring to the classroom as assets and uses these assets as resources for teaching and learning [4,13,14];
- 2 draws upon students' cultures to strengthen and sustain their cultural connections to them [5,12,36];
- 3 holds high expectations for all students' academic learning [5,8]; and
- 4 adopts a critical stance toward sociopolitical structures and processes and supports students in developing the same [5,12,34]. (See Figure 1.)

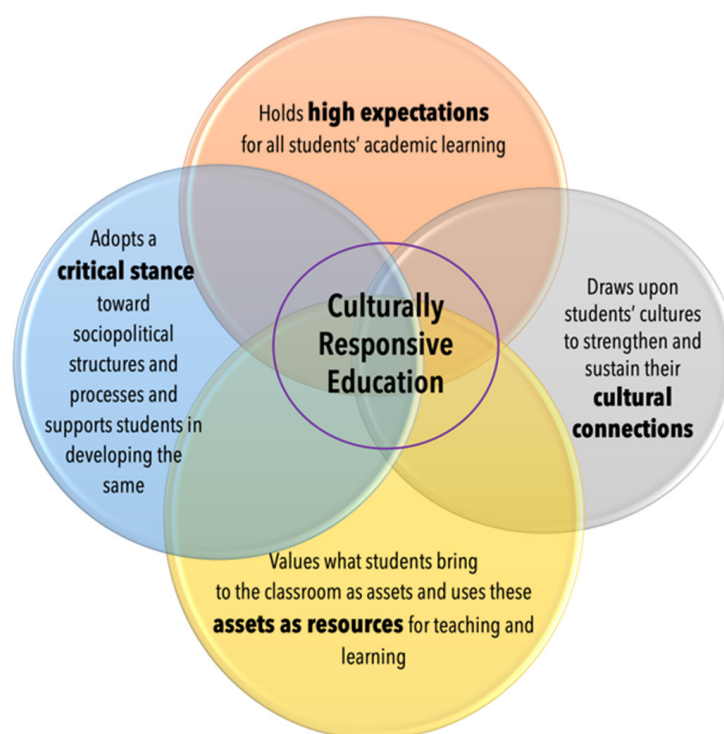


Figure 1. Tenets of Culturally Responsive Education.

1.1.2. Teacher Professional Learning Communities

The CRE PLG is grounded in the claim that effective professional development experiences for practicing teachers are ongoing within a community of teacher learners [37,38], feeding off of and into everyday classroom instruction [39–41]. Within this community, teachers engage in shared learning around an area of focus, with common resources and experiences, and provide support for one another that is based in practice as a process over time [42]. A community of practice perspective provides an important frame for the collaborative sensemaking in which the teachers in the group engage when sharing experiences and insights about their practice. Rooted in a social theory of learning, professional communities of practice are designed to “give an account of learning as a socially constituted experience of meaning making” [42] (p. 5). A teacher professional community focuses on the process of sharing understandings, norms, routines, and trust in relation to teachers' practice with colleagues and students [43]. Teacher communities have a dual concentration on student and teacher learning; this interrelationship informs and shapes teachers' sensemaking in this collaborative setting [44].

Investigating impacts of high-quality, well implemented teacher professional learning communities that provide continuous learning that is “active, collaborative, and reflective”, research suggests that participating teachers can experience cognitive and affective changes, shifts in perspectives, and a collaborative culture focused on improving

practice [45,46] (p. 17), and can support improvements in teaching practice and student learning outcomes [46].

Professional learning groups provide a community in which teachers can share beliefs, build and construct knowledge, raise questions, and challenge their own assumptions [47]. CRE PLG voices and experiences are the foundation for our explorations of CRE in science instruction, which stem from our own questions and reflections, and help improve our practice or provide practical solutions [48]. The group was well positioned to engage with the complexities of teaching in culturally responsive ways because they had established relationships having worked closely together in their preparation program and induction for two years after. When the group launched, members were beginning their third year of teaching and were able to share ideas and feelings openly, and challenge each other in supportive ways. Additionally, as they taught similar content in the same city, they could design, implement, reflect on, and critique teaching approaches collaboratively.

1.1.3. Teachers' Stories and Storytelling

Storytelling is a tradition embedded across cultures and histories throughout the world, and can provide both a window into someone else's lived experiences and a mirror to reflect on one's own thinking. The stories in this paper are ones that teachers related during a conversational routine at the beginning of each meeting called Stories from the Field. We adopt a broad and flexible definition of "stories" to encompass that which teachers in this context and for this purpose tell as a story as part of this routine [49]. Stories contain characters, a place or setting, and a temporal dimension that captures an event or situation in context. By nature, storytelling includes a storyteller and a listener; the interaction between the storyteller and the listener is part of what makes a story a story.

Teacher stories have been studied for decades, as they provide a window into the lives of teachers, students, and other characters in which a way of knowing and making sense of the world unfolds [50–53]. Stories can be told, retold, relived, constructed, reconstructed, and deconstructed [50,52]. However, it is not the story alone that we explore, but also the *act* of telling a story—the reflection, learning, and understanding that the teacher experiences when telling a story is equally important [54,55]. As Connelly & Clandinin assert, "It is in the telling and retellings that entanglements become acute, for it is here that temporal and social, cultural horizons are set and reset" [55] (p. 4).

Teachers often tell or exchange stories that recount a situation that already took place, or verbally rehearse something that has yet to transpire [56,57]. The act of telling a story causes the storyteller to relive the experience, teetering between the past and the present, and the retelling "shifts our knowing of experience, ourselves, and the meanings we hold of things like teaching and learning" [58] (p. 56). In the context of teacher learning, storytelling can be viewed as a pedagogical strategy [52]. Teachers' stories have been examined as both a representation of practice and/or a means to explore identities [57] as well as norms and patterns of the group [56,59]. In this paper, we explore teachers' stories to gain a deeper understanding of teachers' perspectives and experiences with culturally responsive science teaching in their individual science classrooms.

2. Study Design

In this section, we discuss the research context and study setting, participants' backgrounds, and acknowledge positionalities.

2.1. Context and Setting

Teachers in the group were graduates of a teacher residency program, from the same cohort. This teacher preparation program was located in an informal education setting called Bickmore Institute (pseudonym) in the USA. The program has multiple school-based partnerships where residents experience year-long clinical placements while taking rigorous academic courses at Bickmore. The geographical context of this study is a complex, urban intensive setting [60], based on the size and density of people in the area, with

attendant implications for resources and broader societal factors that inevitably feed back into the school system. In our state, while the student body is increasingly diverse in terms of race, ethnicity, gender, and age, teachers are 80% white with teachers of color underrepresented [61]. As we see an expansion of the diversity of students, teacher demographics particularly in terms of race and ethnicity remain relatively unchanged, especially in regard to Black and African-American teachers [61]. Thus, it is common that teachers in our area have racial, cultural, and linguistic backgrounds that differ from their students.

