



Theorizing and Designing Relational Possibilities in Teaching and Learning

D. Teo Keifert (chair), University of North Texas, danielle.keifert@unt.edu

Ashlyn Pierson (co-chair), Sophia Jeong, The Ohio State University

pierson.199@osu.edu, jeong.387@osu.edu

Natalie De Lucca (co-chair), Jessica Watkins (co-chair), Adam Bell, Sarah Lee, Bethany Daniel, Andrea Henrie, Heather Johnson, Vanderbilt University

natalie.delucca@vanderbilt.edu, jessica.watkins@vanderbilt.edu, adam.bell@vanderbilt.edu, sarah.lee@vanderbilt.edu, andrea.bethany.r.daniel@vanderbilt.edu, andrea.henrie@vanderbilt.edu, heather.j.johnson@vanderbilt.edu

Déana Scipio, IslandWood, deanas@islandwood.org

Philip Bell, University of Washington Seattle, pbell@uw.edu

Abstract: Challenging assimilationist science requires examining relationalities—the ways we are bound to each other, our personal histories and interactions, and the broader sociopolitical histories of learning contexts. We take up the need for understanding powered relations in this innovative extended-time and hybrid engagement symposium with opportunities for engagement before, during, and after ISLS23. We recognize all learning as political and examine powered relations and relational possibilities across four settings: drawing on Black methodology to disrupt how researchers and educators come to understand Black girls' learning in a summer camp, two pre-service teacher programs to explore "becoming" and challenging dominant logics, and how an in-service teachers' shifts towards humanizing and empowering kindergarten learners. Together we explore how participants' and researchers' understandings of relations in how we "see" science teaching and learning and ways to theorize and design for spaces that open multiple relational possibilities in science learning and teaching.

Session overview

In the past few decades, the Learning Sciences community has increasingly considered power, purpose, and positionality in teaching, learning, and research (e.g., Esmonde & Booker 2017). In particular, a growing body of work points to how normative K-12 science learning experiences require assimilation into unevenly powered relations between students, teachers, more-than-humans, and science disciplinary knowledge and practice, foreclosing opportunities to consider more just and heterogenous relations between learners and science (Barrett et al., 2017; Rosebery et al., 2010; Warren et al., 2001; Warren et al., 2020). In these assimilationist approaches, science learning has been designed to apprentice children into one way of doing science, established by the standards and not always reflective of professional scientific practice, learners' competence, nor their cultural repertoires (e.g., Hudicourt-Barnes, 2003; Keifert & Stevens, 2019; Levine et al., 2020). Rather than intercultural processes (Warren & Rosebery, 2011), assimilationist science learning imposes forms of alienation; "untenable epistemological positions that work against engagement in meaningful learning of scientific ideas, practices, and phenomena," actively harming learners from nondominant communities (Bang et al., 2012, p. 304).

Challenging this assimilationist approach requires us to reflect on our relationalities—the ways we are bound to each other, our personal histories and interactions, and to the broader sociopolitical histories of learning contexts. Developing alternatives to assimilationist approaches to science motivates us to re-think the relationships between teachers and students, between researcher and researched, between scientists and laypeople, between dominant communities and marginalized ones, and between humans and more-than-humans. Yet, this re-thinking must also involve recognizing the powered histories of these relationships. Recognizing, for instance, that historically, young White women were recruited as teachers to enculturate Native and immigrant populations (d'Amico Pawlewicz, 2020p; we capitalize White per APA 7). Western Modern Science constructed scientific knowledge as property of colonial (White male) scientists that led to the exclusion of the plurality of Black Diasporic and Indigenous peoples' humanity and knowledge systems (Palmié, 2002). That dominant portrayals of science maintain their dominance by continuing to narrate scientists as separate from nature, as omniscient observers and manipulators of the natural world (Castro-Gómez, 2021). Working towards more just and caring relations in science teaching and learning involves reflecting on our conceptual, epistemological, and ontological goals. It also involves interrogating our values, reflecting on our axiological goals to consider "the moral and ethical underpinnings that guide learning and participation in scientific and engineering practices" (Krist & Suárez, 2018, p. 424; see also Philip et al., 2017).



We take up the need for understanding powered relations in this innovative extended-time, hybrid engagement symposium. We explore the design and interactional space held by foregrounding axiological goals as we conceptualize relational possibilities between learners, teachers, more-than-humans, and cultural repertoires of knowledge and practice, including Western and other scientific practices. Considering caring relations (Krist & Suárez, 2018) in this work, we hope to engage members of the Learning Sciences and Science Education community in theorizing & designing for relational possibilities in science teaching and learning. We first draw on prior work to conceptualize the idea of power relations and relational possibilities. We then present questions we will examine together, followed by an overview of the extended temporal wings of this session, starting before the ISLS annual meeting, including a synchronous recorded session during the meeting, and concluding the week after the meeting.

Conceptualizing powered relations and relational possibilities

We are particularly interested in understanding how learners, educators, and science knowledge and practice are positioned in relation to one another. Specifically, our efforts are towards theorizing and designing in ways that explicitly acknowledge the power dynamics in these multiple relationships. Rather than develop new theory in this symposium, we draw on existing conceptualizations of power, relationships, roles, responsibilities, privileges, and relationalities in STEM teaching and learning to examine possibilities that emerge(d) in particular STEM designs. Forwarding a power explicit lens to understand relationships, we enter a speculative space to examine and imagine relational arrangements and possibilities that do not yet exist within dominant power structures.

