Wondering With People, Places, and More-Than-Humans as an Ontological Orientation to Ethical Socio-Ecological Education: Towards More Just & Livable Futures through Design-Based, Mediational, and Quantitative Analyses

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A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

University of Washington

2023

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Program Authorized to Offer Degree:

College of Education

Abstract

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This dissertation is aimed at articulating and empirically characterizing an expansive orientation to field-based socio-ecological systems learning that elevates participatory and ethically-engaged approaches to teaching and learning. Grounded in relational ways of knowing, this dissertation works to expand and transform normative educational paradigms towards the realization of more just and healthful ways of being through recognizing the agency and dignity of youth, places, and more-than-human beings. Elevating the role of wonder as central to scientific sensemaking, ethical deliberation, and the creation of new forms life and learning, this dissertation contributes to scholarship, practices, and the construction of life-worlds critically engaged with the increasingly pressing challenges and possibilities of the 21st century. Situated within a space of problem and possibilities, this dissertation addressed the need to shift nature-culture relations through analysis of design and interactions situated in the Learning in Places project.

Across five chapters I situate and develop three related papers which characterize and empirically ground a framework for *ethical wondering with people, places, and more-than-humans*. The first chapter situates this work in transdisciplinary approaches to science education and begins to construct a framework for how we have taken up the role of wondering in our context of work. The three following chapters represent the primary papers in this dissertation. In Chapter 2, I analyze materials designed in the Learning in Places project to explicate key dimensions and commitments of our work and build out an empirically-grounded conceptual framework for ethical wondering with people, places, and more-than-humans. In Chapter 3 I conduct a deep case study analysis of knowledge and interaction to examine how dimensions of ethical wondering with people, places, and more-than-humans were manifest and mediated within wondering walk data gathered from the pilot year of Learning in Places implementation. Complimenting this deep qualitative focus, Chapter 4 shares findings from a broad statistical analysis of over 98 hours of wondering walk data collected in our first full year of school-based storyline implementation to identify significant correlations and comparisons between descriptors of interest. By way of synthesis and conclusion, Chapter 5 closes out this dissertation through offering up principles of design to guide work in similar spaces alongside reflections salient strengths, limitations, and pathways for future work.

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Acknowledgements

I am grateful to be a guest on the lands of the Indigenous peoples of the places that I have called home. These include lands of the Ute, Cheyanne, Apache, and Arapahoe, (colloquially the greater Denver area), area as well as those of the Coast Salish and Lushootseed speaking Peoples, including the Duwamish, Suquamish, Snoqualmie, Tulalip, and Muckleshoot within what is currently known as Seattle. Grown from these places, lands, and waters, this dissertation aims to honor my commitments to the natural kinds and original peoples of these places.

To my biological parents, Tim and Nadine Sherry, thank you for believing in me and always doing your best to support me in becoming the person I am today. To my bonus parent, Ede Wagner, thank you for helping me learn new ways of being and relating to this weird and awesome world. To my late maternal Grandmother, Connie Gardener, thank you for showing me what it means to live life as an educator. I am also grateful for the support of my siblings Janae Sherry, Hero Wagner, Devon Lamoreaux, and Tyler Martin who have taught me so much about what it means to be an older brother. Thank you also to the extended family I have felt continual support from, including my brothers in-law Josh Frederickson and Sean Casey, as well as a host of other family including David Clipp and Amanda Sertich-Clipp; the d'Estrée clan of Claude, Tamra, Jean-Marc, Alec, and Daniel; the Dwyer/Sherry clan of Marie Lou, Erik, Marnie, Connor, and Mackenzie; and my childhood Sensei Lyle Benson – I am who I am because of you all.

To Dr. Megan Bang, thank you for being the best mentor (and friend) a student could ask for. Thank you for believing in, supporting, and pushing me; for not only talking about the good work, but for living it in the small and significant moments of everyday life. Working with you continues to make me a better scholar, educator, father, and person.

My deep gratitude extends also to my doctoral committee, Drs Carrie Tzou, Phil Bell, Katie Taylor, and Jana Lone, as well as a host of other scholars and supporters from whom I have learned with including Deborah Kerdeman, Nancy Hertzog, Lilian Katz, Shirin Vossoughi, Gail Joseph, Ananda Marin, Anna Lees, Martia Horton, Leah Bricker, Holly Schindler, Leslie Herrenkohl, Susan Nolen, Filiberto Barajas-López, Nancie Beadie, Kristie Kauerz, Sara Goering, Karen Emmerman, Mary Clevenger-Bright, Joy Williamson-Lott, Jennie Woodring, Cassady Glass Hastings, James Banks, Mia Tuan, Jodi Newman, Lynn Dietrich, Jondou Chen, Kendall Becherer, Paula Wetterhahn, Norah Fisher, and Marty Howell.

I also extend gratitude to all the graduate students, colleagues, and friends who have mentored, supported, and commiserated with me in some way in this journey. At a minimum, this includes: Priya Pugh, Nat Mengist, Alice Tsoodle, Nikki McDaid Barry, Charlene Montaño

Nolan, Meixi, Elizabeth Starks, Emma Elliott, Gage Kleinman, Mario Guerra, Adam Bell, Gabe de los Angeles, Deborah Silvis, Megan McGinty, Rose O'Leary, Felicia Peters, Ceni Miles, Cory Campbell, Veronica Anne, Miguel Ovies-Bocanegra, Forrest Bruce, Alejandra Frausto, Corey Winchester, Briegh Rhodes, Elyanah Posner, Michelle Salgado, Erin Moser, Peter Moser, Bridgitte Hamilton, Debi Talukdar, Janice Moskalik, Natalie Janson, Christina Zaccagnino, David Phelps, Krister Johnson, Hollie Wagner, Bridget DuRuz, Deborah Silvis, Caitlin Wubbena, John Benner, Joh Howard, Erin Lane, Jiyoung Lee, Ari Hock, Erin Riesland, Stacey Alfonso, Maria Hays, La'akea Yoshida, Rae Han, Ada Onyewuenyi, Soleil Boyd, Erin Chapters, Christian Love, Katie Kuhl, Miriam Packard da Silva, Jenny Gawronski, AJ Balatico, Heena Lakhani, Nancy Price, Anastasia Sanchez, Maries Huening, Dawn Williams, Virginia Tse, Jamie Phillips-Jimenez, Nick Gillon, Winston Benjamin, Sara Stull, Saba Kawas, Gina Tesoriero, Don LaBonte, Christina Guevara, Abby Rhinehart, Marijke Hecht, Michelle Turner, Chris Jadallah, Tylir McKenzie, Elsha Tivera, Kevin Cummings, Alivia Britton, Cinthia Palomino, and Zainab Alhassani.

Of course, this work would not be possible without numerous collaborators within the Learning in Places project. These includes community-based partners Sharon Seihl and Anna Johnson; classroom educators Emily Cordova, Kirsten Erickson, Lora Nelson, Miguel SanzSastre, YiBing Zheng, Cindy MacIssac, Annalisa Moore, Gail Myles, Lily Robbins, and Yushen Liu; district partners Christine Benita, MaryMargaret Welch, Angie Swartz, and Bethany Sjoberg; as well as numerous youths including Jihaan, Sascha, Sidney, and Samuel.

I am grateful for the many undergraduate students who I have had the honor to teach throughout my doctoral studies, and specifically those work-study students who assisted in the application and refinement of coding categories through the process of data organization and logging; my sincere thanks extend to Robin Steuteville, Kierthan Lathrop, Yaurie Hwang, Kristina Hsu, and Alice Qui for their partnership in this work.

Finally, this dissertation would not be possible without the day-in and day-out love and support of my partner and the love of my life, Katie McKellar. Thank you for always supporting my work, my health, and for indulging my tendencies to wonder about wonder with you. Loving you continues to be the adventure of a lifetime. While writing this dissertation, we welcomed our child, Alletta Lilith, to the world. A special thank you to my newest and youngest teacher for helping me continue to reach beyond myself and showing me what it means to greet the world through wonder.

Dedication

For Alletta.

May you greet the world through wonder.

Chapter 1: Introduction

Introduction and Key Framing

Complex Socio-Ecological Systems, Wonder, and Worldmaking in These Times

Imaging and enacting more healthful ways of life and livable futures is increasingly vital given the broad range of social and ecological challenges facing our species and world. From rapid deforestation and species extinction, to extreme weather, food insecurity, and maintaining essential infrastructure, these challenges necessitate shifts in prevailing logics guiding socio-ecological decision-making from local to international scales. Indeed, the values that guide these kinds of decisions over the coming decades will directly determine the extent to which we can collectively realize sustainable forms of knowing, being, and doing so essential to the long-term health and well-being of life on this planet.

As human communities work to adapt to shifting global landscapes, we have the opportunity and responsibility to address long stand inequities that have enabled unjust and harmful relationships between and among humans and the rest of the natural world (Berkes, 2017; Steffen et al., 2015; Whyte, 2018). Core to these possibilities are the relationships between social and ecological systems, and how we can remake such "nature-culture" relations from a recognition of the complex ways in which humans exist as interdependent and reciprocal parts of the natural world (Bang & Marin, 2015). Within education, this involves imagining and enacting new forms of teaching and learning that disallow the objectification of natural kinds through grounding processes of noticing, wondering, deliberation, and decision-making within understandings of the complex relationality and reciprocity between social ways of life, ecological forms of life, and shifting climatic conditions.

From these commitments, this dissertation intervenes in educational paradigms that

exacerbate ecological harm through design and analysis of activities that foreground the ontological relationality between people, places, and more-than-human beings. Through a grounding in the particularities of places, alongside an emphasis on the fundamentally co-constitutive nature of human and more-than-human life, this work elevates the role of complex socio-ecological sensemaking for productive engagement with the challenges and possibilities of our present moment.