The CRE PLG was formed after these teachers' second year of teaching with the intention of studying CRE and its implications for science teaching. Teachers volunteered to join and were supported financially through a grant that was allocated to this specific cohort. Throughout one academic year, the group met twice monthly to study CRE, share and analyze teaching experiences, and develop culturally responsive instructional strategies. Two program personnel acted as facilitators and brought their teacher education and research expertise to the collaborative work of the group. Teachers' participation was grounded in their own perspectives as science educators in urban high-needs schools [62–64]. This study therefore focuses on "the perspectives of those who do the work" [65] (p. 58).

CRE PLG Participants and Positionality

At the time of this study, the CRE PLG was composed of six Earth science high school teachers (Bennett, Lily, Marigold, Seamus, Theo, and Zen) and two facilitators (Elaine and Jamie). While educational backgrounds varied across group members, the teachers received the same certification and degree from Bickmore's teacher residency program. The teachers worked at schools that served populations of 81% economically disadvantaged or higher. With grant funding to support the group, graduates from one particular cohort were invited and volunteered to participate in the PLG. The majority of the members spoke English as a first language; two were bi-lingual with fluency in languages in addition to English. The group was mostly of White European background, part of the dominant culture, and did not reflect the racial and ethnic backgrounds of the majority of their student populations. Teachers were comfortable with science content and several had careers in science or engineering prior to teaching. Teachers' self-reported background information is embedded throughout the paper. The facilitators both identify as White American females. Elaine is a teacher educator, raised in a Protestant family of mixed European descent, and has lived in rural, suburban and urban settings. Jamie is an educational researcher and evaluator, raised in a city in the Northeast in a family of Eastern European descent, and has lived in multiple international settings. Prior to the formation of the CRE PLG, the teachers knew Elaine as a professor in the program and were familiar with Jamie through program evaluation and research. (See Appendix A on participants and school demographics).

As we work in the area of "cultural responsiveness," it is our responsibility to address and reflect on our cultural and racial positionalities [60,66] and lived experiences that inform and influence our perspectives. As Merriam and colleagues eloquently articulate, "The reconstruing of insider/outsider status in terms of one's positionality vis-a-vis race, class, gender, culture and other factors, offer us better tools for understanding the dynamics of researching within and across one's culture" [66] (p. 405). Not surprisingly, positionality also emerges in teachers' stories and has been central in our work. Teachers' positionalities are woven into their stories in an effort to help connect their lived experiences and backgrounds to their perspectives and what they are learning and doing in regard to CRE.

As Cochran-Smith and Lytle [47] brought to light, boundaries between research and practice can become blurry when one's professional setting becomes the research site. They state that it is often the convergence and intersection of the two roles—in our case, teacher educator and researcher—that promote critical reflection, opportunities, predicaments and innovation. They examine this duality, citing the dilemmas that can surface in terms of ethics, methodology, epistemology, politics, and personal/professional development. Learning to leverage these seemingly dichotomous tensions is what Cochran-Smith &

Lytle refer to as “working the dialectic” [47], producing blurred boundaries of research and practice instead of opposing forces. Others also discuss the complexity of being both an insider and outsider to the research group and how concepts of positionality, representation, and power become particularly useful to explore [66]. Similarly, these tensions and complexities are common in the anthropological landscape when researchers conduct fieldwork in the familiar (e.g., within their own culture or environment), raising questions about ethics and representation. These are unresolved tensions we’ve experienced as we continue to aim for transparency in our work with teachers.

Teachers provided information related to their identities that they felt comfortable sharing, and selected pseudonyms to represent them and their schools. As facilitators and researchers working with the residency program from which these teachers graduated, there are power dynamics in play. One way that we attempted to mitigate this was in the design of the professional learning group, in which teachers led and guided the development of the work based on their needs and interests.

2.2. Methods

As members and facilitators of the CRE PLG, we employed qualitative methods using a single case study design [67], as this allowed for an in-depth and nuanced exploration of the group’s stories over a prolonged period of time, in which the researchers became participant observers immersed in the ongoing actions, behavior, and language of the group [68,69]. We selected the conversational routine of Stories from the Field as our focus as it offered a rich, descriptive opportunity for all members of the group to reflect and share current and changing understandings and experiences. As there is a large amount of data, we chose to bound the timeframe of this case to examine the first year in particular [68,70].

Multiple sources of data were collected throughout the 2018–2019 academic year, including semi-structured teacher interviews, observations, meeting notes, collaboratively designed artifacts (e.g., strategies and protocols, activities, video analysis tools), teacher artifacts (e.g., lesson plans, worksheets), and samples of student work. We relied heavily on meeting notes for this analysis, which we found to be a rich data source to examine with 19 sessions and an estimated 48 h of meetings throughout the year. We incorporated interviews as supplemental data for additional perspectives, experiences, and context. Collaboratively designed artifacts were developed in the context of meetings and are woven into some of the stories. Similarly, teachers shared teaching artifacts and samples of student work during meetings, which also contribute to our understanding and interpretation of stories.

2.3. Analysis

We engaged in two rounds of coding of meeting and interview transcripts using the data analysis software, Dedoose [71]. We used an iterative process of inductive and deductive coding techniques to identify emerging themes [72], applying a grounded theory approach in constructing codes to see what was surfacing in the data [73]. Our analysis was also informed by an additional layer of our experience with the group, which helped shape what we saw in the data. For instance, while we anticipated seeing systemic challenges and constraints emerge in teachers’ stories, we also noticed in the data instances where teachers were supported in engaging in culturally responsive work. This informed the development of a code for systemic supports, which we later approached with an ecological model [74] and nested layers of context model for context-specific teacher education programs [75] to inform our thinking and analysis of the various levels represented and situated within broader social, political, and historic contexts.

Collecting multiple data sources allowed for triangulation to enhance accuracy and helped identify themes [76]. We also drafted analytic and conceptual memos, which we drew on throughout the writing process. We engaged teachers in member checks as a critical ethical step in preserving trustworthiness and an attempt to moderate power dynamics, confirming teachers’ comfort with the analysis, and checking for accuracy in

interpretation. This was essential for maintaining our relationships, and incorporating teachers' feedback as co-authors.

2.4. Affordances and Limitations

As the group met regularly over an extended period of time, we could see ebbs and flows in teachers' stories, as well as connections made between and across stories. We saw how narratives, personalities, and characters emerged and resurfaced, and how connections were made to past stories. The stories helped the group to develop norms and provided a grounding for what was happening in each other's school contexts and lives. In this respect, the stories provided a multi-layered approach to collaboratively explore culturally responsive science education.

To portray and highlight the conversational routine, stories were extracted from their original flow. While we have added background context, seeing each story in isolation can help to focus on a particular point but also separates it from the fluidity with other stories and nuance from the group setting. As storytelling involves interactions and exchanges between the narrator and the listeners, subtleties and nonverbal behavior can be challenging to capture. In addition, by focusing primarily on Stories from the Field, we limit our examination of other work of the group, such as classroom video analyses and presentations and workshops for teacher professional learning. Storytelling is one lens through which to explore and does not represent or portray all of the work carried out over the year.