Collectively we recognize all learning as political (e.g., Freire, 1970). We assert educators and teachers can both be learners, all relationships are powered, power must be interrogated, and the authority and agency for learning must be (re)distributed across participants. We recognize that science learning is fundamentally a relational activity (Calabrese Barton & Tan, 2018), contextualized and embedded in histories of the discipline, particularly science as White property—science as objective, neutral, separate from, based in Eurocentric thought and practice, and owned by White men (e.g., Bang et al., 2012; Mensah & Jackson, 2018).

To understand the particulars of each study and the multiple dimensions of relationality, we draw on multiple perspectives to understand powered relations and relational possibilities. Specifically, while all teacher-student (or adult-child, adult-youth) relations are inherently powered, these relations are multiply impacted by individuals' identities and relations with oppressive systems. Identities may include members in Black, Indigenous, Asian, LatinX, disabled, LGBTQIA+, multilingual, immigrant, and other communities that experience historical and continuing oppression in the U.S. Thus, powered relations between standards-teachers-students, old-timers-newcomers, researcher-researched, scientists-laypeople, dominant communities and marginalized ones, and humans and more-than-humans must be understood within the histories of oppression relevant in their context (i.e., in our case, U.S. informal and formal learning). Thus, to explore ways of disrupting oppressive relationalities in science education, we draw on interdisciplinary Black methodologies (McKittrick, 2020), becoming and diffraction (Barad, 2007, 2014), redressing multiple harms (race- class- gender-based) experienced by pre-service teachers of color (Mensah & Jackson, 2018), and humanizing approaches to teacher education (Kang, 2022; Louie et al., 2021).

Our work in the theorization and design of each learning context requires a powered analysis of “both interconnectedness and difference through how we subjectively construct ourselves and the other” (Calabrese Barton & Tan, 2018, p. 766). As we do this work, we hold space for participants to draw upon existing relations often excluded from traditional STEM learning environments (e.g., teacher as learner, imaginative embodiment) and for potential new emergent relations. This work is critical as it centers meaningful and humanizing STEM learning in ways that acknowledge that “my humanity, my integrity, and my dignity are rooted in my willingness to safeguard your humanity, secure your integrity, and protect your dignity” (Olivares & Tucker-Raymond, 2020).

Session summary and shared questions

Across multiple contexts, our presentations explore powered relations between teachers, learners, science, and culture, as well as how hegemonic relations can be disrupted. The first paper deploys Black methodology to disrupt how we, as researchers and science educators, come to understand Black girls' learning in the context of a summer camp exploration of light through photography and in the context of connections to Beyoncé's music and visuals. This paper questions how normative understandings of “seeing” background political labors and powered relationship dynamics that honor Black girls' brilliance. The second and third papers explore powered relations in the context of pre-service teacher learning, exploring pre-service teachers' relations to science and their own teaching. One paper considers pre-service teachers' “becoming” through noticing focused on videos of their own teaching, and the other explores how pre-service teachers challenge dominant logics to acknowledge relationality in their own scientific journeys. The last paper explores how in-service teachers' relationships to



students and science shift in the context of a multi-year professional development to contribute to more inclusive kindergarten science teaching.

In the four presentations and the two discussants' comments, we examine the following questions about powered relationships and their role in science teaching and learning across contexts.

1. How do participants' and researchers' understanding of relations shape how we "see" science teaching and learning?
2. What are the different ways in which we theorize and design for spaces that open multiple relational possibilities in science learning and teaching, particularly in light of dominant relations that often repeat?

Innovative hybrid symposium design

We are excited to submit this symposium in the innovative hybrid category. Our goals are to extend engagement beyond the immediate synchronous session to include broader temporal wings (before/after the annual meeting) and multiple modalities of engagement.

Table 1: Temporal wings and multiple modalities of engagement for the hybrid symposium

	Pre-Conference	During Conference Session	Post-Conference
Discussion Forum	Proceedings include focal studies + discussants Prompts prepared + posted	Discussion forum topics/questions summarized and shared by chair	New prompts based on synchronous session
Video	Short clips visible to ISLS members to intro the four focal studies	Live Zoom Session In-Room chat monitoring + mic use Full hybrid format engagement across in-person and virtual attendees supported	Link to recorded Zoom session available for 1-week post-conference

The primary hybrid recorded session will include a 5-minute introduction by co-chairs, 10 minutes for each focal study, 5 minutes for each discussant, and 25 minutes for collective discussion. Please note, the pre-conference is one week before the opening session and post-conference is one week after the closing session. We have done this to attend to concerns about the safety of making recordings of scholars and their data of learners in action, particularly scholars and learners from nondominant communities, visible over long periods of time and to unknown audiences. We feel that the one-week extended temporal arms give opportunity for the more intentional engagement of the conference with the possibilities of hybrid and asynchronous engagement.

We also wish to point out that the proceedings submission will include brief discussant remarks including recognition of themes and articulation of preliminary questions that push forward our conversation (see next). As a result, the pre-conference proceedings and initial discussion forum prompts will include input from the four focal papers as well as discussants to invite the broader ISLS community into conversation.