Thus, this work operates from an understanding of how scientific sensemaking practices are among the most impactful forms of meaning-making afforded to us. The systematic, empirical study of the world we find ourselves thrown into together is a primary means through which we come to understand natural phenomena, their complex relationships, and our place within it all (Lemke, 2001). Since time immemorial, peoples the world over have cultivated particular forms of nature-culture sensemaking – ways of speculating about and predicting patterns and changes across natural systems of inter-related phenomena. Slowly refined through social processes of observation, questioning, and experimentation, our present existence is rooted in and manifest from a broad and diverse range of scientific orientations that weave values, ways of knowing, and ways of being together within and through the ongoing activities of everyday life (Bang et al., 2014).

Recognizing the power of such scientific sensemaking, this dissertation formulates and operationalizes the role of wonder in ways that elevate the axiological, ontological, and affective dimension of socio-ecological sensemaking within designed trajectories of deliberation and decision-making. Opening beyond normative foci on epistemic and delivery of content knowledge, this focus on wonder is positioned as requisite for imagining more ethical otherwises and enacting pluralistic designs for transitional times such as these (Escobar, 2018). That is, we

forward that capacities for wonder are intimately tied to opportunities to experience awe through learning in ways that cultivate expansive senses of possibility (Engeström, 2015).

Against a backdrop of rapid socio-ecological change, systemic destabilization, socio-political unrest, and the possibility for new ways of being they present, this dissertation reaches for and formalizes new assemblages of theory, design, and mediation that can help us live and learn in more reciprocal relations. To wit, the purpose of this dissertation is to develop a conceptual framework for, and analyze empirical data through, the lens of *ethical wondering with people, places, and more-than-humans* as emergent within the *Learning in Places* project. In doing so, I propose this body of work as a justice-oriented intervention to teaching and learning aimed at expanding forms of pedagogy towards ontological and axiological engagement.

Focusing on interactional dynamics of complex socio-ecological sensemaking, I characterize the emergence, form, and function of emplaced observation and speculative practices in ways that contribute towards collective understandings of how we imagine, deliberate on, and enact more healthful ways of knowing and being within the natural world. In developing this socio-ecologically specific form of wondering, I contribute to scholarship that recognizes the importance of desettling anthropocentric conceptions of human-nature relationships (Bang et al., 2013; Bang & Marin 2015; Medin 2010; Medin & Bang, 2014, see also Latour 1993; 2013). Through analysis of video data through qualitative and quantitative methods, I surface the interactional complexities and pedagogical possibilities of activities designed to support ethically engaged forms of field-based science with young learners. In doing so this work bridges philosophical and conceptual orientation with empirical, practice and design-based accounts (Wilson & Santoro, 2015).

Recognizing how contexts of science education are central sites where nature-culture relations are made and remade (Bang, 2015), I first locate this work within historical developments in science education to position this dissertation's contributions at the edges of the field. Building upon decades of prior work, I then move towards a deep uptake of questioning practices to make the case that educators are obliged to design for authentic opportunities for learners' wonderings and questions to meaningfully impact flows of inquiry. Positioning wondering as ontologically prior to questioning, and intimately related with attentional capacities to notice, I then characterize the orientation towards wonder characterized throughout this dissertation. By way of conclusion, the end of this chapter provides a high-level overview of the Learning in Places project, as well as an overview of subsequent chapters.

Historical Trajectories in Early Science Learning

Conceptions of what it means to teach and learn science have shifted over time, often in parallel to developments in psychology and our collective understanding of human learning. Evolving from the mid-century behaviorist methods of Skinner and Thorndyke through the cognitive and developmental revolutions led by Bruner, Piaget, their contemporaries into the 60s and 70s, to today where the work of sociocultural, activity, and critical design theorists has expanded our engagement with the material, interactional, and powered dynamics, our understandings of human learning has come a long way in a short time (see also Rudolf, 2008).

Responding to behaviorist perspectives which define learning solely in terms of observable behaviors (Skinner 1953, 1968), work in developmental and maturationalist perspectives posits that individuals construct internally-organized knowledge in linearly increasing levels of sophistication as they develop (Piaget, 1964). In such a view, it is assumed that young children are generally incapable of engaging in the complex and abstract thinking

necessary for sophisticated scientific engagement. It is not until a child matures the appropriate "stage" of development where they achieve the required "formal" cognitive operational capacities needed to learn and reason about abstract ideas (starting around age 11) (see, for example: Piaget, 1971; Von Glasersfeld, 1983). Because this orientation assumes young children are not capable of participating in authentic sophisticated scientific practices, developmental models focus instead on teaching preselected curricular content focused on the findings and outcomes of scientific processes, rather than the processes themselves. Situated in developmental assumptions, this approach to education has historically conceptualized science as a body of settled knowledge and rote facts to be learned and memorized.

Though developmental perspectives and individualist assumptions remains deeply, and often problematically, rooted in both science and early childhood education, recent decades have seen a changing tide towards increased focus on the social dynamics and cultural contexts in which scientific sensemaking occurs (Lemke, 1994, 2001; NRC, 2012; Roth et al, 2013). For example, Russian psychologist Lev Vygotsky (1962, 1966, 1978, 1987) and fellow sociohistorical activity theorists (Cole, 1996; Wertch, 1998; Engström, 1990, 2015) operate from the stance that higher cognitive functions exist in and as sociocultural relations first. Positioning learning as a cultural accomplishment (Rogoff, 2003; Nasir et al., 2014), this approach challenges deficit assumptions about children's capability to participate in sophisticated sensemaking practices through shifting focus onto what kinds of social and material scaffold best support young children's participation in scientific practices. With this shift, research has moved towards ways of designing science education that foreground the importance of engaging learners in *authentic* scientific practices and processes (NRC, 2012; NGSS, 2013/2017; Jirout & Zimmerman, 2015; Wright & Gotwals 2017; Michaels & O'Connor 2017; Schwarz, et al., 2017;

Trundle & Saçkes, 2015).

Recognizing the situated nature of education across the life-course through greater attention to the "who" and "how" of learning (e.g., Lave & Wenger, 1991; Banks et al. 2007) the field of science education increasingly works from the foundational assumption that science is, "heavily dependent on cultural contexts, power relationships, value systems, ideological dogma, and human emotional needs" such that "What counts as learning and what types of knowledge are seen as important are closely tied to a community's values and what is useful in that community context." (NRC, 2012, p. 284). That is, epistemic orientations are shaped through cultural practices (Lee, 2008; Bell et al, 2012; Bang & Marin, 2015), centrally involving the navigation of heterogeneous ways of knowing, being, and valuing (Bang & Medin, 2010; Rosebery et al., 2010; Warren et al. 2020). A far reach from behaviorist and developmentalist perspectives, all learning is conceptualized as deeply cultural, inextricably connected to youth, family, community participation in everyday activities in which disciplinary practices and identities are navigated and developed (e.g., Bang & Medin, 2010; Moll et al., 1992; Rosebery et al., 2010; Paris & Alim, 2017; Warren et al., 2020).

While developmental perspectives are still prevalent in learning theory and science education, this shift towards understanding science as a cultural endeavor is starting to be seen across major frameworks and content standards for both science education and early childhood (e.g., NRC, 2012; NGSS, 2013/2017; NAEYC, 2013; NSTA, 2014). In tandem with this work, conceptions of early science education have slowly shifted to those that foreground the social, discursive, and practice-based nature of sophisticated science instruction. Addressing deeply rooted deficit models of young children's sensemaking capacities, the field is beginning to shift towards a view that recognizes sophisticated scientific capabilities of young learners (Metz,

2004). For example, the NGSS states that young children are indeed capable of using, "a variety of high-level causal and relational patterns" to reason about scientific phenomena (p. 69, 2013/2017). Indeed, we now have a rich base of empirical evidence which suggests young children are capable of far more sophisticated thinking than we previously assumed; able to engage in complex perspective taking, abstract sensemaking, meaningful generalization, and navigation of complex epistemic landscapes provided the right supports (e.g., Roth et al. 2013; Medin & Bang 2014; Metz 1997; Marin & Bang, 2018; Pugh et al., 2019; Danish et al. 2017; Hokayem & Gotwals, 2016; Yoon, et al., 2018; Pugh 2019; McDaid Barry et al., 2023).

As such, the field has increasingly focused on what social and material supports might best facilitate sophisticated science engagement for early-grade learners. Specific to the work described in this dissertation is the increased focus on learner talk and the role of speculation and questioning practices, centrally involving the role of discourse in science engagement (Forman & Cazden, 1988; Cazden, 2001; Lemke, 2001; Michaels & O'Connor, 2017). Within this focus, the role of questions and questioning practices continues to be central to so-called "authentic" scientific discourse. In particular, the role of student-generated ideas and questions is increasingly seen as integral to the deep sensemaking processes that structure and motivate meaningful science learning (Chin & Osborne 2008; Duckworth, 2001; Hadzigeorgiou, 2013; Reiser et al., 2017).

Questioning in Science Education

Structurally embedded in a range of epistemic operations, questions and question asking is fundamental to critical thinking, creative sensemaking, and problem solving (Chin & Osborne 2008; Reiser et al, 2017). Within pedagogical practice, questioning enables a wide range of sensemaking, such as eliciting explanations, constructing hypotheses, postulating reasons,

evaluating evidence, justifying reasons, and clarifying doubts (Lemke, 1990, 2001; NRC 2012; NGSS, 2013). Reflecting the deeply social nature of scientific practice, thoughtful questioning requires ongoing collaboration and trust between educators and learners as they collaboratively make sense of complex phenomena (Reiser et al, 2017; Chin & Brown, 2002). For learners, questioning practices kickstart independent sensemaking (e.g., Chin, 2006, Vygotsky, 1962, 1986) and provide a means for formative self-assessments that help learners monitor their own thinking and locate inconsistencies between prior knowledge and immediate experience (Black et al., 2002; Brown & Campione, 1990. Graesser & Olde, 2003; Graesser et al, 1992).