The group often used different language and terminology for what we call "culturally responsive". At times, language used in stories oscillated between various derivations of CRE, including "cultural relevance". One consideration is that our data are grounded in free-flowing conversations that might not always be screened and filtered when in a comfortable and trusting environment. We do not aim to isolate and simplify "takeaways" from stories, as we recognize their complexity and multidimensionality and believe that CRE is not a checklist of items or strategies. We share what we are learning about teachers' perspectives, experiences, and reflections on their own practice in regard to CRE in their science classrooms and how they are represented in the stories they tell.

3. Emergent Findings from Teachers' Stories

First, we discuss three primary themes that surfaced from the data and inform our learning about teachers' perspectives and experiences with culturally responsive science teaching in their unique and distinct settings: (1) Navigating systemic constraints and supports for culturally responsive science education at various levels of the ecosystem, (2) Connecting through science, and (3) Sensemaking and learning from developing and analyzing culturally responsive strategies and practices. We examine these themes to gain a better understanding of what teachers chose to represent in their stories, and connect them to our developing understanding and experiences with culturally responsive science education by using the CRE tenets as a framework (see Figure 1 above). Throughout the section, we examine ways in which stories shed light on teachers' experiences and practice.

3.1. Navigating Systemic Constraints and Supports for CRE at Various Levels of the Ecosystem

Throughout the stories, teachers acknowledged, addressed, and navigated constraints and supports associated with system wide issues, structures, policies, and practices embedded in the larger educational context. Systemic constraints and supports surface in the stories at four levels: school, administration, city, and state. Within this theme, issues of power and inequity are revealed through the stories teachers tell about their experiences in classrooms and in the wider educational context.

3.1.1. Systemic Constraints

Systemic constraints emerged in teachers' stories in distinct ways. For some, the statewide standardized assessment was perceived as a barrier to implementing CRE,

particularly regarding the time and focus on required predetermined content and test-taking skills. With one exception, the schools in which the teachers worked aimed to prepare students for a statewide exam in Earth science. Therefore, most teachers were responsible, and often accountable, for their students' performance on the high-stakes test (hereafter called "the state test"). Teachers frequently questioned how to make test preparation culturally responsive, and many perceived an inherent contradiction between the state test and CRE. For instance, throughout several stories, Seamus emphasized uncertainty about how to bring test review and CRE together. Seamus, who identifies as a White cisgender male, taught at a large urban high school that concentrated on the state test; thus, he spent a lot of time in class preparing students for the test. Toward the end of the year, he shared, "I'm starting (the state test) review . . . I'm thinking of a wide range of different abilities and levels and kids not taking it seriously . . . I'm not sure how to make (the state test) review culturally responsive" (Seamus, Session 17, 20 May 2019). This uncertainty manifested as a tension, and was a thread that resurfaced and wove through multiple stories, as the concern was picked up and added to over time.

One story highlights how a teacher attempted to reconcile this apparent contradiction by resisting what the school expected of her as a science teacher. Marigold, who identifies as a White Jewish female, taught at Explorer's High School. In efforts to bring a CRE focus into her classroom, Marigold sought to push against her administration's expectations by providing the option for students to demonstrate learning in other ways and interrupt the standardized assessments. Marigold shared her thinking with the group about her school's approach to testing and described her plan to combat this for herself and her students through project-based learning. This storyline resurfaced in several meetings as Marigold recounted what was taking place in her classroom and school:

My school does periodic assessments five times a year. They shut down the school and . . . over the course of three days, students will have double periods in all of their classes and then another extra period of testing for three days straight. It's (state test)-based multiple choice as well as (state test)-based short answer and long answer writing and it's just brutal. It's tortuous. All the kids fail because . . . their testing stamina isn't there, nor should their testing stamina be there. They'll never again be in a situation like this ever in their lives. . . . Our school does it to expose students to the tests but also we collect very, very rigorous data on it. We have a program that you can evaluate from all of the multiple choice proficiency in different learning standards. I can tell test content proficiency as well as see how many of my kids are able to make inferences, how many of my kids are able to apply concepts, which is really powerful. So I'm still going to have to give a multiple choice test at some point.

I decided that instead. . . I'm going to do a project and give the kids a break from the testing during that time period. I'm nervous . . . It'll be a time for them to do a rigorous scientific activity that's more similar to what scientists actually do and that is more compassionate than what my school is doing . . . It's very strictly not what my school does. I'm very much going against what I'm supposed to be doing. . . I'll still give them a multiple choice and full answer and I'll still analyze it, but I'm not going to do it in those three days. I can't do it—it's also tortuous for me. (Marigold, Session 5, 12 March 2018)

As the story unfolded over several meetings, we learned that Marigold engaged her students in a project on conflict minerals, drawing on a unit that Lily (another CRE PLG teacher) uses in her class. For the project, students worked in groups to conduct research on conflict minerals and develop presentations. Reflecting on the project a few sessions later, Marigold shared, "It was definitely a new thing for the students to do that kind of research and have that freedom. It wasn't perfect, which things never are for the first time, but it was cool. Some kids got interested. . . . It was a good thing to do" (Marigold, Session 8, 24 January 2019).

One of the stories that Bennett told and expanded on over time depicts systemic structures at the school and city levels. Close to the end of the year, Bennett described his school's expectation for him to teach a pre-Advanced Placement (AP) course as part of a city department of education initiative. This story is another example of a teacher negotiating his role and responsibility in the face of a perceived contradiction with CRE, and confronting systemic structures that were playing a role in his school. A primary objection for Bennett was that the course and exam would be required instead of optional, and he felt that he would be responsible for "teaching to the test" and in tension with CRE.

My school is doing a push for AP (initiative) as a way to respond to feedback that our school hasn't been rigorous enough. I feel weird because rigor is different for each person ... They want me to teach a course. I've been fighting with my admin. The idea is to make it more challenging for students, but AP doesn't do that for students ... Why are we doing AP if the kids aren't passing? Why (this initiative)? ... I don't want to teach another class for the test ... In the interest of the kids, should I be like screw it (and do my own curriculum)? I'm in a fight right now and it's kind of relevant because the school wants this to look good but to be responsible to students. ... Why another test? ... It's irresponsible to make the school look good at the cost of the students. (Bennett, Session 17, 20 May 2019)

Evident in stories from Seamus, Marigold, and Bennett, a persistent tension between CRE and preparing students for standardized exams, which their schools deemed necessary for students' academic success, became a common theme. Teachers navigated this conflict in different and varied ways. For instance, Seamus remained "not sure how to make (the state test) review culturally responsive," and Marigold saw school leadership requiring instruction that she described as "anti-culturally responsive." Bennett's next story focuses on his school's teachers:

We just finished ... an inquiry cycle of our science department ... (and are) trying to figure out what our next move is for the next half of the year. I made the suggestion that we try to focus on culturally responsive teaching practices to see if we can get some buy-in from some of the teachers... I guess some of the teachers think that there's other more basic needs... that they have to focus on before that. My argument is it shouldn't be a separate thing but it should be an "and", it should be included. (Bennett, Session 6, 15 December 2018)

Bennett actively tried to focus on CRE with fellow science teachers, arguing for its importance for student and teacher learning, but encountered push back as it was not as highly prioritized.