Weaving together intersectional identities and positionalities to center Justice, Equity, Diversity, and Inclusion

Discussant Déana Scipio

As I enter into conversation with these scholars and practitioners I am struck by the foundational commitments to relationality across contexts. I am eager to enter into conversations about how relationality foregrounds intersectional identities and creates opportunities for teachers, students, and researchers to explore the relations between their intersectional identities and positionalities within science teaching and learning contexts in order to center justice, equity, diversity, and inclusion. Thinking about intersectionality (Crenshaw, 1991) and positionality can allow us to hold multiple relations while honoring the complexity that students, teachers, and researchers are bringing to science teaching and learning contexts. Humans are negotiating their position with respect to joy, community, relationships, power, privilege, and oppression. I look forward to continued discussions with the scholars in this session that will draw out these commitments and connections across this innovative hybrid session.

How centering relationality in learning leads to just and humanizing education

Discussant Phil Bell



The images of science learning and science teacher learning lifted up in this session sequence significantly advance our understanding of how **centering relationality in learning environments** promotes more just and humanizing education. The approaches explore how to center multiple ways of knowing from across academic and community life (Warren et al., 2020), how to support learning and becoming around the diversities of learners' subjectivities and multiplicities in a relational universe, and how to instructionally attend to the significant relations held by learners in humanizing ways. I look forward to learning more about: (a) specific learning and interactional processes from these situations, (b) the life-wide interactions experienced by learners (e.g., how preservice teachers made sense of the supported relational worldview in relation to others in their program), (c) how the centering of multiple, coordinated epistemologies becomes a desired platform for the learners amidst a powered landscape that is frequently hostile and resistant to such efforts (e.g., how learners learn how to fight the epistemic and ontological harms and insecurities that may resurface in other contexts), and (d) how might we as a field learn to support these vital, insurgent campaigns for a 'science otherwise' (Stengers) centered on multiple ways of knowing in active resistance to the hegemonic, multi-scalar structures of science education?

Slaying and seeing: Light and optics with Black girls

Natalie De Lucca, Vanderbilt University

Viewing Blackness, whether within a K-12 physical science classroom or a learning sciences research space, is a deeply political process.

This study emerges from my experiences as a Black woman co-designing and instructing a four-week science course in a summer camp (n=35) predominantly attended by Black girls (n=33). Throughout the class, I prompted students to explore phenomena of light and color towards developing an aesthetic sense of "meaningful" digital photos. Notions of "meaningful" were student-developed: inflected with their lived experiences and evolved as a collaborative photographic practice where students learned to adjust the manual settings of digital single-lens reflex (DSLR) cameras. From a collection of field notes, class session video and audio recordings, and course products, I weave together a narrative case that stitches Beyoncé's (2016) music video and song, Formation, together with a trajectory of a single group of girls' photographic experimentation for two weeks. I present this case to raise questions about how we—as learning scientists, science educators, and researchers—approach "seeing" as an empirical practice.

Here, I deploy an interdisciplinary Black methodology: bringing together multifarious texts "not to capture something or someone, but to question the analytical work of capturing" (McKittrick, 2020, p. 4). Bringing different texts together — relationally — engenders a wonder and curiosity which treats Blackness as a living and active knowledge-making endeavor. The wonder that arises from convening interdisciplinary Black texts is responsive to (yet outside of) violent logics whose claim to absolute knowledge apprehends and delegitimizes Black intellectual labors (McKittrick, 2022). This attunement rejects the extraction of meaning from Black girls as objects of study. Instead, wondering involves posing questions as rigorous scholarly activities that build more livable and intellectually affirming learning spaces for Black girls. For AbdouMaliq Simone (2019), this is a strongly ethical stance toward Blackness: a "care that comes from having endured nearly everything" (p. 58). Reading across two texts (a single group of Black girls' experimental trajectories and Beyoncé's music video and song Formation), I produce a narrative case which wonders about how we come to "see" Black girls within science educational literature and how we come to "see" Black girls' knowledge production. The narrative case stems from a pivotal moment where members of this group seemed to cohere around the production of a meaningful genre of photos. I reproduce part of this episode below:

Cycling through the photos taken as the girls adjust their ISO settings and positions relative to the ring light, we see an ecology of meanings developing as they experiment with their visual expression. Jaelyn photographs Janine and suddenly shrieks: "Oh my god, that's BOOTIFUL ... SLAY!" Jaelyn shrieks "YASSSS" as she looks at the five-second previews of an image just taken on the camera screen. In the tens of pictures just taken, as both Janine and Jaelyn shift their choreography in response to their shared endeavor, it becomes clear that this is not just a win for Jaelyn or just Jaelyn and Janine. The entire group shifts their orientations and settings in light of this discovery, their experimentation - purposive changes in camera settings, spatial organization, light, and intimacy - to give texture to a shared affective terrain of visuality. In this terrain, sociohistorical grammars of object/capture are not legible; instead, the ways the girls hype each other up, negotiate what settings to change, and share intermediate results signals sensibilities towards forms of self-making and world-making (Monday, June 27th)

Jaelyn's proud cry of "SLAY!" is etched in my memory; it signals a creative genealogy of Blackness outside of the audio-visual record. The term "slay" as an affirmation of stunning self-presentation in attitudes, posture, clothing, and accessories dates back to Black queer Ballroom communities in the 1970s-80s (Livingston,



1990), with particular genres shaped by hyper-local Black queer music cultures and histories (Tan & Smith, 2014). So, while Beyoncé is often credited with popularizing the term with the lyrics in Formation, foregrounding this genealogy centers on the creative, political labor of Black queer and gender-expansive communities for self-definition within intimate spaces of creativity. In Formation, Beyoncé's use of slay is not only to characterize herself, "Sometimes I go off (I go off), I go hard (I go hard)/ Get what's mine (take what's mine), I'm a star (I'm a star)/ Cause I slay (slay)..." her chorus calls in Black femmes to also use this term in a call and response fashion: "We gon' slay (slay), gon' slay (okay), we slay (okay), I slay (okay)." Jaelyn, Janine, and their peers' verbal and visual arrangements call and respond to each other, signaling shared ways of Black living and being beyond the audio-visual record.