For educators, questions can provide formative insights into learner sensemaking processes, as conceptual understandings are often reflected in the form and content of student questions (White & Gunstone, 1992; Chin & Brown, 2002; Black et al, 2002). In science, these questions can be provoked by immediate observations, noticing a knowledge discrepancy, wondering about a phenomenon, encountering previously unknown ideas, or any other experience that engenders skepticism, epistemic curiosity, or cognitive dissonance (Chin & Osborne 2008; Reiser et al., 2017; Jirout, & Klahr 2012; Opdal 2001; Hadzigeorgiou, 2016). True for educators as well as students, Watts et al. (1997) have suggested that student questions can be powerful in generating conceptual change and critical reflection on classroom practice for educators as well; leading educators to become aware of gaps in their own knowledge and contributing towards developing deeper understandings of their approach to teaching and learning across subject areas.

Importantly, the quality of questions are often determined by the type of answer they require (Yarden et al. 2001; Chin & Osbourn, 2008), with “high-level” questions requiring continued investigation and further refined lines of inquiry (Hofstein, et al., 2005). In a broader

sense, the ability to ask a relevant question is central to scientific literacy and the critical production and consumption of scientific knowledge (Millar & Osborne, 1998; Chin & Osborne, 2008; NGSS, 2013). As such, there has been an increase in focus on student-generated questions in recent decades, including their role in stimulating curiosity, determining the scope of investigation, and encouraging sophisticated thinking about the relationships among observations, phenomena, data, and conclusions (Crawford et al., 2000; Reiser et al., 2017). Said simply, questions indicate that learners are taking up the ideas presented and are trying to connect them with previous experiences, understandings, and/or other concepts (Chin & Osborne 2008). Educators attentive to student-generated questions can make pedagogical adjustments both in-the-moment as well as in design of future activities to build alongside learner interests and prior knowledge.

Connecting home and school contexts, Chin and Chia (2004) found that the majority of student's questions derived from out-of-school experiences, including wonderment about phenomena and information propagated in everyday life. Grounding school-based science learning in student questions thus also creates meaningful opportunities to bridge formal and informal learning contexts, a persistent challenge in science education (Bell et al. 2009). Indeed, in our own work we've seen how learner questions enhance learning processes through formalizing personally relevant wondering into more tangible investigable premises; serving to heighten interest in a topic through generating curiosity and motivation to explore possible answers.

These dimensions are particularly elevated when learners themselves formulate questions that drive investigation, producing consequential changes in student affect and engagement with investigative activity (Chin & Kayalvizhi 2005). Scholarship in this area suggests that certain

kinds of *learner-generated questions*, particularly those asked in response to puzzlement or "wonderment", can provoke cascades of epistemically generative deliberative activity as, explanations are generated, investigations unfold, and potential solutions are proposed (Chin & Osborne, 2008). This is particularly true when educators use their own questioning practices to guide the flow of activity through shifting learner focus, eliciting explanations, highlighting possible relationships, and provoking reflective practices , a sharp contrast to normative approaches to pedagogy and curriculum centered around the delivery of pre-determined content.

While notable exceptions exist (see Duckworth, 2001), it is not until more recently that learner-generated questions have been recognized as so important to science education. Recent focus on science practices and process skills notwithstanding (e.g., NRC, NGSS, 2013; Jirout & Zimmerman, 2015; Schwarz et al. 2017) science education has historically privileged text-based, known-answer, and/or educator-generated questions (Roth et al. 2013; Chin & Osborne, 2008). If learners are afforded the opportunity to ask questions that drive investigations at all, who gets to ask questions and whose questions are positioned as scientifically relevant often reinscribe unjust power dynamics that perpetuate damaging epistemic hierarchies between adults and children. A focus on learner-generated questions (and the processes by which they arise) hold potential to remediate powered dynamics between educator and learner, home and school, adult and child.

Given all that we know about the importance of questioning, and learner-generated questioning in particular (see: Chin & Osborne, 2008 for a more extensive review), it is a wonder that many practice-focused science curricula do not allow much space (if any) for learner-generated questions to authentically guide inquiry processes (e.g., Windschitl, et al. 2018). Indeed, when held alongside other scientific activities such as questioning, modeling, and experimentation, the role of wonder and wondering in science education has received

considerably less attention (Hadzigeorgiou, 2016), and explicit references to wonder as a pedagogical tool are few (Egan, 2005; Stolberg, 2008). Wonder "at best, has not received enough attention, and, at worst, has been overlooked, by mainstream science education" (Hadzigeorgiou, 2014, p. 41). While many well-intentioned academics and curriculum developers might claim to authentically engage learner wonderings, too often learner contributions are over-constrained by the demands of predetermined curricular units premised on primarily indoor activities. From such observations, it is our stance that in not authentically engaging the everyday sources of learners' questions, educators lose powerful opportunities to design activities that truly resonate with and fully engage the interests, motivations, and identities learners bring to the table. While a great many resources continue to be devoted to articulating the role of questions in science education, it is our contention that educators are ethically obligated to go beyond a focus on valuing student-generated questions to also seriously considering what generates and motivates students questioning in the first place (i.e., a sense of wonder).

To wit, we argue that processes of wondering are ontologically prior to those of questioning. While questions are one way that wonder is expressed, wonder is a broader and deeper experience that lends itself toward pedagogies that authentically grow from what is relevant to learners. Representing a reversal of designs for learning that begin with content standards and pre-made curriculum for teachers to deliver, our approach begins inquiry with learner noticings and wonderings as facilitated through routine activities within local outdoor places. Situated within this space, we aim to better understand the role of place-based wonder in generating tangible and investigable scientific premises in ways that can better prepare educators to notice and build with learner's interests and diverse sensemaking repertoires. From these groundings, the next section turns towards a more detailed characterization of how we

understand wonder.

What is Wonder?

Since time immemorial, people the world over have experienced wonder from the world we find ourselves within. We have been awed by the immense complexity of our experiences, and we have been curious to know more about the complex relationships that give rise to such varied phenomena. Wondering–understood as a central cognitive practice in navigating uncertainty, considering possibilities, and speculative problem solving–is particular in that it is attended by affective landscapes that can also include enthusiasm, fascination, amazement, and admiration. Affectively charged, wonder compels a sense of awe that can motivate more holistic engagement with the world through locating ourselves as a small yet significant part of larger system in ways. Cultivating reverence, curiosity, and care, we understand the human experience of wonder as common to all peoples, and essential to well-being and healthfulness of the human experience. As such, we work from the stance that tending to the affective and cognitive landscapes generated through wondering, perspective taking, and playing with possibilities ought to be a central goal of education, as our capacities for wondering are tied to our collective ability to imagine more just arrangements and enact new worlds of meaning through our everyday practices. In this way, we position wondering as essential to world-making efforts in the design of innovative ontological practices from particular values and axiologies.

In describing our particular uptake of speculative practices, we address several recurring themes in scholarship on wondering. These include the epistemic utility of wonder (Egan 2005; Hadzigeorgiou, 2013, 2016; Lone & Burroughs, 2016), variations in core philosophical distinctions of wonder (Vasalou 2015; Piersol, 2013; Schinkel, 2017); distinctions between awe, wonder, and curiosity (Opdal, 2001; Taylor, 1998; Hadzigeorgiou, 2013); and the affective

implications of wonder (Quinn, 2002; Fleer 2013). Situated within the Learning in Places project, this dissertation addresses major limitations in how wonder is positioned within science education. Specifically, our uptake of wonder redresses over-generalized conceptions of wonder (Scardamalia & Bereiter, 1992), assumptions of indoor or lab-based teaching methods (Hadzigeorgiou et al., 2010; Hadzigeorgiou, 2011, Hadzigeorgiou et al., 2012; King et al. 2015), exclusive focus on educator perceptions (Stolberg 2008; Gilbert & Byers, 2017), and persistent disconnects between what scientists report (e.g., research findings) and what motivates their extended engagement with particular fields of study (i.e. an affect of wonder; Root-Bernstein 1996, 2002; Midgley, 2000; Jaber & Hammer, 2016).

In contrast to prior work on wonder, we emphasize the ways in which wondering necessarily occurs through and within flows of history and power that are both conceptually and pedagogically consequential for whose wonderings are positions as intellectually rich within learning environments. In so doing, this paper constructs a novel framework that represents the intersection of our design work with these literatures, laying the groundwork for future empirical work. Centrally, we assert that wonder can generate epistemic momentum, ontological shifts, and axiological interest in ways that better supports learners navigating uncertainty through speculative discourses that reflect greater depth of engagement than "known-answer" or "display" questions frequently deployed within educational activities (Long & Soto, 1983; see also Cazden, 2001; Mehan, 1979; O'Keeffe et al., 2007).

As an experience and activity common to all peoples, we also position wonder as the starting point of all inquiry (philosophical or otherwise, e.g., Lipman et al, 1980). That is, wonder is the source and foundation of all sensemaking (Plato, *Theaetetus*, 115d) – a vibrant sustaining force within all learning and inquiry (Toulmin, 1976). Reflecting humility and awe,

wonder can be elicited through the awareness of one's ignorance before something vast in scope or complexity (Quinn, 2002; Hadzigeorgiou, 2013). Indeed, Rubenstein (2008) makes a distinction between Aristotelian and Socratic/Platonic conceptions of wonder, the latter intended to motivate an "escape from ignorance" (*Metaphysics*, 982b10-25, cited in Quinn, 2002, p. 18, see also Rubenstein, 2012) before being replaced by true knowledge, the former inviting us to linger in *aporia* (lacking a way forward), the "conceptual vertigo" of vulnerable uncertainty (Matthews, 1980; Vasalou, 2015).