3.1.2. Systemic Supports

Supports for teachers engaging in culturally responsive work also emerged in the data. We explore particular storylines from Seamus and Lily that spanned multiple meetings and provided examples of systemic supports encountered at the administration and school levels.

Over several stories, Seamus recounted conversations he had with his administrator about CRE and the work of the group.

I had my first observation from my (Assistant Principal) ... we were talking about how to ... relate (content) more to (students') lives or society in general. ... Right now in the landscapes unit (we) talked about how groundwater is a natural resource for a lot of communities. Which isn't really culturally responsive to these particular kids because (groundwater is) not their source of water ... Talking about urbanization, how (our neighborhood) ... now is built up. Why when it rains we have disgusting puddles, and kids seemed to relate to that. (Seamus, Session 5, 3 December 2018)

Seamus related an experience attending to his students' lives and society in general, connecting science content to his students' community through discussing the neighborhood, and their own lived experiences with rain puddles. While he may not have been relating to his students' cultures, he was relating to their everyday lives. In this, he implied that relating to students' lives and to society in general are aspects of culturally responsive pedagogy. A few months later, Seamus replayed a conversation with his principal on applying for tenure. While he was expecting to discuss areas for growth, Seamus expressed pleasant surprise that his school leadership agreed with and was supportive of his interest in focusing on CRE in the upcoming year.

Relating how other teachers at school provided support during a particularly charged classroom experience, Lily told a story about her student who was trying to process discovering something new about her identity. Lily and her colleagues discussed how drawing on their school's core values could provide support in addressing the issue directly with the student, Tiffany. In her story, Lily quoted from a book that the CRE PLG was reading at the time, Hammond's *Culturally Responsive Teaching & the Brain* [1].

I had this girl who's processing this genetic testing she's done on herself. We're doing data collection (in class). There's a lot of free time where kids are talking and doing lab. It's fun, they're connecting to each other. She's been processing that she's Prussian ... She appears very much Black, however that's not how she identifies. She is processing out loud that she is excited to go to college, she's European, she's going to Europe to college, she's going to Germany, she doesn't want to date any more "N-words", only date Europeans because they're hot. I was thinking about it while reading this *Ready for Rigor* framework and the learning partnerships and how I want my students to be in a "community of learners", being safe, "making space for student voice and agency". But she's totally stereotyping and all these microaggressions ... and some of my students, especially Black males, are shutting down. One of them had a really wonderful response, a lot of them aren't able to formulate why they're feeling so angry towards her. The greatest retort, he walked in, she was going on and on again. I was like 'Tiffany, let's talk about this later,' and trying to redirect her... I want her to process, just not out loud in the classroom. Marco goes, 'Europeans have no toes.' She got really upset. She was like 'I have toes' and got really defensive and taking off her shoe and telling me to take off my shoe. And he was like, 'You're not European if you have toes.' ...

This has been going on for weeks. Weeks! ... Social workers called home, her advisor has called home, this is coming from mom, and (the) child is trying to process this in a (school) space which is called Maya Angelou ... The crew advisor, me and my co-teacher [are] trying to meet, try to plan what to say when Tiffany starts to process. We go like, 'Hmmm let's try to think about this. What's our core value? Respect for diversity.' We came up with that's what we want to say because we want her to process, just in a separate space, and it's been really hard on this one class. It's so hard to get her to focus. I don't know what to do. (Lily, Session 6, 15 December 2018)

As Lily told the story, others listened, asked clarifying questions and helped her think through what Tiffany might have been experiencing. Marigold responded, "It sounds like she's trying to distance herself from all the things that have applied to her her entire life". Lily affirmed, referencing her own positionality in informing her experience in this situation, "Exactly, yes, I think that's what's coming from her mother and she's internalizing that, exactly. It is so strange and to be in there as a White teacher".

This story is packed with areas prime for analysis. We could examine it from the perspectives of the students and look at the microaggressions and internalized racism that were taking place in the classroom. Alternatively, we could explore what Lily did as a White teacher in the room, such as giving students the time and space to process race

and internalized racism or trying to protect Black male students from a young woman's internalized racism. For our present purpose, we concentrate on the systemic supports in place at the school that assisted the teacher in navigating the situation. Lily's colleagues provided support to help her address the situation with Tiffany, collaborating on next steps and planning for anticipated conversations. They also drew on the institutional structure of the school itself, emphasizing Angelou's core values, which Lily felt helped reinforce her stance and the beliefs that the school promotes. It also reinforced to the student the importance of continuing to process this new aspect of her identity, but in a separate space, to make sure that the classroom and community of learners remained a welcoming, affirming, and respectful environment.

3.1.3. Summary: Systemic Constraints and Supports

In exploring this theme, examples of constraints and supports are entangled throughout teachers' stories at various systemic levels (school, administration, city, and state). Systemic structures play a role in how teachers integrate culturally responsive practices in their science classrooms, and influence the power teachers do or do not hold to be able to do so. Systemic structures provided both limitations in what teachers perceived as constraints and affordances in the types of supports received from colleagues, as well as administration at the school-level. In the stories, we did not see instances of systemic supports at the city and state level, but these data are not exhaustive. We saw commonalities and distinct variations in school settings and structures that can help and/or hinder teachers' integration of culturally responsive practices in their science classrooms. As teachers emphasized these strands in their stories, we saw evidence of recognizing and adopting a critical stance toward structures and processes, an essential CRE tenet. In some cases, this appeared as resisting expectations or opposing and interrupting inequitable practices or structures in place, as seen with Marigold and Bennett. In other stories, teachers showed signs of navigating and mediating their responsibilities within these structures or systems, as we saw with Seamus and test preparation. We also see an indication of high expectations for students' learning, as Marigold substituted standardized assessments with project-based learning, evidence that she viewed "rigor" and "real science" as components of CRE. While one story highlighted relating to students' lives, another affirmed that student choice and interest as important criteria of CRE, and another focused on ensuring a safe and welcoming environment through respect in the science classroom. In each of these stories, teachers attempted to navigate perceived obstacles to culturally responsive science teaching, whether due to or in support of various systemic structures in place.

3.2. *Connecting through Science*

Within many of the stories, establishing relationships with students is centered; this, at times, helped teachers to further their learning about CRE. Inside this theme, we hear from Seamus, Lily, and Zen about specific approaches to form meaningful connections with their students related to science content. As Seamus related,

Yesterday I felt we were doing really good, wrapping up unit four on landscapes and depositions (rivers, glaciers). (We) talked about glacial features ... one of the more boring things. I felt like it actually was going pretty okay ... (We were) talking about (our neighborhood and others nearby) —dead people buried in landscapes. Used the natural landscape, rolling hills, glacial stuff. Kids were really into it, actually paying attention for once. ... My kids were saying, 'By my house there's this weird thing that the land does. Do you think that could be made by a glacier?' That was a really cool suggestion. ... The day before yesterday, I had a really frustrating day because every single class was out of control. Then after school there was a group of half a dozen students in the classroom and ... they were asking (me and my co-teacher) about our lives and 'what were you like when you were my age?' Cool to talk to them about that kind of thing and I snuck in some more teaching without them realizing it. I

was talking about geology, showing an example... (I) pulled up pictures I took out in the west coast this summer. They were making connections to things we did in class. Kids (were) getting into it. Really cool they admitted that, 'I know we violate you about the rocks but this is actually really cool.' (Session 6, 15 December 2018)

Focusing on building relationships with his students, Seamus depicted in his story how, through connecting to geology where his students lived and by sharing personal information about himself with photos from a recent trip, students opened up more about themselves. He saw students making connections to landscape features, geology, and other Earth science content.