A Black interdisciplinary methodology allows us to complicate the underlying assumptions behind empirical questions of "seeing," drawing into relief non-linear ecologies of Black cultural and political practice that actively produce racial and gender formations of Black girlhood. When assumptions of "seeing" — within K-12 physical settings and common video-analysis methods used to understand the process of learning — often depend on describing what is in linear observable time-space, we miss ways of understanding our relationship to the "viewed." Here, we see empirical questions of "seeing" involve withdrawing one's active engagement and solidarity when "viewer" of Black life and precarity (Campt, 2021). When translated into other spheres, bringing these texts into analytic proximity prompts questions about how we come to know Black girls (as subjects of learning research) and Black girls' knowledge (as social-cultural-political activities).

Diffracting noticing to become differently: Re-imagining relationalities

Sophia Jeong

Drawing on posthuman theories, in particular, Barad's (2007, 2014) work on becoming and diffraction, this conceptual paper investigates the productive interplay of diffracting noticing as a novel concept for elementary preservice teachers of science to become differently and re-imagine relationalities in their science teaching and learning. As accounts of wicked problems cause sufferings and loss caused by discrimination, oppression, marginalization, and violence across geo-political contexts (Crowley & Head, 2017), science educators are urged to consider concepts that assume the subject as irreducible, multiple, and continually re-assembled through social, discursive, material relational entanglements with other entities (both human and more-than-humans).

The purpose of this conceptual paper is to provide empirical illustrations and groundings of the concept, diffracting noticing that can be used to nurture elementary preservice teachers' diverse array of becomings in the context of a science methods course. Diffracting noticing theorized in this paper is a relational-ontology-oriented experimentation: it is a concept that can be used to rupture ontological concerns about stable entities that often take a stronghold in our worlds. This paper uses posthuman theories to re-conceptualize our stable "beings" as effects of work produced from the entanglements of the actors of an assemblage - thus, as vibrant becomings.

First, the author re-conceptualizes the notion of preservice teachers' learning as becomings (Barad, 2007, 2014). As opposed to static beings, becoming is based on the notion of dynamicity, multiplicities and differences. Second, Barad's radical concept of diffraction entails "re-turning" as in turning" it on its head over and over again, "iteratively intra-acting, re-diffracting, diffracting anew" (Barad, 2014, p. 168) as a way to re-turn what we would do with the different way of becoming. In addition, the author also applies Haraway's (2016)'s concept of response-ability that invokes ethical sensitivity and the ability to respond accordingly and that offers insights into fostering collective knowing and doing, and considering one's becoming with others and rendering them capable. In the context of this study, diffracting noticing demands one's attention to relational encounters: 1) articulation of the differences that were produced when preservice teachers juxtapose and "see" themselves in relation to others, and 2) the effects or a discursive-material mark on entities that were left by these differences. Diffracting noticing engages preservice teachers to reflect on their experiences in relation to others by re-turning and re-diffracting on what they "see," thereby iteratively shedding new insights about their experiences as well as producing new temporalities, patterns, understandings etc. (Barad, 2014). Diffracting noticing is both a process and an effect of the work produced from the actors who are entangled in that process.

The author's position as the science methods instructor of the course was to provide conditions for fostering preservice science teachers' becomings, or people-yet-to-come (Tillmanns & Salomão Filho, 2020, p. 1), and providing opportunities to enact their conceptualization of equity and inclusion in the way that mattered to them. This science methods course used Science & Engineering Practices (NGSS Lead States, 2013) as entry points to anchor and frame science teaching practices through an equity lens. Alongside the practices, the author shared her own tenets of Duty of Care that articulated ways to foster respect for the preservice teachers, their peers, and their future K-12 students. This paper used and analyzed artifacts of preservice teachers' learning that included videotapes of themselves teaching a science lesson incorporating Science & Engineering Practices.



Preservice teachers engaged in course activities to view, discuss and provide feedback. Using feedback, preservice teachers planned or modified their lesson planning.

Preservice teachers' discussion of what they noticed provided an opportunity for them to juxtapose, challenge, and contest their teaching practices as a collective relational experience. They were entangled with one another along with the artifacts of their teaching in these modes of encounters: 1) Articulating, 2) Reflecting+Diffraacting, 3) Analyzing, and 4) Re-articulating. During these encounters, preservice teachers reflected on where they were in the "middle" (Deleuze & Guattari, 1987) of their becomings in relation to others' becoming as they began to see and make sense of equitable and inclusive teaching. In so doing, they were able to "see" differences that were produced in terms of their teaching practices and ideas, and the differences became an artifact that could be used to re-turn to, turn it over to diffract and look at them through a new lens (Articulating and Reflecting+Diffraacting). Once these differences were produced, the juxtapositions created productive tensions (Analyzing). The productive tensions with which preservice teachers tried to wrestle seemed to leave a mark on the preservice teachers in the form of re-articulating what they could or would do differently in their future teaching (Re-articulating) and what began to show up as effects.