In day-to-day discourse wonder is used to characterize a variety of experiences related to contemplation, amazement, curiosity, mystery, awe, motivation, and even fear (Hadzigeorgiou 2013; Schinkel, 2019). Throughout history, communities have oriented to wonder in differing ways, and the many ways in which wonder has been used (sometimes conflictingly) across several overlapping domains of human activity (e.g., philosophy, poetry, science, art, education) has resulted in wonder being associated with other ideas that reduce its perceived epistemic value, such as science fiction, magic, aesthetics, and/or utter incomprehensibility (Silverman, 1989; Hadzigeorgiou, 2016). As a consequence, there exists little empirical evidence on the role of wonder, with some scholars arguing that the *concept* of wonder itself is not a unified phenomenon (Vasalou, 2015). In recognizing the multiplicities contained in such a concept, educators and researchers taking up wonder have increasingly oriented to particular *experiences* of wonder rather than attempting to enclose wonder in its entirety (Schinkel, 2017).

Part of the reason that the concept of wonder is difficult to define is because wonder is particularly sensitive to context. Semiotically, it is a "floating" or "open signifier" (Lévi-Strauss, 1987, pp. 63–64) resisting static or unitary meaning through a heavy reliance on the context of its interpretation. Separated from particular contexts, wonder can be a somewhat vague and

nebulous concept, as it necessarily takes on aspects of the situation in which it is experienced. The nature of wonder is that which takes on dimensions of the social, conceptual, material, and affective environments in which it is manifest. From this, we hold that there is no wondering from nowhere, wondering is always situated in particular places and times, within unfolding flows of history and saturated with powered dynamics relative to specific contexts of activity. This explains how wonder can be appropriately invoked in a broad range of experiences, as what one wonders about is necessarily the focus-of their attention within any given moment of experience. How one prepares the conceptual, social, and semiotic grounds of activity thus determines the kinds of wonder that might take root, grow, and thrive.

Wondering, Curiosity, & Awe

A common distinction made in scholarship surrounding wonder in education is between forms of wonder that tends more towards awe, and those that overlap more with curiosity (e.g., Hadzigeorgiou, 2013, 2016; Silverman, 1989; Taylor, 1998; Schinkel, 2017). Using similar categories, Goodwin (1994) separates wondering *about* (likened to the disciplined and deconstructive pursuits of scientific inquiry) from *wondering at* (denoting the fundamental human response involved in our ability to experience wonder and awe in the first place).

While it is certainly the case that diverse forms of wonder so overlap with one another in practice (Zazkis & Zazkis, 2014), distinctions like these are consequential insofar as they constitute fundamental assumptions in how one interprets wonder, as well as how such interpretations are reflected through the designs for learning. Core to our uptake of wonder has been a recognition of the ways in which wonderings rooted in awe *and* curiosity develops through pedagogical mediation that emphasizes the ethical dimensions of wondering, deliberation, and decision-making. We briefly locate our uptake of wonder alongside awe and

curiosity as a means of grounding this emphasis before moving onto the specific forms of wondering we have designed for in our particular context of activity.

Akin to wonder, awe is often described as a feeling of reverential respect, implying notions of amazement, admiration, veneration, or even fear (Schinkel, 2018). Awe is apparent when one is so struck by their present experience that they marvel in contemplation, amazement, and ineffable puzzlement at the vastness, complexity, and profundity of the world and their place within it. In the experience of awe, one recognizes that the focus of their attention is particularly great and should thus be afforded respect, admiration, or reverence). It is decidedly "awesome". Through awe, the experience of wonder leads to developing a more refined ignorance, often credited with cultivating compassion, humility, or reverence through decentering individual knowledge and experience. The experience awe thus contributes toward situating one's awareness in the holistic experience of being a small part of vast systems of immense complexity that stretch across time and space beyond any immediate individual experience.

In contrast, curiosity aims towards the addition of what is known. Diverging from a meditative appreciation upon reaching the limits of one's understanding, curious wonderings encounter uncertainty and look immediately for what's coming next. That is, curiosity is conceptualized as moving forward; a drive and motivation to know more about some particular new thing (Hadzigeorgiou, 2013, Opdal 2001). Of apparent pedagogical use, curiosity operationalizes wonder into active and ongoing social processes of sensemaking, most often through questions (Hadzigeorgiou, 2016; Lone & Burroughs, 2016).

Often (mis)characterized as epistemically "slower" in nature, the value of wondering from awe is not often obvious nor available to educators experiencing institutional pressures to generate quick curiosity about novel content. Due to this, connections between wonder and

curiosity are often overemphasized at the expense of those tending more towards awe. This is troubling because curiosity alone is limiting in at least two important ways. First, curiosity is more vulnerable to impulses and values associated with domination and control. Likened to an overly analytic "itch to take things apart" (Taylor 1998 p. 169) curiosity alone distorts wonder in ways that can prevent us from understanding the world in more holistic ways. In contrast, awe-based wonder supports understanding the world in its "wholeness and full context" allowing one to "gaze on things as they are" in all their complexity (Hadzigeorgiou, 2014, p. 46).

Second, because curiosity implies that there is some particular thing one is unaware of, it only serves as a motivating force within preexisting frameworks of thought and activity (Opdal, 2001). Unlike wonder, curiosity does not signal that the limits of understanding have been reached. In contrast, an awe-woven wonder cultivates an "uneasiness towards the given" (2001, p. 331) - a heightened awareness that one sensemaking is incomplete in ways that require imagining new frameworks and relations (Hadzigeorgiou, 2014; Quinn 2002). Distinct from curiosity alone, wonder nurtures expansive imaginative and speculative sensemaking, encouraging us to question what is otherwise taken for granted. In reflecting awe, wonder holds greater depth in its ability to engage the "big" questions that "engage the whole person" (Opdal, 2001, p. 332) across cognitive, affective, and existential levels.

Implications for Design. We contend that when designing from curiosity *and* awe, the pedagogical potentiality of wonder is apparent in how it braids together affective-emotional and cognitive-motivational characteristics that nurture expansive forms of social dreaming and educational practice. Wonder imbues incoming information with emotional qualities, making us "more likely to pay attention to it, [and] continue to think about it over a period of time, and repeatedly elaborate on it" (Ormod, 1999, p. 420). Generated within present experience, wonder

comes always already infused with personal relevance, a mix of wondering at and wondering about, that engages why the world appears the way it does (Lone & Burroughs, 2016). Through being necessarily grounded in the culture, learning, and identities of particular places and people, such wondering indicates that wonderers are both intellectually present and affectively engaged with the focus of their puzzlement, encouraging playful opportunities for sophisticated speculative sensemaking where affect is high, and the stakes are low. The experience of being in awe of, and curious about, what one notices in particular places can generate ethically grounded epistemic momentum and axiological interest as one moves through and within the world, navigating both familiar and novel situations containing varying uncertainties and possibilities. Thus, our design works from an understanding that opportunities for learning are most potent when awe *and* curiosity can coexist such that strict conceptual distinctions are rarely necessary in practice.

Recognizing the person-specific and context-dependent nature of wonder, our design work takes a phenomenological approach to wonder that recognizes the primacy of attention in all sensemaking efforts (Husserl, 1900/1901; Merleau-Ponty, 1945;). Rather than attention conceived as an analytic spotlight on one thing, we position the acts of attending to, noticing, and making sense of the world as primarily relational and embodied endeavors (Schuback, 2006; D'Angelo, 2020). When someone notices, they are brought into an immediate relationship with the focus of their attention and the context in which they are present. In this view, direction of attention is understood as a creative transformation of the mental field which presents new ways for consciousness to become present to others – a perspective from "turning points" between perceptual and conceptual activities that, "enables the rare instant in which one becomes one with things and others, experiencing oneself as a being-with and no longer as a thing which

exists together with other things" (Schuback, 2006, p. 139). Beyond just "paying attention", we work towards nurturing a deeper attentiveness to the world within and beyond our immediate surroundings; a disposition to carefully attend to one's positionality from within complex webs of relation in ways that encourage ongoing wondering and deliberation about possible courses of action from *within* unfolding activity (see also Shotter, 2006).

By positioning attention and the act of noticing as ontologically prior to wonder, we take seriously the situational linkages always present within wonder through recognizing the multiplicities inherent in both the idea and experience of wonder. In our own particular context, this is reflected through routine practices of field-based noticing and observation as the basis of inquiry. Embodying these conceptual and philosophical premises in our practice through routine outdoor learning engagements, we aim to cultivate multiplicities of awe and wonder in ways that support the development of dispositions towards noticing and wondering characterized by careful and ongoing attention to our very being in the world.

Mediated by such noticing, we position wonder as emergent from places via plural and active means. We hold this emphasis through use of wonder*ings*, rather than imagining wonder as isolated or separate from the dynamic ebbs and flows of attention within unfolding flows of activity. Said more simply, we argue and design for dynamic simultaneity in emplaced and embodied noticings, alongside both awe and curiosity via wonderings, as key to generating conditions whereby learners can engage in ethical deliberation and decision-making in locally relevant ways (e.g., see Chapters 2-4).

More than just characterizing such a conception, we continue to practice this approach to wondering through the design of materials within the Learning in Places project ecosystem. In Chapter 2, I build from this conception of wonder by introducing three related dimensions that

more sharply characterize what we call *ethical wondering with people, places, and more-than-humans* as it has emerged through iterative co-design processes. While we maintain that our broader orientation towards *wondering* is applicable across disciplinary contexts of learning, the particular context of activity in which these ideas emerged is important for understanding how the genesis of fundamental ideas influences connections to the concrete practice and materials we introduce. Towards a fuller understanding on the conceptual and discursive ecologies in which these notions are rooted, the next section describes the research context of Learning in Places. Laying the groundwork for the dissertation, I describe the general arc of activity in Learning in Places, paying particular attention to our orientations towards noticings, wondering, and ethical deliberation. I sum up this focus on research context by locating my own participation in the project since its inception in 2017.