For Lily, who described herself as White, cisgender female and who grew up near a large cosmopolitan city, questions about connecting with her students emerged in a different way. In one story, she described her confidence in her abilities to understand her students, commenting "I can speak my kids' language and understand what's going on". However, one day when engaging her students in crew (an advisory group for students outside of subject matter classes that meets regularly), Lily noticed she could not follow their discussion about their lives outside of school, and suddenly felt humbled and said, "I don't know what they're saying and it's so obvious and it really pushed me back on my heels that I don't speak the same language as my children When they're talking about what they do when they go home, what they're watching, what they're doing ... It took me down a notch in my ego" (Lily, Session 15, 11 May 2019).

Shortly after relating her difficulties in relating to her students' lives out of school, Lily shared what she called a "success story" concerning one student who was conducting an experiment on water quality in a local river.

(She) was in my first class I ever taught at (Angelou). She was supposed to graduate last year, but (my science class is) the only class she needs to graduate. She's been really disengaged in school for an entire year. I've been really hard on her—I've been like, 'Take agency, what do you want to do with this?' She meets me at 7:45 (in the morning) all this week at the (river), she does the experiment with me and then we go to school together. She's super chipper. 100% attendance all week. I'm feeling really good about that. (Lily, Session 15, 11 May 2019)

Following this story, Lily shared, "Although I can't understand what my crew is saying, I've got her meeting me at 7:45 in the morning." Here two aspects of Lily's identity—White woman and science teacher—pushed her "back on her heels" in recognizing what she needs to learn, but also allowed her to use what she knows as a science teacher with a deep understanding of the local environment to support her student in doing science and earning her high school diploma.

Zen's story and the subsequent interactions below provide an example of how an impromptu classroom interaction led to discussion about "what counts" as cultural relevance:

I had a really interesting talk about culturally relevant... I asked today about who could remember what a contour line is (and) what it means. And Carter goes, 'It's like my hair!' ... His waves are exactly in contour lines.... He goes, 'Yeah, they're like my hair style!' He was able to make that connection. I don't know if that's culturally relevant or crossing some sort of line. That was one of my questions. He was the one [who] volunteered it. (Session 4, 19 November 2018)

Marigold responded to the story, drawing on a Ladson-Billings [5] article the group had recently read,

Every kid in the school is going to know what waves are. ... I think part of cultural relevancy is using examples that are relevant to kids. In the article, she talked about the second grade teacher who let the kids bring in rap songs [so] that they could figure out literary devices. If talking about waves helps them understand contour lines—

To which Zen responded,

Priceless, because it was all him. ... And that kind of ties into one statement in the article I thought was very interesting ... (Paraphrasing) 'Education has tried to insert culture into the education rather than inserting education into the culture.' I was really trying to think more about that, but I will say that you know Carter and I can have a long discussion about no matter how hard I try, my hair is never going to be as cool looking as his hair; it's never going to make contour lines.

In this story, Zen's and Marigold's interchange linked teachers' uncertainty about the kinds of appropriate connections they could make to students' lives and experiences and science content. Marigold noted that other students in Zen's school would be familiar with contour lines (in terms of hair styles), implying that the information that Carter shared could potentially be useful to others to better understand this particular science content. Zen took the discussion in a different direction, wondering about the distinction between inserting "culture into the education instead of inserting education into the culture" [5] (p.159). Zen also noted that her hair will never be like Carter's, referencing a noticeable difference in their physical appearance (and by implication, race and ethnicity).

Summary: Connecting through Science

In these stories, teachers described relational aspects of teaching and establishing connections with their students in science. Teachers also examined their own identities as they related to their students'. Aware that they had different lived experiences from their students, teachers' stories foregrounded interactions with students, and often provided strategies for bridging their knowledge and experiences with their students' and forming teacher-student relationships in science. They also brought their strengths in science content knowledge and experiences as scientists into their teaching, as we saw with Seamus's landscape photography and Lily's connection with a student through a water quality experiment. As teachers worked to help their students thrive in science classrooms, they continually returned to the question "Is this culturally responsive?" In addition, we see a puzzlement of what might be considered appropriate relationally and culturally in making connections, including those made by students. These stories exemplify teachers' efforts to form relationships with students around science, and make connections to their students' cultural backgrounds and lived experiences, thus illustrating the second CRE tenet.

3.3. Sensemaking and Learning in a Collaborative Setting from Developing and Analyzing Culturally Responsive Strategies

The group was grounded in the understanding that we would collectively examine implementations of culturally responsive science teaching practice. As Lily once shared, "I want strategies ... This is what I can use to get students ... talking. This is an analysis practice that we can use that has students make connections to the data. This is a dataset we can use that is relevant to student lives because that's what I want (from the group)" (Interview, fall 2019). This was integral to the group, as evidenced in recurring stories about classroom practice and strategies and their potential links to CRE. Below, stories from Theo and Zen offer examples of how teachers shared their thinking and learning through discussing individually-developed projects for their classes. Then we delve into two subthemes on teachers' thinking about code switching as a culturally responsive strategy and implementing and analyzing a collaboratively-developed strategy with students.

3.3.1. Discussing Independent Science Projects and Activities

During a session in November, Theo told a story describing a new Earth science project he was planning for his students, who were recent immigrants and learning English as a new language.

My ... class is starting a project, next time I see them. It's a hazards safety pamphlet. The students were given a choice of five hazards—earthquakes, volcanoes, tsunamis, hurricanes, and thunderstorms, which are the ones they're tested on I asked them for the three they would be most interested in and ... (for) the

students who didn't submit to me (their choices), I'm putting them into groups based off of where they come from. Because everyone is from another location.... A couple of the (students) that didn't submit are from India, and one of them is from Nepal, so okay I'm going to put you guys in the earthquake group because that is relevant for you. One of them is a Chinese student ... he's pretty new to the country, so I'm putting him with hurricanes, because it's very similar to monsoon rains. They're going (to teach) each other in terms of having to prepare for each type of hazard. I'm thinking of offering a second portion where they would get extra credit if they ... do it in their own language and in English. That way, they have one that they're more comfortable with and one that they create for the entire class. ... They all have very very different language backgrounds. English is the only [language] they can [use to communicate] with each other.

(Session 4, 19 November 2018)

Marigold immediately responded, "Cool. Are you giving them freedom to do research to do it?" Theo replied, "Yeah, so we're going to have two days of research in class ... collect all the data. I'm going to be giving them a rubric. That way they know exactly what it is they're going to be graded on. ... " Marigold followed up asking, "Have you taught them research skills already?" Theo answered, "No, I have not". Marigold pressed further, "Are you going to?" Theo responded, "That is an excellent question, I have not yet quite decided that".