Differences and juxtapositions about how they made sense of and chose to enact equitable science teaching left a mark by way of preservice teachers becoming accountable or response-able for the knowledge that was collectively co-constructed about equity and equitable science teaching and learning. Briefly, the author argued that preservice teachers were part of an assemblage that is organized and re-organized, and is composed of and entangled with heterogeneous actors or entities (Deleuze & Guattari, 1987). Assemblages produce effects of work that actors do as they organize, re-organize their relations. In this vein, preservice teachers who could "see" themselves and their teaching practices in relation to others were becoming differently. In becoming differently as they were sense-making equitable and inclusive teaching practices in the manner that mattered to them, what began to vibrantly matter (Bennett, 2010) in their becomings was ethics and duty of care showing up in their teaching practices. Preservice teachers were also becoming more response-able and rendering themselves and others capable to become more equitable science teachers.

In summary, diffracting noticing as a concept is not just an experimentation: it is meant to be used, distilled, and applied in order to offer re-imaginings and find infinite possibilities for a different way of becoming. In so doing, science educators can work alongside preservice teachers and other entities to provide a different way of becoming (i.e., knowing and learning) for our preservice teachers and their future K-12 students, thereby creating conditions for more equitable and inclusive learning environments. This notion of becoming differently through diffracting noticing contributes to a re-imagination of the traditional notion of teacher change and agency. Allowing teachers' diverse array of subjectivities and multiplicities of enactment of teaching practices (Kayumova & Buxton, 2021) is a first step in rupturing the notion of power as we know it, and fostering similar opportunities and possibilities for K-12 students' multiple ways of knowing and learning.

Redressing harm: Relationalities in preservice secondary teachers' science prep

Jessica Watkins and Natalie De Lucca

Preservice science teachers (PSTs)—particularly PSTs of color—often endure racialized, classed, and gendered harm in their scientific preparation (Mensah & Jackson, 2018). In this paper we are interested in how PSTs grapple with *relationalities* in science to navigate and redress this harm and to imagine more equitable futures for their students. We foreground relationality to acknowledge that the ways we make sense of ourselves, the broader cultural narratives about our communities, and our social structures are not formed in isolation, but rather through our engagement with others' identities, with other cultural narratives and structures (Hoagland, 2007; Shah, 2017). For instance, historically, Anglo-European scientists did not emerge as a community independently or autonomously, but by demonizing and exterminating of pagan and Jewish women healers during the Roman Catholic Inquisition (Hoagland, 2007, p. 98). Critical race scholars have emphasized relationality in the construction of whiteness: White people obtain privileges through the objectification and exclusion of Black people (Harris, 1995). Leonardo and Broderick (2011) extend this perspective on relationality to smartness, arguing that the ways schooling constructs some students as "smart" (thereby deserving of resources and opportunities) simultaneously constructs other students as "not smart" (thereby less deserving of these resources).

While these relationalities are fundamental to the construction of our world, dominant logics of oppression center on denying relational perspectives (Hoagland, 2007). For instance, Western Modernity is narrated as the culmination of a natural progression of thought, rejecting the ways it developed through colonial and imperial interactions (Castro-Gómez, 2021). These logics therefore position dominant cultures as autonomous, independent and ignore the agency and voice of the oppressed. While these logics pervade dominant



discourses, we argue that a relational perspective is imperative for PSTs to make sense of themselves, their students, and the disciplines they plan to teach. Here we analyze how two PSTs grapple with relationalities coming from different worlds, yet both troubled by how to make sense of their family histories, academic presents, and futures as science educators.

This study is conducted within a larger project to redesign a content-focused science teacher education course to create opportunities for PSTs to engage in expansive scientific sensemaking themselves, in which multiple ways of knowing and engaging are valued and integrated. In the course, students engage in two extended units in which they pursue coherent and causal understandings of phenomena. The first unit focuses on light and color, framed by the question “Are all the colors in the rainbow?”. The second unit pairs formal experiments with Wisconsin FastPlants with field work in their local neighborhoods to explore the expression of purple/red color in plant leaves and stems. In each unit, students kept an online science journal with their wonderings, observations, reflections, procedures, photographs, and personal notes. Inspired by Kimmerer’s (2013) reflection: “Isn’t this the purpose of education, to learn the nature of your own gifts and how to use them for good in the world?” (p. 239), students are asked to create a final project that reflected their “gifts” in science, how these could be disruptive and do good in the world. We present case studies of two PSTs to explore how they challenge dominant logics that deny the relationalities that shaped their experiences.

Case 1. Carla grew up in rural Georgia, as a White woman with Cherokee ancestry and the first person in her family to attend college. She pursued a PhD in chemistry before switching to teaching as her intended career. Carla spoke about a rupture in who she is across contexts: At home with her family, her ways of knowing, communicating, and relating to the natural world stood in conflict with how she experienced academic science. In the university, she changed her Southern accent to not be perceived as ignorant or dumb, and separated from her family’s knowledge about the natural world in her chemistry pursuits.

While Carla experienced a chasm between her home and academic science, we consider how these parts of herself are relational, constructed as counterpoints to each other. Carla’s status as a scientist—the recognition of her and other scientists’ intellectual abilities to understand the natural world—comes about due to the subjugation of the ways of knowing and communicating in her family and rural community. Dominant logics of oppression deny this relationality (Hoagland, 2007), positioning scientists as separate, independent entities, while laypeople are recipients of their knowledge, dependent on their discoveries. These logics limited who she could be in science, keeping her from bringing these parts of herself together. For Carla, the field work conducted in the class became a site for the seemingly disparate parts of herself to meet, a place to marry her understandings developed as a PhD student in chemistry with her family stories and farming practices. “I was able to make connections [between]... my field work in class and then my knowledge from my family... Trying to make sure I honor both parts of knowledge.”