Research Context: Learning in Places

The aim of the Learning in Places project is to co-design innovative research and practice with children, families, educators, and community members that cultivates equitable, culturally based, complex socio-ecological systems learning and sustainable decision-making see (Bang et al., in prep; Montaño Nolan et al, accepted). Using community-based (Bang et al., 2016) and participatory design research methods (Bang & Vossoughi, 2016), we have partnered with children, families, educators, university researchers, and community-based organizations to co-design materials and practices that supports ethical field-based science education towards community wellbeing and ethical world-making.

As a co-design project, LiP builds upon previous work in *design-based research* (DBR), an interventionist "meta-mixed-method" used to iteratively imagine and design innovative forms of educational practice in applied contexts (e.g., Brown 1992; Barab & Squire, 2004; Cobb et al,

2003; Design-Based Research Collective, 2003; Bell, 2004). As an applied methodology, design-based research is concerned with developing innovative approaches to educational practice, while also generating and refining foundational theories and knowledge from these real-world contexts (diSessa & Cobb, 2004). Holding theory and practice together in mutually constitutive ways, DBR thus focuses on contextualized adaptation rather than static adoption of design work in recognition of how "knowledge production and its uses as always a social and cultural process that cannot exist independent of context and local meaning-making" (Bevan et al., 2018, p. 19).

Distinct from other approaches to design, *participatory design research* (PDR; Bang & Vossoughi, 2016) takes a deeply relational approach to imagining and enacting more just forms of education, design, and partnership within educational endeavors. Resonating with work in social design experiments (Gutiérrez & Jurow, 2016), PDR aims to expand roles and relationships between and among all participants in ways that encourage the emergence of new identities, expertise, and agency. Critically attentive to the ways in which power dynamics shape opportunities for such expansions, PDR works towards "role remediations" that deliberately disrupt normative power relations towards more "porous" roles (Bang & Vossoughi, 2016) where community members, researchers, youth, practitioners, and more are positioned as equal partners in design processes while moving among several different contributive roles.

Central to this methodology is the assumption that so-called "participants" can and do bring valuable experiences, perspective, and sets of expertise to bear throughout iterative design cycles. In doing so, participants become partners in design with a meaningful say in all aspects of a project. Who participates in design, and how design processes occur, and the kinds of relational dynamics that are prioritized shape the opportunities for learning that are enacted. In doing so, PRD encourages collective dreaming that resists enclosures by "politics of practicality" (Bang &

Vossoughi, 2016) that can constrain imaginative design possibilities and stifle processes in ways that afford little room for transformative changes to take root. As leading conceptualizations of participatory design work assert:

> "… transformative social change involves the interweaving of structural critiques with the enactment of alternative forms of here-and-now activity that open up qualitatively distinct social relations, forms of learning and knowledge development, and contribute to the intellectual thriving and well-being of students, teachers, families, and communities" (Bang and Vossoughi, 2016, p. 175).

Rhizomatically woven throughout the Learning in Places ecosystem, these commitments to applied theory, expansive participation, and social transformation are central to how we understand the education potentialities for ethical wondering, deliberation, and decision-making. One way that we continue to concretize these stances is through developing an ecosystem of interconnected structures and materials that support ethically-engaged science investigations as they unfold within particular places.

Project Rhizome

A foundational structure in the LiP ecosystem is what we call the project's *Rhizome* (see Figure 1.1), which represents the core set of commitments and foci that guide the design material throughout the LiP ecosystem. In botany, a rhizome is an underground, horizontal stem that puts out new shoots and roots from its nodes, connecting and supporting the ongoing growth and proliferation of a plant. In philosophy, rhizomatic theory operates on principles of heterogeneous interconnection and non-hierarchical multiplicity, where connections proliferate from multiple centers that coalesce to create new conceptual connections and horizons for practice (Deleuze & Guattari, 1980; Gadamer, 2004). We use the metaphor of a rhizome to hold the ways in which

the core dimensions of LiP guide and represent the forms of science learning we are committed to cultivating.

Incorporating these commitments, a primary goal of our Rhizome structure is the pedagogical refiguring of relations between human and more-than-human worlds (nature-culture relations) through critical engagement with dynamics of power and historicity, complex socio-ecological sensemaking, and field-based science learning that centers the cultural identities of families and communities as lived within places, lands, and waters. Taking inspiration from rhizomatic growth in plants, these core design commitments grow horizontally throughout our work, giving structure to activities while also supporting the emergence of novel arrangements.

Figure 1.1

Learning in Places Project Rhizome

Seasonal Storylines for Field-Based Science Education

In part, this rhizome is operationalized through engagement in our Field-Based Seasonal Storylines: curricularly agnostic systems of activity meant to engage students, families, and educators in iterative field-based seasonal investigations grounded in field-based noticings, wonderings, and questions. We have developed three related storylines designed to elevate ideas from our Rhizome in different contexts of activity. For example, the Garden Storyline was developed for use by garden-based educators working in contexts such as multi-week summer camps, while the Our Family Storyline is intended for use within and across familial units without the expectation of more formal (i.e., classroom) mediation (see Appendix 1a for garden and family storyline examples).

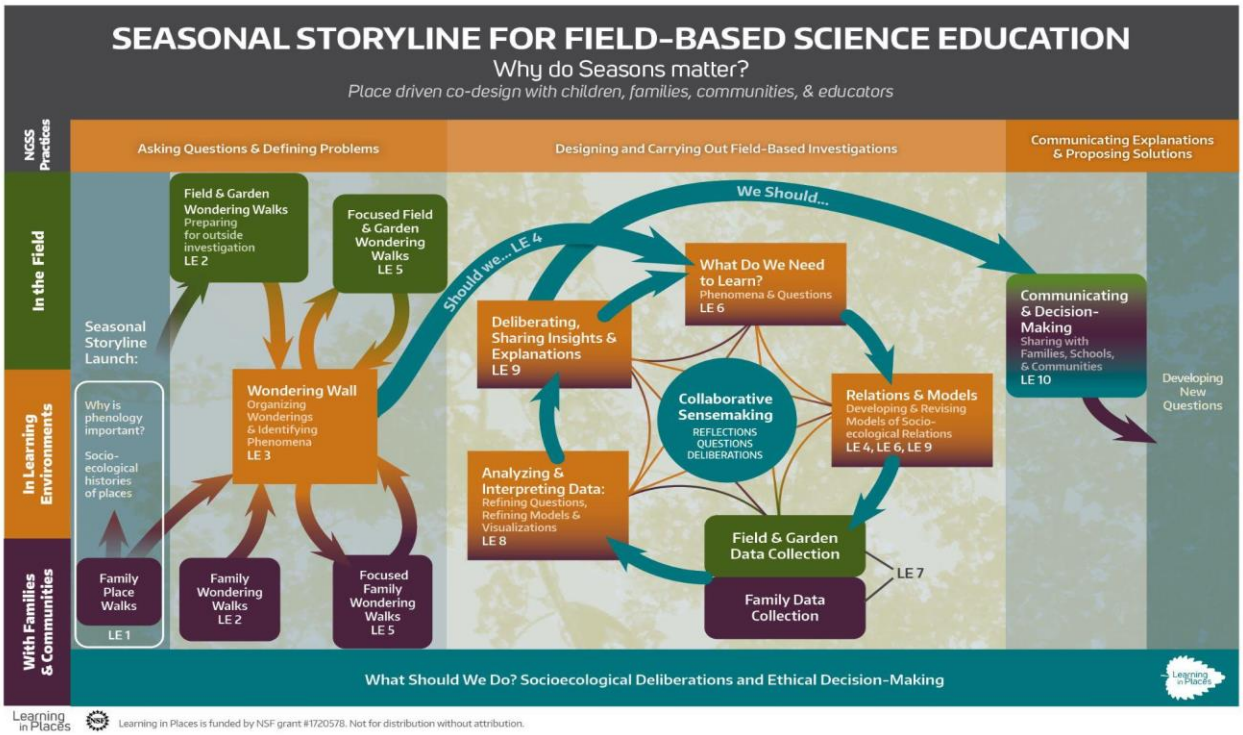
While we reference each storyline, the primary focus of this dissertation is the classroom-based storyline (figure 1.2, hereafter referred to as the FBSS), designed for use in classroom-based contexts through the partnered activities of educators, youth, families, and the places they inhabit. The FBSS is meant to be implemented in three major stages (asking questions and defining problems, designing and carrying out field-based investigations, communicating explanations and proposing solutions) and 10 *Learning Engagements* (LEs) that are aligned with (and often exceed) expectations of NGSS frameworks for science and engineering practices.

Learning Engagements are a series of semi-linear learning activities that guide the development of investigations and trajectories of learning and embodied movement as rooted in learner wonderings. Starting with a grounding in phenology, socio-ecological histories of places, and learner noticings and wondering (LEs 1-3), storyline materials support classroom communities in developing a "should we" question that informs more focused wondering walks (LE 4-5). Producing an array of "investigation" questions, the back end of the FBSS supports

engagement in iterative cycles of collaborative sensemaking designed to explore these emergent questions through model development and revision, data collected and analysis, explanations generation and deliberation, and communication of insights that inform what "should be" done (LEs 6-10). We highlight two aspects as relevant to the work described here: *wondering walks* and *should-we questions.*

Figure 1.2

Seasonal Storyline for Field-Based Education



Wondering Walks. This activity system begins through, and is foundationally shaped by, repeated noticings and wonderings of youth and families in local places through a series of *open wondering walks*. Foundational to the launching of the storyline, these activities consist of scaffolded walks in local, outdoor places where learners are encouraged to wonder and ask questions about what they notice. Importantly, there are no predetermined phenomena of

investigation at the outset of these wondering walks. Rather, focus is directed towards becoming accustomed to routinely walking together in outdoor places and beginning to build relationships with local places and kinds.