As Theo planned, implemented, and later on reflected on the project, he shared his thinking with the group; thus the hazards pamphlet project became a thread throughout multiple stories. Over time, we were able to see in stories how Theo built out the research component of the project, and learned about students' development of the pamphlets and about their engagement. (See Figure 2a–c for samples of students' pamphlets).

Later the same month, Theo recollected impressions about this approach where students described preparation for natural hazards in their native countries and his perspective on how it went. "One of my students was like, 'In this river in my country we used to have these really weird thunderstorms and we used to have to hide here so that way we don't get hit or anything like that.' So that went surprisingly well". (Session 6, 15 December 2018)

In the next story, Zen connected a vocabulary activity in her astronomy class to her recent reading about "storytelling" widely used in many cultures as a way to express knowledge, to help her puzzle through what CRE could mean in her classroom.

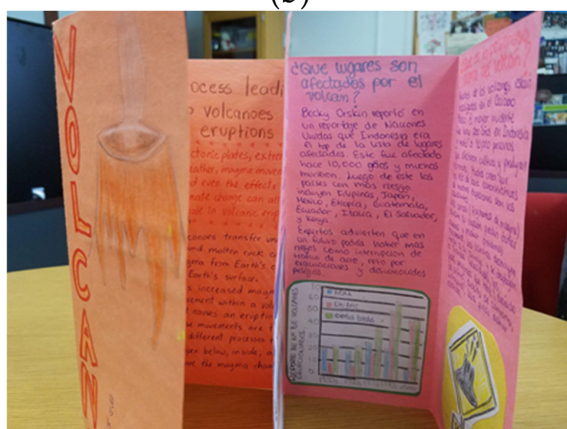


(a)

Figure 2. Cont.



(b)



(c)

Figure 2. (a–c) Photos of students’ natural hazards pamphlets translated into different languages. (a) displays three pamphlets of earthquakes. The two pamphlets in (b) focus on tsunamis. (c) features pamphlets on volcanos in English and Spanish.

(Students) take a list of astronomy words Table teams take all words and (put them in the) four categories . . . objects, motions, theories, or question marks. When they finish, they come up with three words and tell me how they relate. . . . One of my students really got to me on the cultural relevance of this whole thing. I’ve been trying to get my head around storytelling. . . . I went over and said ‘that’s an interesting grouping. Can you explain?’ When she did it blew my mind. . . . ‘An asteroid hit the Earth and killed the Earth before. Then the Big Bang theory happened causing the Earth to reset. Finally a revolution took place where the Earth changed for the better.’ Isn’t that wonderful? It makes perfect sense. The word revolution here We’ve come up with a new theory—not evolution, revolution. That dinosaurs died. An asteroid hit with such force. I went, ‘Wow, that could be the storytelling’; she in her mind linked it to a story that made perfect sense and also helped me in my mind with the struggle my students have with vocabulary. That’s a perfectly legitimate use of the word revolution. (Zen, Session 11, 23 March 2019)

Zen’s excitement about what her student did with this vocabulary activity, and her own ability to step outside of her science understanding to appreciate her students’ thinking, was clear in how she told her story.

3.3.2. Code Switching as a Culturally Responsive Strategy?

In another set of stories, teachers discussed the idea of “code switching” as a strategy to respectfully interact with students’ ways of speaking while helping them learn to commu-

nicate academically like scientists. This discussion began in a story where Zen wondered if “by always asking the students to behave a certain way ... I’m not being culturally relevant.” She shared, “if I’m asking students to be more academic in my classroom ... how does that cross a line that I maybe am not being culturally relevant?” (Session 13, 8 April 2019) Lily responded, “In order to be successful, no matter what career you’re in, you need to be able to code switch.” Lily continued, “I think being really explicit about that is super helpful, and would buy you a lot of credit with the students ... If you can’t figure out how to code switch, you might find yourself in a pickle down the road. So let’s practice here, these are my expectations. ... It’s more low-stakes here than it will be in the real world.” Bennett responded in support of Lily’s suggestion, adding “And finding examples you know where they do that... Lots of my kids go to church and so I’ve been saying, ‘Do you talk like this in church? Why not?’” In his support of being explicit about code switching, Bennett provided an example that could help students realize that code switching is something that they already do, and that school is another place to practice.

This interchange indicated agreement that being explicit about code switching was a valuable approach to support their students in adopting academic and scientific language. Zen returned to this thread in another story a few weeks later, saying, “I’m asking my kids to code switch ... I’ll be totally honest with them but I’ll ask them to come into the room and let’s be scientists” (Zen, Session 15, 11 May 2019). Zen’s reference to code switching suggests that she believed that this strategy supported her goal to make her classroom into one where students are expected to talk in the ways scientists do.

3.3.3. The Idea Exchange—A Collaboratively Developed Strategy

The group’s efforts to shape their instruction in ways that would suit their students was informed by a shared interest in encouraging more student talk about science in their classrooms. One instructional strategy, “The Idea Exchange”, wove throughout multiple stories focused on implementation, reflection, and what teachers were learning from it. These stories surfaced over time, thus illustrating the ebb and flow of Stories from the Field. Early in the year, the group chose a protocol to modify and enact in their science classes that they believed would encourage their students to share ideas and questions. Several teachers had encountered the “Rumors” protocol [77] in previous professional development experiences, and the CRE PLG adapted it to fit their individual classrooms and goals, renaming it the “Idea Exchange”. In the protocol, students are given questions or situations and asked to write their ideas or questions on post-it notes, which they replicate twice. Students move around the classroom and repeatedly share their post-it notes with others until they have all been exchanged. Throughout the year, teachers shared their experiences with implementing the Idea Exchange in stories, often including modifications made for their students and current thinking. Below, we look at stories told by Marigold and Lily.

In one story in the fall, Marigold described a lesson about what causes the seasons and experience with incorporating the Idea Exchange:

I’m doing seasons right now. (I’m) trying to make it Hallowe’en friendly. My lesson was Spooky Seasons: Alaska’s Endless Night. The question was ‘why does Alaska have a night that lasts for 67 days?’ We started the whole lesson by reading a paragraph about what it’s like to be there and get ready for that long night and watched the time lapse video ... I followed the (Idea Exchange) protocol that we had written up ... It was awesome! ... I wasn’t sure how culturally relevant it can be considered. ... But at the same time the kids were so excited. I think it was a really engaging question because even though it’s not something relevant to their lives, it’s still something they can imagine. They can’t necessarily imagine Earth’s tilt, making it so that Alaska doesn’t get sunlight, but they can imagine what it would be like to be dark for that long. I think it was really beneficial for the kids to have a protocol to follow ... (and) to have ideas written down because even though I made sure they read them—they couldn’t just trade post-its (there were

a couple of kids who tried)—they were grounded by having their idea already written down. So I think it was a fun form of communication.