Case 2. Ally was a sophomore Japanese American student majoring in chemistry and secondary education. Her case highlights the ways Japanese Americans have had to navigate the dominant relationality of serving as “model minorities.” Within dominant logics of oppression, Japanese Americans had to transform from “problem minority” to “model minority” to be rendered worthy to be citizens. To realize this transformation, Japanese American internees were forced to pledge loyalty to the country that imprisoned them, suppress their cultural identities, and maintain silence about their oppression; these practices contributed to intergenerational, cultural trauma (Nagata, Kim, Nguyen, 2015). In STEM fields, this trauma re-emerges in the model minority myth that “Asians are good at math,” which serves to deny Asian Americans full personhood and again positions them against other minority groups (Shah, 2017). Indeed, Ally grappled with the ways that she is minoritized, but as an Asian American not under-represented in science, leading her to question how she belongs.

In her final presentation, Ally positioned crafting as a practice that pierced these dominant logics. Throughout the course, Ally’s journals were populated with images showing her joy and facility with materials: she used her feet to project filtered flashlights on the wall, developed new color filters with nail polish and eyeshadow, used string to develop a grid system to keep track of her plants. For her final project, Ally drew on these material experiences to narrate herself in new ways in science, connecting to her family’s history with crafting. She linked her cultural practices to her family’s experiences in Japanese internment camps. Ally described that “Crafts were used as a form of expression for internees,” elaborating that these practices helped Japanese Americans cope with the emotions of enacting as “model” citizens while being incarcerated and tap into their cultural histories. By incorporating and celebrating these cultural practices as part of her scientific work, Ally re-negotiated the relationalities of the model minority myth, positioning science as entangled with culture, politics, art, and emotion.

Both Ally and Carla experienced harm in their scientific preparation as teachers, in which they had to forgo parts of themselves in science to feel as though they belonged. Our analysis highlights the relational dimensions of this harm, unpacking the relationalities not just between broader narratives or structures, but within



their personal stories. Importantly, their stories do not end with harm, but with the reparative work they did to resist dominant logics and acknowledge the social, historical, and political relationalities of their experiences. As teacher educators conceptualize expansive and humanizing teacher education (Carter Andrews, et al., 2019), these cases shed light on the need to create opportunities for PSTs to grapple with relationalities as part of their becoming in science and as future educators.

Teacher-student relationships and inclusive kindergarten science teaching

Ashlyn Pierson, Adam Bell, Bethany Daniel, D. Teo Keifert, Sarah Lee, Andrea Henrie, Heather Johnson

Teacher education has historically focused on the role of teachers and teaching practices (e.g., core practices; Philip et al., 2019). This focus backgrounds students, their knowledge, practices, and interactions, which is particularly harmful for learners from non-dominant communities (Bang et al., 2012; Warren et al., 2020). Additionally, those in power can interpret national to state standards in harmful ways, positioning young learners (e.g., Kindergartners) as not capable of the practices and interactions central to science inquiry (e.g., Keifert & Stevens, 2019). Along with normative expectations about children, families, and cultural repertoires, these powered dimensions shape how teachers design for learning.

Recently, researchers have called for humanizing approaches to teacher education to attend to students as full human beings with many resources (e.g., Kang, 2022; Keifert & Stevens, 2019). This focus can help teachers see *relations* (between teachers, students, standards, and practices) in ways that challenge previous assumptions about students and about science (e.g., ideologies rooted in whiteness; Mensah & Jackson, 2018). We ask: How do teachers' shifting relations—with young students and science— influence learning designs? We analyze data from 2 years of professional development (PD). In the 1st year (2019-20), PD focused on phenomenon-first science instruction and representations, foregrounding the teacher's role in the elementary classroom. In the 2nd year (2021-22), PD focused on multiple ways of knowing in science and on the many resources that students bring to classroom learning (Warren et al., 2020). We analyze data (video, artifacts) from a kindergarten teaching team's planning and implementation of the same two units after the 1st and 2nd PD years, demonstrating how this shift in teachers' perspectives resulted in more inclusive learning designs.

We draw on the FAIR noticing framework (Louie et al., 2021) and Olivares and Tucker-Raymond's framework for *critical relationality* (2020) to understand how ideological framing influences teachers' relationships with their students and the disciplines they teach. These frameworks are premised on humanizing pedagogies that require teachers to welcome relationships that students have in their lives. We consider how PD helped teachers shift the focus of their teaching to center on relationships students have out-of-school and with classroom peers, in addition to student-teacher and phenomena relationships, all of which are foundational for student-driven learning.

We analyze episodes that make visible shifts in teachers' perceptions of students' *relationships* with others and the relevance of relationships to science learning. We focused on the kindergarten team because we could follow the same unit over multiple years. We created content logs and rough transcripts (Erickson & Schultz, 1997) as a basis for turn-by-turn analyses. We analyzed transcripts of classroom observations and triangulated them with video of PD sessions and interviews with participating teachers. We used Discourse Analysis (Gee, 2014) to closely analyze the ways teachers attended to students, science, and relationships (Louie et al., 2021).