While individual walks may foreground broad socio-ecological foci (e.g., relationships, human decisions making, seasons, histories of places), all wondering walks are conceptually united in the focus on routine observation and youth-generated wonderings within local places. Within walks, educators use co-designed materials to model and support forms of noticing and wondering that cultivate attention towards relevant dimensions of socio-ecological sensemaking across longer timescales of investigation (i.e. seasonally). During wondering walks, participants are often equipped with clipboards and observational scaffolds prompting them to look and attend to socio-ecological phenomena and natural kinds in particular ways. Depending on the context and focus of a given walk, additional data collection tools (magnifying glasses, thermometers, trowels, etc.) may also be used.

Marking an important distinction in how wondering walks are conducted, the first walks in the FBSS (e.g., LE 2) are *open* wondering walks. In this intentionally under-constrained space, the activity is flexible – open to whatever emerges as learners wonder and ask questions about what they are noticing. Over the course of these initial walks, learner wonderings are gradually compiled, frequently revisited, and thematically organized through use of a *wondering wall* (LE 3). Using the wondering wall, learners and educators relationally organize wonderings as they emerge, eventually selecting a smaller number of phenomena and relationships to focus on as they move forward in the FBSS. This serves as a conceptual and practical pivot in activity, where the group begins to move from *open* to *focused* wondering walks (e.g., LE 5) as patterns, changes, and relationships become more evident in emergent phenomena of interest.

Characteristic of more focused walks, attention is guided towards particular phenomena of interest for deeper investigation. This practice results in the creation of a "should we" question that drives lines of collective investigation and analysis designed to inform what *should* (or shouldn't) be done in response to a specific socio-ecological situation (LE 4 and beyond).

Should-We Questions. Fundamental to activity within the FBSS is the development of what we call a "should we" question: a locally relevant ethical inquiry that informs processes of designing and carrying out field-based investigations as grounded in the socio-ecological wonderings of youth and families. The kinds of ethical wonderings that we have found most supportive contain several key dimensions. Namely, a should-we question contains at least the following: 1) doesn't have a strictly right or wrong answer, involves considering socio-ecological tradeoffs and perspective taking; 2) they involve 5 dimensions of socio-ecological sensemaking (Bang et al., in prep); 3) they are not predetermined at the outset - they emerge as connected to our schools and/or neighborhoods and are interesting and important to our families; 4) they involve multiple timescales and have a connection to the seasons; 5) we could apply our decision-making process when trying to figure out what to do. Beyond contexts of science learning in isolation, we recognize should-we questions as also presenting deep connections to educational scholarship in civic reasoning and discourse (Lee, White, & Dong, 2021; Rudolf & Horibe, 2016).

While this dissertation remains rhizomatically connected to the broader LiP project and storyline, the explicit focus of this work and the data analyzed in subsequent chapters is primarily concerned with the first half of the storyline, specifically where participants are engaged in outdoor "wondering walks" (LEs 2 & 5).

Locating the Researcher

Within the larger scope of this project, it is important to recognize the ways in which my own experiences as a participant, analyst, and author are centrally implicated in the entangled messy and complex "doings" of research. Methodologically, I engage this process as one of also discipling of my own professional perception (Stevens & Hall, 1998; Goodwin, 1994) towards becoming a more trained observer that can engage data of interest within reasonable timescales towards identification of "rich points" (Agar, 1996) and "critical events" (Powell, Francisco, & Maher, 2003, p. 413) that inform how we understand the role of ethical wondering in education. Beyond a compilation of theory, method, and empirical analysis, this work also represents tangible steps on my own learning trajectory into particular communities of practice as an explore, investigate, and share my answers-in-progress to my ethical wonderings. Personally, this work is an emerging response to the question: "How can I contribute towards the design and implementation of educational experiences that better prepare educators, youth, and future generations for healthful living in times characterized by rapidly shifting socio-ecological landscapes?" To this end, developing the socio-ecological forms of ethical wondering I share in this dissertation represents more than just a conceptual activity, but my own lived inquiry and contribution to ways in which we might live from an ethic of relational reciprocity with people, places, and more-than-humans.

Of central consideration, my work as a Research Assistant on the Learning in Places project since 2017 has increasingly intertwined the rhythms of LiP with those of my own life. Concretely, I am a participant and co-designer throughout much of the data I analyzed here. While some methodological traditions might view my deep subjective involvement problematic, I position my intimate knowledge of LiP and the contexts in which these data were collected as a

strength that lends additional credibility to the interpretations I articulate. In the weaving of myself within Learning in Places, particular axiological stances have developed about what it means to think with data collected from place encounters as a sacred act (Marin, 2020; Marin & Bang, 2018; Nxumalo, 2016; Ma et al., 2019). Taking this seriously, my engagement with this project is fundamentally grounded in an ethic of epistemic openness and ontological generosity. Put into practice through analysis of data, my interpretations are grounded in a view of participants as sensible, capable, and acting with intelligence, ingenuity, and dignity (Espinoza & Vossoughi, 2014) while also recognizing the contingency, messiness, complexity, and partiality of any activity and its interpretive account (Law, 2004). As such, the work compiled in this dissertation represents a story-so-far (Massey, 2005), a temporary crystallization of emergent and living trajectories of work that continued to flux and flow through iterative process of co-design within and beyond this written artifact.

Recognizing how research in the Learning Sciences is limited insofar focus on individual achievement (Enyedy & Stevens, 2014), I reach beyond individual notions of authorship towards understanding this dissertation as a product collective and joint activity. While this collective includes academic scholars and researchers, it is the contributions of numerous children, families, educators, more-than-human community members, and places themselves whose participation makes this work possible in the first place. Practically, while I use the first person nominative singular pronoun “I” in this text, this is not meant to suggest that this work is primarily the result of individual activity. In this way, I honor innumerable inter-species participants with whom this work has been nurtured and express deep gratitude for the opportunity to share insights that are the product of such socio-ecological partnership.

Overview of Chapters

In this dissertation, I present three interrelated papers that engage, explore, and empirically examine a particular orientation towards teaching and learning emergent from our collaborative work: ethical wondering with people, places, and more-than-humans. In so doing, I construct conceptual and empirical grounds that contribute toward understanding how we might create the conditions for such and orientation towards teaching and learning in ways that can contribute toward desettling powered hierarchies that privilege indoor learning, adult-led pedagogy, and humans over the rest of the natural world. Pursuing this work, I pose several overarching questions developed to probe into the layered significance of wondering in the LiP conceptual and material ecosystem. Attendant to my grounding in participatory co-design, I ask both "how can" questions that encourage imagining and reaching towards new possibilities, as well as "how do" questions that identify current arrangements to support iterative process of design and re-design (Bang & Vossoughi, 2016). Positioned as descriptive and imaginative, these questions should be understood as interwoven and reciprocally developed, rather than linear or disconnected, over the course of this dissertation. Together, these questions explore the affordances and constraints of wondering walks as activities for socio-ecological learning through the use of multiple complimentary methods aimed at better understanding how a pedagogical focus on wonder can contribute towards co-designing expansive forms of learning with people, places, and more-than-humans that support educational wellbeing, dignity, and justice.

In Chapter 2 (Paper 1) I ask:

- *What conceptual ecologies and commitments support our approach towards ethical wondering with people, places, and more-than-humans; and how are these stances*

embodied, concretized, and/or operationalized within our design materials?

In Chapter 3 (Paper 2) I elaborate on:

- *What are the interactional characteristics of ethical wondering with people, places and more than humans and how do they reconfigure relationships and shape sensemaking within contexts of socio-ecological learning?*

In Chapter 4 (Paper 3) I analyze data to answer:

- *What kinds of socio-ecological sensemaking practices, specifically in relation to our core design propositions, are represented across wondering walks? Are there significant correlations? If so, what are their implications?*
- *(How) does the representation of coded sensemaking practices shift between open wondering walks in LE 2 and focused walks in LE 5, as well as between storyline engagement indoors and outdoors? What are possible implications of these variations?*

In responding to these questions, I study the forms of design, emergent sensemaking, and pedagogical interactions that "grew" within the Learning in Places ecosystem by illustrating the concepts and conditions through which ethical wondering with people, places, and more-than-humans was designed towards. These papers represent three loosely sequential and highly interwoven phases of analysis, each attending to complementary scopes of work.

In Paper 1 (Chapter 2) I build from the uptake of wonder introduced above to construct and a conceptual framework for ethical wondering, pedagogical mediation, and complex socio-ecological sensemaking. Here, I bring together scholarship in ethical speculation (Schinkel, 2018), withness (Shotter 2005, 2006), interpretive power (Rosebery et al., 2016) and disciplined improvisation (Stevens & Hall, 1998; Sawyer, 2011) in ways that expand notions of educational dignity to explicitly include more-than-human beings and places themselves as agentic

facilitators of learning. Bridging the philosophical and empirical (Wilson & Santoro, 2015), I illustrate the ways we have concretized these ideas within a range of materials designed to support pedagogical decision-making and complex socio-ecological sensemaking within and across learning engagements. In this section, conceptual analysis of ethical wondering with people, places, and more-than-humans within designed materials is organized into five broad and overlapping categories: nature-culture relations, more-than-human agency, place design through histories of places, seasonal change and phenological rhythms, and place-based pedagogies that foreground routine field-based observation.