(Marigold, Session 3, 3 November 2018)

Marigold followed up with a second story about one student who demonstrated his intrigue of the “endless night” lesson:

I had a kid who is in my first period class and he hasn’t been in class for about a month. He was there that day, and he’s been there every single day since. He told me that he went home and was playing PS4 on one of those games where you talk to people around the world He met someone in Alaska and asked him if it was true. He came back the next day actually telling me about it. And then was asking me all about time zones and everything. So that was pretty cool.

(Marigold, Session 3, 3 November 2018)

This story reveals Marigold’s learning that choosing an intriguing question and discussion protocol can engage students in learning Earth science content—even outside the scope of the lesson, as evidenced by the previously disengaged student who talked with someone from Alaska about time zones. She also shared her thinking that a beneficial aspect of the protocol was that students wrote and shared their ideas with others aloud—not just traded post-its.

Lily also told a story on the Idea Exchange activity in her classroom, where she placed it after her students presented on carbon data. The purpose of the Idea Exchange was to create a list of student generated questions to pursue as a whole class (students were writing and exchanging questions rather than responses), and to help students believe that their questions were valid in science class. She related that it was challenging to get the students “up and moving” but once they do “they like it”. She continued,

Because kids didn’t want to move, I had one of the students choose one song. He tried to find the shortest song he possibly could So there is super-intense rap music blasting in my classroom but kids finally got moving. How effective it was at creating student voice around questions, and the ability to socialize, that asking questions are okay and no ideas are stupid? I don’t know if it was effective, but it definitely broke up the cliques. It got students talking to each other who never spoke to each other before, so that was a benefit. (Lily, Session 3, 3 November 2018)

Lily’s story was a reminder that the Idea Exchange carried multiple opportunities for student interaction: to get students’ ideas out in the classroom, help students talk to one another, and support that “asking questions are okay and no ideas are stupid”. At the end of her story, Lily shared how one student responded to the activity by commenting “What are we doing this for? I don’t see this as learning”. This student’s reaction prompted Lily to respond that she needed to explicitly voice, “This is relevant to our education because ...”

Implementations of the Idea Exchange continued to surface in teachers’ stories. For instance, several months later, Marigold described another implementation where she found increased student engagement:

I had planned ... an (introduction) to Earth’s history. I started the class with ... a picture of some rock layers and Jeremy thinks the youngest layers are on the top, xx thinks on the bottom. . . . Every single person participated in discussion about the (Idea Exchange) My second period class is usually quiet . . . I’ve been having a lot of trouble with my Spanish speaking class. . . . (The Idea Exchange) went really well with them because it was discussion-based. It’s really fun to give kids a challenge. Even though not necessarily culturally relevant, they got really engaged because they knew enough to be able to approach without being able to all have written the same answer. Kids were standing up and shouting at each other, pretty cool. (Session 11, 23 March 2019).

Marigold reiterated her uncertainty that the Idea Exchange was culturally relevant/responsive in this story, even though it took place a few months later—and yet it clearly engaged her students in discussion, which was an intention of the activity. In these stories about implementations across their varied classrooms, teachers indicated that this strategy could encourage students' sharing of ideas and questions in the classroom, and also become a vehicle for developing a classroom community in which ideas and questions are safely shared and welcomed. As Bennett described,

For culturally responsive, (the Idea Exchange is) really promoting diverse social interactions in a safe environment. I think this type of activity is really, no matter how you apply it, engaging because it gives everybody a voice, it keeps everybody in an engaged safe space, and I think that's a fundamental pillar of what we're trying to do. (Bennett, Session 3, 3 November 2018)

Arguing that the Idea Exchange is an example of culturally responsive science teaching, Bennett put a stake in the ground: We have got this aspect of CRE right, as indicated by "promoting diverse social interactions" and "engaging" in a "safe space", and referred to it as a "fundamental pillar" of CRE as discussed and practiced by the group.

3.3.4. Summary: Sensemaking and Learning through Developing and Analyzing CRE Strategies and Practice

Evident throughout these stories was a central goal of the group: to develop science instruction that attended to the CRE tenets, as teachers began to understand and make sense of them. The group came to believe that CRE required an active stance in learning about their students' cultures as assets and incorporating them to support teaching and learning. This is particularly evident in Theo's stories about the natural hazards project, which valued and integrated his students' diverse languages and lived experiences. Instructional strategies and approaches strongly came out in teachers' stories where they connected to their thinking, current understanding, and what they were learning and processing about CRE in their unique contexts. The structure of Stories from the Field, where storytellers and listeners interacted around strategies, offered an additional layer to process, engage in sensemaking, and potentially gain understanding. Teachers shared reflections on implementations of the Idea Exchange in their classrooms, which often resulted in revisions in instruction. Yet, it also raised the question, "Is what I'm doing truly culturally responsive?" Teachers noted that students found The Idea Exchange engaging; the strategy was adapted to match individual classroom communities and content in distinct ways. In some cases, it flopped and teachers thought through modifying and trying again. In other cases, teachers found that it helped to solidify one purpose of CRE, as expressed by Bennett, in "(giving) everybody a voice, it keeps everybody in an engaged safe space".

4. Discussion and Implications

We recognize that developing CRE is a lifelong approach, and the group provided a space for tentatively, mistakes, and honesty. This exploratory study of stories drawn from the first year of the group was designed to help us consider what we are learning as educators and researchers about culturally responsive science teaching in our diverse contexts. Teachers' stories helped us consider what CRE can look like in science classrooms, and what it takes from teachers "on the ground" and actively engaged in the work of teaching [65]. It is through their telling and retelling of stories [55], rooted in their teaching experiences, that we explore potential images of culturally responsive science teaching.

Teachers often made connections between what was happening in their classrooms and the readings, bridging theory and practice by threading references to works by Ladson-Billings and Hammond, among others, into their stories. For instance, teachers frequently questioned if what they were doing in their science classes could be considered culturally responsive or an indication of "just good teaching," using Ladson-Billings' [5] foundational piece as an anchor. At times this led to rich discussions about "what counts" as culturally responsive, allowing for the development of shared language and description about what

they deemed appropriate—a practice common in teacher communities of practice [78] and one that supports teachers in collaborating with other teachers and feeling less isolated in thinking about and enacting this complex work [79]. In fact, one thread woven throughout several stories is wondering to what extent the approaches were culturally responsive. This suggests that teachers perceived that there could be some type of continuum or spectrum in their development as culturally responsive educators.

Three central ideas surfaced in the stories that provide a glimpse at teachers' experiences and perspectives. First, navigating systemic influences at various levels (both affordances and constraints) played a role in teachers' enactment of culturally responsive science teaching practices in their classrooms. Second, teachers focused on making connections with their students through science. Finally, teachers were engaging in sensemaking and learning through sharing and discussing CRE strategies that they implemented with their students. We also learned about the role of stories in our professional learning group through this analysis, coming to believe that it provided a structure for individual and collaborative sensemaking about various facets of CRE in science classrooms.