Our findings consider two units the kindergarten teaching team designed which responded to shifts in our PD wherein students' inquiry (e.g., feeling, exploring, questioning) and life experiences (e.g., family structures) were central to the science lessons. First, we present data from a unit called "What animal am I?" designed to address the state standard "make observations to show that young plants and animals resemble their parents." Building on the initial PD of phenomena-based instruction, the teachers focused on selecting a phenomenon familiar to students: baby and parent squirrels in a park near the school because "squirrels abound and kiddos see them every day." This foregrounded an in-school shared experience between students and the nearby park. To describe the phenomenon, students were asked to "compare and contrast a *mother* and her baby, then write about ways the baby is similar to its mother." During the second summer PD, teachers were asked to consider how they could make space (Haverly et al., 2020). One way this was demonstrated was through our use of a Summary Chart. In addition to a space for noting claims and evidence, we added a column for students to make connections to their family, friends, language, experiences as home, culture, etc. One teacher explained a shift to the language of *parent* and *baby*: "in my classroom, I have students who are adopted [and] students who don't have a mom...Even though they're adopted by someone who has a different skin, they have features that are the same as humans, and that helps us understand that this is still a parent and a baby." This inclusive framing came as teachers attended to students' out-of-school relationships as relevant to science.



Second, we present data from a unit about materials. The unit shifted from teaching students a classification system (e.g., “draw the stick part, that’s the wood part”) to allowing students to develop their own personally meaningful categories (e.g., sound alike; has a hole in it) and engage with one another as sensemakers. Positioning students as sensemakers led teachers to shift from a traditional Initiate-Respond-Evaluate pattern (Cazden, 1988) in the initial implementation (e.g., “Oh, I’m asking [student]...hold onto that connection, we’ll talk about it”) towards cultivating Kindergartners’ capacity to share their thinking with their peers (e.g., “Orange Tiger, do you agree with that?” and “Blue Cheetah, I like your thinking but you need to share it with your group.”). With students positioned as sensemakers, teachers centered students’ considerable repertoires of practice in classroom conversation. Ultimately, attention to relationships created a more inclusive classroom environment that honored students’ interactions in the shared development of knowledge, recognized young learners’ competence as inquirers and sensemakers, and honored multiple ways of understanding the standard.

References

Beyoncé. [YouTube]. (2022, November 1). *Beyoncé - Formation (Official Video)* [Video]. https://www.youtube.com/watch?v=WDZJPJV_bQ

Bang, M., Warren, B., Rosebery, A. S., & Medin, D. (2012). Desettling expectations in science education. *Human Development*, 55(5-6), 302-318.

Barad, K. (2014). Diffracting diffraction: Cutting together-apart. *Parallax*, 20(3), 168-187.

Barad, K. (2007). Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning. Duke University Press

Barrett, M. J., Harmin, M., Maracle, B., Patterson, M., Thomson, C., Flowers, M., & Bors, K. (2017). Shifting relations with the more-than-human: Six threshold concepts for transformative sustainability learning. *Environmental Education Research*, 23(1), 131-143.

Bennett, J. (2010). Vibrant matter: A political ecology of things. Duke University Press.

Calabrese Barton, A., & Tan, E. (2018). A longitudinal study of equity-oriented STEM-rich making among youth from historically marginalized communities. *American Educational Research Journal*, 55(4), 761-800.

Campt, T. M. (2021). *A Black Gaze: Artists Changing How We See*. MIT Press.

Carter Andrews, D. J., Brown, T., Castillo, B. M., Jackson, D., & Vellanki, V. (2019). Beyond damage-centered teacher education: Humanizing pedagogy for teacher educators and preservice teachers. *Teachers College Record*, 121(6), 1-28.

Castro-Gómez, S. (2021). *Zero-Point Hubris: Science, Race, and Enlightenment in Eighteenth-Century Latin America*. Lanham, MD: Rowman & Littlefield.

Collins, P. H., & Bilge, S. (2020). Intersectionality. John Wiley & Sons.

Cazden, C. B. (1988). *Classroom discourse: The language of teaching and learning*.

Crenshaw. (1991). Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color. *Stanford Law Review*, 43(6), 1241-1299. <https://doi.org/10.2307/1229039>

Crowley, K. and Head, B (2017). The enduring challenge of ‘wicked problems’: Revisiting Rittel and Webber. *Policy Sciences*, 50(5), 539-547.

D’Amico Pawlewicz, D. (2020). *Blaming teachers: Professionalization policies and the failure of reform in American history*. Rutgers University Press.

Deleuze, G., & Guattari, F. (1987). Capitalism and Schizophrenia: A Thousand Plateaus. University of Minnesota Press.

Erickson, F., & Schultz, J. (1997). When is a context? Some issues and methods in the analysis of social competence. *Mind, culture, and activity: Seminal papers from the laboratory of comparative human cognition*, 22, 31.

Esmonde, I., & Booker, A. N. (2017). Power and privilege in the learning sciences.

Freire, P. (2020). Pedagogy of the oppressed. In *Toward a Sociology of Education* (pp. 374-386). Routledge.

Gee, J. P. (2014). *An introduction to discourse analysis: theory and method* (4th ed.). New York: Routledge.

Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational researcher*, 32(5), 19-25.

Haraway, D. (2016). Staying with the trouble: Making Kin in the Chthulucene. Duke University Press.

Harris, C. I. (1993). Whiteness as property. *Harvard Law Review*, 1707-1791.