Developed in parallel, Paper 2 (Chapter 3) presents a qualitative case study analysis of a wondering walk collected in our pilot design year of implementation. Orienting to micro-interaction scales of storyline design and implementation, this paper charts grounded methodological processes used to develop and progressively refine (e.g., Engle et al., 2007) emergent coding categories to identify a "rich" case that has been central to our developing understanding of ethical wondering with people, places, and more-than-humans. Through grounded coding (Jordan & Henderson, 1995) and analysis of interaction (e.g., Derry et al., 2010; Erickson, 2004; Goodwin 2017; Hall & Stevens, 2016), this paper characterizes consequential features of the social and semiotic landscape that generate and continually renew contexts of emergent ethical investigation as participants move, notice, and wonder with people, places, and more-than-humans. Utilizing extended transcript segments (Duranti 2006; Jefferson, 2002; Ochs, 1979; Goodwin 2017; Marin & Bang, 2018) this paper characterizes interactional dimensions of ethical wondering with people, places, and more-than-humans within the moment-to-moment unfolding of wondering walks. These include: design-disciplined socio-ecological improvisation; emergent place-facilitated inquiry; structure, function, and behavior or species,

kinds, and places; expansive perspective taking; and complementary nature-culture relations.

The third and final Paper of this dissertation (Chapter 4) describes a broad quantitative analysis conducted on data gathered in Year 3 of the Learning in Places project. Representing the most recent work in this dissertation, this phase of analysis progressively refines coding categories developed in Papers 1 and 2 through inductive and grounded approaches over approximately 98 hours of wondering walk data collected during our first full year of implementation (year 3). By documenting the presence or absence of socio-ecological, speculative, and place-based codes across 5-minute intervals of recorded activity, this Paper complements the qualitative depth of Paper 2 with a focus on quantitative breadth to produce quantitative characterizations of walks. In addition to sharing findings through descriptive measures and calculation of correlational coefficients, we direct specific focus on comparing the representational density of child codes between indoor and outdoor learning environment, as well as between open (LE 2) and focused (LE 5) wondering walks.

By way of conclusion, Chapter 5 reflects holistically on this dissertation as through triangulating evidence of ethical wondering with people, places, and more-than-humans through analysis of design (Chapter 2), deep qualitative approaches (Chapter 3), and broad quantitative analyses (Ch 4). In summarizing the work so far, we present a series of high-level design principles intended to guide work in similar spaces. By way of conclusion, the limitations and implications of this work are considered alongside and future trajectories of analysis and publication.

Chapter 2. Paper 1: Towards a Design-Based Theoretical Framework for Pedagogical Mediation and Socio-Ecological Sensemaking through Ethically Wondering With

Introduction

Our capacities for wondering are intimately related to our abilities to imagine new forms of worldmaking that reach towards more just and reciprocal nature-culture relationships in recognition of our place within complex social and ecological systems. Developed in parallel to emerging empirical work in *ethical wondering with people, places, and more-than-humans* (see Chapters 3 & 4), the goal of this paper is to concretely characterize aspects of the conceptual framework that undergirds our approach to co-design of materials within the Learning in Places ecosystem. In ascending from abstract to concrete (Engeström, 2020), this paper speaks to the affordances and constraints of our materials for nurturing expansive forms of noticing and wondering in science learning through cultivating attention to complex socio-ecological relations.

As such, the purpose of this paper is twofold. I first introduce a framework for understanding that the conceptual, pedagogical, and socio-ecological significance of *ethical wonderings with people places, and more-than-humans* as emergent from our collaborative educational work within the Learning in Places project. Second, I demonstrate how core dimensions of this design ethic are operationalized and supported in our place-based co-design tools through review of select designed materials. In doing so, I highlight the ways in which we extend our pedagogical focus via ethical wondering *with* and design-disciplined mediation beyond human participants to recognize the facilitative agency of places and more-than-human beings.

Connecting contexts of philosophical theorization and those of everyday practice, I draw

on methods in empirical philosophy, where empirical projects are shaped by philosophical questions, frameworks, and analytical approaches (Wilson & Santoro, 2015). The work presented throughout this dissertation reflects three key commitments of empirically engaged philosophy projects by: adopting broadly pragmatic and experimental approaches to inquiry, exploring the moral and ethical dimensions of education, and aiming to improve the precision of conceptual frameworks in different areas of educational research and practice (Wilson & Santoro, 2015). Through the first commitment, the empirical study of wonder reflects a Deweyan (1925) orientation to learning wherein "education is the laboratory in which philosophic distinctions become concrete and tested" (Dewey 1916, p. 329) through adopting a hybridized approach that integrates social science research and philosophy (Feinberg, 2015).

To the second commitment, the uptake of wondering presented here explicitly explores how a pedagogical focus on wondering might engage and expand the axiological terrain of education through desettling relations between and among educators, learners, education, and the rest of the natural world (Bang et al., 2013). As a philosophical project, this work engages both what *is* as well as what *ought* to be (Wilson & Santoro, 2015), in ways that challenge normative frameworks of science education that too frequently operate from indoor, adult-led, human-centric, assumptions. In doing so, this work offers new forms of language for educators to approach their work, lives, and teaching practices in ways that productively overlap with commitments of participatory design projects (Bang & Vossoughi, 2016; Bang et al, in preparation). This work offers novel responses to calls for philosophy to be more explicitly connected to empirical research (e.g., Fenstermacher, 2002), while also recognizing how philosophy itself begins in wonder (Plato, *Theaetetus*, 115d; Lipman et al., 1980). Simultaneously, we recognize philosophy and values as active and concrete; practiced through

processes of co-design and emergent interaction rather than purely conceptual tasks.

We draw on a complementary array of scholarship, including work in structure and improvisation in education (Sawyer, 2011), just and dignified education (Espinoza, 2009; Espinoza & Vossoughi, 2014) relational epistemologies (Deloria, 1999; Cajete, 1999a, 1999b; Shotter, 2005; Bang, 2015), onto-epistemic heterogeneity (Rosebery et al., 2010; Bang & Vossoughi, 2016; Warren et al. 2020), and interpretive power (Rosebery et al., 2016) to describe how an uptake of wondering can refigure nature-culture, child-adult, and home-school relations. In doing so, we propose ethical wondering with people, places, and more-than-humans as desettling pedagogy that carries profound onto-epistemic and axiological potentialities that inform both theoretical and practical efforts to refigure the goals and means of education towards relational responsivity (Shotter, 2006). This paper describes how these bodies of scholarship facilitate our approach to designing novel systems of education from orientations and commitments towards ethical everyday socio-ecological sensemaking.

Key to the framework developed below is our contention that a pedagogical focus on wondering can desettle powered relations in education at multiple scales (Bang et al. 2012). Requiring the imagining of new frameworks and relations, wonder invites onto-epistemic heterogeneity (Rosebery et al., 2010; Bang & Vossoughi, 2016; Warren et al. 2020), opening up spaces where we might develop an "uneasiness towards the given" when evaluating normative frameworks of knowing and being. Specifically, we elevate how wonder can open up the conditions under which anthropocentrism, school-centrism, and adult superiority can be productively engaged and refigured in everyday interaction. In doing so, we position wondering as a necessary precondition to the collective imagining and enactment of alternative possibilities for human learning and relations (Espinoza et al., 2020).

To these ends, we describe the conceptual and experiential significance of wonder as it has informed our design and interaction within the Learning in Places project (Bang et al., in prep). Building with the uptake of wondering in Chapter 1, I sharpen this orientation through characterizing three more focused forms of wonder that undergird our design work: 1) the speculative structure of *ethical* wondering, 2) wondering *with* as pedagogical mediation, and 3) our *context* of socio-ecological speculation with people, places, and more-than-humans.

Organized as such, we argue for expanding normative focuses on human, adult, and school-centric activity by describing how *ethical wondering with people, places, and more-than-humans* emerged within our particular context of educational design. Within the context of the Learning in Places project, we demonstrate how we have operationalized these frameworks through empirically charting how key characteristics and commitments of ethical wondering with people, places, and more-than-humans shows up in materials designed to support complex socio-ecological sensemaking in local places. By way of conclusion, we briefly discuss several broader implications of these ideas on education committed to ethical teaching and learning.

Ethical Wonderings

Building from and further focusing the framework in Chapter 1, we conceptualize *ethical wonderings* as having at least the following characteristics; . Ethical wonderings: Navigate possibilities and uncertainties through asking normative questions about what should or ought to be done in a given situation; Involves social deliberation and anticipates applied decision-making; Can cultivate other-acknowledgement, humility, and compassion through perspective taking; and is axiologically and existentially engaged through imbuing particular value judgements with importance and meaning.

At the most basic lexical level, placing the prefix of “ethical” semantically sharpens

wonderings (Vossoughi, 2014) to a more focused reference to forms of speculation concerned with possible action, or what one "should" do given their wonderings about a particular situation. More intentionally shaped than wonder in general, this is a specific kind of speculative inquiry that specifically necessitates axiological considerations. Because decisions are always made from particular values, stances, and priorities, ethical wondering implies moral judgements about what one considers good, right, beautiful, worthy, or deserving. Well-known ethical wonderings include "What should I do", "How ought we to treat others", and "Is this fair/just?".

Our view of ethical wonderings builds with existent work on the axiological and existential dynamics of wondering. For example, Stolberg's (2008) data of preservice science teachers describes three important dimensions of wonder: *physical* wonder, induced by interaction with objects and natural phenomena; *personal* wonder, manifest through engagement with human beings and their achievements; and *metaphysical* wonder, which describes wonder-laden interaction that leads to shift in perspective. The metaphysical perspective shift we are after in this work also relates to Goodwin's (2001) third category of speculation - wondering *whether*. Later added to his wondering *at/about* model (Goodwin, 1994), *wondering whether* implies questions that explore our values and axiological stances within particular experiences of wonder. When wondering whether, we ask questions about our ethical judgements and possible decisions, such as "Should I do this?", "Must I do this?", "Is this right?", and "Why is this important?" (Bianchi, 2013). These kinds of open-ended questions necessitate processes of perspective taking, which in turn can cultivate wonderers awareness of the priorities and values that underlie both decisions already made as well as possible courses of action.