The framework of the CRE tenets provided a structure to ground the stories more explicitly in CRE in science. Using the CRE tenets as a framework (see Figure 1 above), we saw examples of particular tenets in the stories and drew connections, which supported our analysis, and noted evidence of the four tenets across the three themes. In some themes, examples of particular tenets emerged more strongly than others. For instance, using students' assets as resources in instruction (first tenet) and high expectations for students (third tenet) surfaced clearly in sensemaking and learning through developing and analyzing CRE strategies and practice. This is not that surprising given the explicit focus on instructional strategies. The second theme connecting through science illustrated examples of cultural connections (second tenet) in stories, although students' assets and high expectations also surfaced. Critical stance (fourth tenet) emerged more in the first theme navigating systemic constraints and supports. The stories also featured specific topics and units across Earth science curricula, including natural hazards, eclipses, astronomy, landscapes and depositions, water, seasons, and Dynamic Earth.

Stories from the Field was a pedagogical tool for teachers to relate and reflect on situations and experiences in their unique settings, as representations of practice [56,57]. Storytelling afforded opportunities to "view" images of the setting (classrooms or schools), key characters (e.g., students, colleagues, administrators), and the narrator's approach to a circumstance or event. Each teacher rotated between the roles of storyteller and listener. Unlike concrete images on video, stories by nature are opaque—they are conveyed through the perspective of the narrator, who holds the reins and guides the listeners, depicting an image that is sculpted and portrayed through a particular lens [57]. In our context, we see that teachers also used stories as a means to explore aspects of identity [56,57], both their own and in relation to learning more about their students. This is apparent across themes, whether through considering one's positionality in relation to their students in the class, or helping a student to process a new facet of their identity, or in continuously asking if what they are doing is culturally responsive for their particular students. Practices of reflection and self-questioning were common and presented more frequently than certainties in regard to terms of culturally responsive science teaching.

The act of telling a story during group meetings and the insights or feedback that listeners provided aided in pushing teachers' thinking, reflection, and learning [54,55]. In this respect, stories can help to illuminate teachers' pedagogical practices and thinking that reflects their learning and sensemaking of what CRE can look like in their specific science classrooms and contexts with their students. Thus, there are important implications that should be considered for teacher professional learning and teacher preparation in terms of the roles that stories can play in teachers' sensemaking, exploration, and examination of CRE. The act of storytelling proved to be a particularly useful method to explore CRE in science classrooms. It has therefore remained an integral aspect of our work together, which is not surprising given the traditions of storytelling in cultures throughout the world.

Teachers' stories reveal tensions between expectations and responsibilities regarding standardized testing and teaching science in culturally responsive ways that echo previous studies [80]. The tensions that emerge highlight the contrast between standardized testing and adopting a critical stance toward sociopolitical structures and processes and helping students to develop the same, a social justice component that recognizes and actively addresses issues of inequities and a tenet of CRE. In an age of accountability, the CRE PLG teachers are not alone in grappling with ways to reconcile and navigate culturally responsive teaching and high-stakes standardized assessments [81,82]; yet not much exists in science education research at this point. Thus, we flag this as an area for further work and support needed for both in-service and preservice teachers.

5. Conclusions

In this article, we shared findings from a study on teachers' stories with six in-service teachers in a professional learning group focused on culturally responsive teaching in science classrooms. Findings highlight how the conversational routine of storytelling has offered an outlet that crossed cultural boundaries to teachers' experiences with CRE and insights into teachers' practice. We found that teachers' stories from the first year of the group surfaced themes of navigating systemic constraints and supports, connecting through science, and engaging in sensemaking through analyzing strategies for culturally responsive science teaching. This helped to shine a light on a critical aspect of our work exploring CRE and what that might look like in science classrooms through the stories that teachers tell. When analyzing stories, one might risk simplifying teachers' sense-making through isolating their stories from the context in which they are told. Nonetheless, we believe that the complexity and multidimensionality of these teachers' stories illustrate that CRE is not a checklist of items or strategies. Our findings suggest that storytelling is a rich, descriptive vehicle for exploration and sensemaking amongst teachers in a professional learning group and an underused resource in studying CRE, especially in science.

Continued Learning and Next Steps

After the first year, two CRE PLG teachers changed schools, and all continue to teach Earth science in high-needs schools in the city. The group continues to work together and Stories from the Field remains an integral routine. In the second year, the group moved from an explicit focus on culturally responsive to culturally responsive-sustaining science education. This mirrors new policies in the shifting landscape with the state department of education's release of a culturally responsive-sustaining education (CR-SE) framework [4]. The group focused on developing teacher inquiries into their own classrooms and practice in the context of CR-SE. Social justice and sociopolitical consciousness have become a strong thread in our second year, captured in the fourth CRE tenet of adopting and supporting students in developing a critical stance. In addition, two cohort members joined the group adding to its size and diversity. As we finalize this paper, the disparities in wealth and power in our city have come even more starkly to the fore during the COVID-19 pandemic. This has required a respite from thinking about what to do in classrooms, as teachers deal with remote teaching and physical distancing, and the effects of the virus on themselves and on their students' families. The group remains active, meeting weekly online, and has followed the ebb and flow of the uncertainties of the pandemic. As the enormous racial, cultural, health, and socio-economic inequities and systemic racism became more transparent, the need for change and to not return to the same place we were before became centered in our work [83]. Keeping the loss and pain of their students central in their thinking and planning, the group has started to bring in more connections to socio-emotional learning and healing-centered, trauma-informed practices. Alas, this is a critical area that we have identified for further collaborative research.

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Appendix A

Table A1. CRE PLG Teacher Participants (self-reported).

Teacher	Background Information
Marigold	White, female, cisgender, Jewish, English/Spanish bilingual, 29 years old
Seamus	Male, cisgender, white, early 30s
Theo	Chinese, Male, grew up in urban setting
Lily	White, female, cisgender, grew up in rural-suburban northeast town outside of a large cosmopolitan city
Bennett	White, male, cisgender, German-Albanian, English speaker, grew up on rural farm, went to college for 12 years, Spanish language learner, 36 years old
Zen	Genderfluid; Swiss-English heritage North American; general professional proficiency in Spanish

Note: Pseudonyms have been applied to all teachers to protect identities.

Table A2. CRE PLG School Demographics.

School	Enrollment	School Demographics (Using the 2018–2019 State’s Enrollment Data and Language) [84]									
		American Indian or Alaska Native	Asian or Native Hawaiian	Black or African American	Hispanic or Latinx	White	Multi-Racial	ELL	Special Needs	Economically Disadvantaged	HomeLess
Explorer’s High School	310	1%	2%	19%	76%	1%	1%	26%	28%	95%	17%
Garden High School	1217	0%	10%	8%	74%	8%	0%	22%	24%	86%	6%
Einstein International High School	823	NA	28%	1%	64%	6%	NA	78%	1%	88%	17%
Maya Angelou High School	241	0%	2%	38%	55%	5%	0%	8%	32%	82%	6%
Performing Arts School	423	1%	1%	27%	66%	1%	4%	6%	24%	87%	7%
IWD High School	172	NA	1%	36%	61%	2%	NA	6%	15%	81%	6%

Note: Pseudonyms have been applied to all teachers and schools to protect identities. Table A2 provides a summary of the schools’ demographic data made public by the state’s Department of Education. “ELL” refers to the number of students in each class who have been officially designated as English Language Learners.

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