Haverly, C., Calabrese Barton, A., Schwarz, C. V., & Braaten, M. (2020). “Making space”: How novice teachers create opportunities for equitable sense-making in elementary science. *Journal of Teacher Education*, 71(1), 63-79.



Hoagland, S. L. (2007). Denying relationality. *Race and Epistemologies of Ignorance*. Ed. S. Sullivan and N. Tuana. State University of New York Press, Albany, NY, 95-118.

Hudicourt-Barnes, J. (2003). The use of argumentation in Haitian Creole science classrooms. *Harvard Educational Review*, 73(1), 73-93.

Kang, H. (2022). Teacher responsiveness that promotes equity in secondary science classrooms. *Cognition and Instruction*, 40(2), 206-232.

Kayumova, S., & Buxton, C. (2021). Teacher subjectivities and multiplicities of enactment: Agential realism and the case of science teacher learning and practice with multilingual Latinx students. *Professional Development in Education*, 47(2-3), 463-477.

Keifert, D., & Stevens, R. (2019). Inquiry as a members' phenomenon: Young children as competent inquirers. *Journal of the Learning Sciences*, 28(2), 240-278.

Kimmerer, R. W. (2013). *Braiding Sweetgrass*. Milkweed Editions.

Krist, C., & Suárez, E. (2018). Doing science with fidelity to persons: Instantiations of caring participation in science practices. International Society of the Learning Sciences, Inc.[ISLS].

Leonardo, Z., & Broderick, A. A. (2011). Smartness as property: A critical exploration of intersections between whiteness and disability studies. *Teachers College Record*, 113(10), 2206-2232.

Levine, S., Keifert, D., Marin, A., & Enyedy, N. (2020). Hybrid argumentation in literature and science for K-12 classrooms. In *Handbook of the cultural foundations of learning* (pp. 141-159). Routledge.

Livingston, J. (1990). *Paris Is Burning*. Off White Productions Inc.

Louie, N., Adiredja, A. P., & Jessup, N. (2021). Teacher noticing from a sociopolitical perspective: the FAIR framework for anti-deficit noticing. *ZDM-Mathematics Education*, 53(1), 95-107.

McKittrick, K. (2020). *Dear science and other stories*. Duke University Press.

McKittrick, K. (2022). Dear April: The Aesthetics of Black Miscellanea. *Antipode*, 54(1), 3-18.

Mensah, F. M., & Jackson, I. (2018). Whiteness as property in science teacher education. *Teachers college record*, 120(1), 1-38.

Nagata, D. K., Kim, J. H. J., Nguyen, T. U. (2015). Processing Cultural Trauma: Intergenerational Effects of the Japanese American Internment. *Journal of Social Issues*. 71(2), 356-370.

NGSS Lead States. (2013). Next generation science standards: For states, by states. Volume 1: The standards. The National Academies Press.

Olivares, M.C., & Tucker-Raymond, E., (2020, November 1). Critical relationality: A justice-oriented approach to education and education research. Medium. https://medium.com/@mariaco_87227/critical-relationality-a-justice-oriented-approach-to-education-and-education-research-8bf911c381b4

Palmié, S. (2002). *Wizards and scientists: explorations in Afro-Cuban modernity and tradition*. Duke University

Philip, T. M., Souto-Manning, M., Anderson, L., Horn, I., J. Carter Andrews, D., Stillman, J., & Varghese, M. (2019). Making justice peripheral by constructing practice as "core": How the increasing prominence of core practices challenges teacher education. *Journal of Teacher Education*, 70(3), 251-264.

Rosebery, A. S., Ogonowski, M., DiSchino, M., & Warren, B. (2010). "The coat traps all your body heat": Heterogeneity as fundamental to learning. *The Journal of the Learning Sciences*, 19(3), 322-357.

Shah, N. (2019). "Asians Are Good at Math" Is Not a Compliment: STEM Success as a Threat to Personhood. *Harvard Educational Review*, 89(4), 661-687.

Simone, A. (2019). *Improvised Lives: Rhythms of Endurance in an Urban South*. Cambridge: Polity

Stengers, I. (2018). *Another Science is Possible: A Manifesto for Slow Science*. Wiley.

Stevens, R. (2010). Learning as a members' phenomenon: Toward an ethnographically adequate science of learning. *Teachers College Record*, 112(13), 82-97.

Tan, T. & Smith B. D., (Producers), & Bagheri, A. (Director). (2014). *That B.E.A.T.* [Video file]. Retrieved from <https://vimeo.com/58423297>

Tillmanns, T., & Salomão Filho, A. (2020). Reflecting on partnerships of sustainability learning: Enacting a Lewin-Deleuze-Guattari rhizome. *Sustainability*, 12(22), 9776-9786.

Warren, B., & Rosebery, A. S. (2011). Navigating interculturality: African American male students and the science classroom. *Journal of African American Males in Education (JAAME)*, 2(1), 98-115.

Warren, B., Vossoughi, S., Rosebery, A. S., Bang, M., & Taylor, E. V. (2020). Multiple ways of knowing*: Re-imagining disciplinary learning. In *Handbook of the cultural foundations of learning*. Routledge.

Authorship & Acknowledgements Statement

The authors of paper 4 acknowledge their full team on the RepTaLs project, particularly our teacher collaborators. These studies have been funded by the Vanderbilt Community Lab for the Intersectional Study of Black Women and Girls in Society, the Ohio State University, National Science Foundation (Grant# 2145260) and the McDonnell Foundation (Grant#220020521).