In wondering whether, we elevate how ethical wonderings do not exist in isolation; they emerge within particular social, historical, and moral contexts. Ethical wondering is never a

purely abstract activity where social deliberation and applied decision-making are separable. That is, ethical wonderings merge theories of action with context of practice. In our view, the potential of ethical wondering for teaching and learning is always linked to ongoing inquiry and deliberation about real-world situations. In linking theories of action with context of practice, ethical wonderings require us to ask existential and axiological questions about the world, our place within it, and how we ascribe meaning and value to our experiences. What kind of people do we want to be? What roles, values, and relationships ought to guide our actions and decisions? What kind of world should we build, and how do we get there? This view asserts that our capacities for ethical wondering, deliberation, and decision-making determine our capacities for imagining change and bringing collectively just, sustainable, and thriving ways of valuing, being with, and knowing about the world.

In this view, potential "answers" to ethical wonderings are contingent and situated, dependent on whose perspective and what values are prioritized in processes of deliberation and decision-making. There is often no "right" answer to an ethical wondering, and such wonderings often produce more new questions than they resolve. Rather, ethical wonderings encourage sensemaking from multiple perspectives as wonderers deliberate on the potential tradeoffs of a given decision (Berkes, 2017; Galafassi et al., 2017). This view also recognizes how everyday decisions are often made with incomplete or partial sets of information. Thus, ethical wondering lacks the enclosure of "known-answer" or "display" questions commonly posed in educational activities (Long & Soto, 1983; see also Mehan, 1979 & O'Keeffe et al., 2007). Through open-ended and applied inquiry, ethical wonderings support low stakes opportunities for learners to collaboratively deliberate from multiple perspectives and imagine the futures entailed through various courses of action.

While this does introduce a level of uncertainty that can take practice for educators to skillfully navigate (Manz & Suárez, 2018), we contend that cultivating an enduring, routine sense of awe, wonder, and curiosity alongside a disposition to consider multiple perspectives should be a central goal of education. Rather than that accumulation of text-based knowledge, the humble and ongoing navigation of uncertainty inherent in our view of ethical wondering frames life and learning as an always unfolding, situated social processes aimed at the development of particular ways of knowing and being over time. We understand the cultivation of such an orientation towards ethical wondering as imperative for the kinds of socio-ecological adaptations that are required of us in these times.

We see this axiologically sensitive form of speculation as resonant with recent work in wonder. Elevating the experience of *deep wonder*, Schinkel (2017) argues for education grounded in contemplative practices that start from an awareness of the beauty and immensity of the world (see also: Hadzigeorgiou, 2016). Responsible for evoking a greater depth of existential engagement and historical awareness, deep wonder is also conceptualized as also having direct moral and ethical consequences. De-centering the speculating individual, Vasalou (2015) finds the moral significance of ethical wondering in its "other-acknowledging" nature. Oriented to as a "non-exploitative awareness", morally salient forms of wonder are bound up in the recognition that the world does not exist for us, "but precedes and outlives us and exists in its separate being, which demands to be honored as such" (Vasalou, 2015, pp. 206-207). This recognition can grow into a sense of personal connectedness and indebtedness within the natural world. It is on these grounds that Schinkel (2018) describes the morally transformative potentialities of wonder through its capacities to encourage non-egocentric reassessment of what we consider important through fostering empathy, love, and compassion.

Building with these perspectives, our work elevates how a deep sense of ethical wonder can impel us to act respectfully in the world through scaffolding perspective taking skills in ways that nurture a sense of love and fundamental connection within the world that encourages us to "see life as something to which we owe respect and care" (Moore, 2005, pp. 273). Aware of how normative colonial, imperial, and human-centered tendencies towards "othering" that lead to marginalization and harm (Anderson, 1983; Said, 1979, 1993; Mignolo 2012; Wynter, 2003), we understand ethical wondering as central to supporting relational understanding of the world characterized by recognition of kin relations and obligations of care between diverse living beings (Kimmerer, 2013; Noddings, 1984; Puig de la Bellacasa, 2017). In ethically wondering about our own existential situations, we can become aware of both the extreme potentiality and fragility of life, an experience that nurtures compassion for self and others (Hepburn, 1980). As Fuller asserts, "No other emotion [wonder] so readily kindles a reverence for life" (2006, p. 158).

Implications for Design

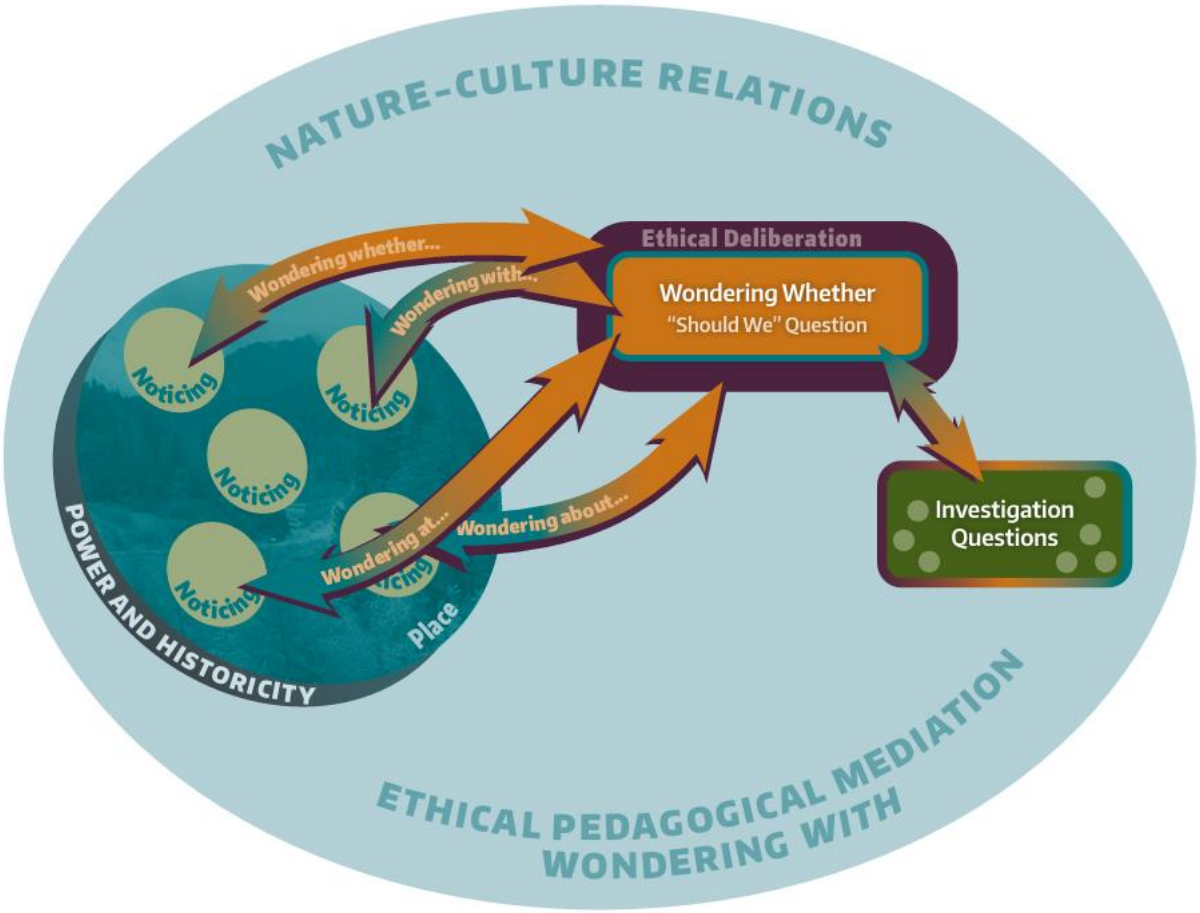
Learning Frameworks. One of the ways we have infrastructured support for ethical wondering in our design is through the creation of *Learning Frameworks*. Designed to support educators in ongoing learning about key project ideas embedded within our project's *Rhizome*, these frameworks synthesize key lines of scholarship into more readily accessible formats. Regular dimension of frameworks include: "front matter", which summarizes key ideas and their importance; "how to use this framework", which elevates connections to learner sense-making, collaborative practice, co-design and assessment, planning and implementation, and educator reflections; "connections to expert thinking" which reflects on focal ideas in context of expert science practice; and "Rhizome connections" which explicitly connects particular idea to broad domains within our Rhizome. To further support practice, each Framework also contains a series

of appendices containing pedagogical vignettes of classroom practice, examples of learning thinking and self-assessments for educators. Central to the development of many frameworks is an emphasis on the creation of novel representations and graphics to support sensemaking about the ideas we put forward. We briefly review two frameworks central to our uptake of ethical wondering, "Wondering, "Should-We", and Investigation Questions in Field-Based Science" and "Ethical Deliberation and Decision-Making in Socio-Ecological Systems."

Wondering, "Should-We", and Investigation Questions in Field-Based Science Framework. In this framework we describe the importance of wondering and ethical questions in driving processes of scientific investigation (Learning in Places collaborative, 2020a). Locating wonder as central to sophisticated scientific practice, we introduce a typology of wonderings to help educators see how multiple forms of wondering are often woven together in place-based activities. Paired with deeper descriptions of salient concepts, we introduce representations that are designed to support educators in seeing the connections between power and historicity, learner noticings and wonderings, ethical questioning, and cycles of place-based investigation into phenomena of interest (figure 2.1). As in all frameworks, we make explicit connections to key ideas in our project Rhizome and offered extended appendices with detailed vignettes of classroom implementation, examples of learner thinking, more detailed typologies of question asking, and a self-assessment for educators.

Figure 2.1

Arc of Noticings, Wonderings, Should-We Questions, and Investigations



Ethical Deliberation and Decision-Making in Socio-Ecological Systems Framework.

Complementing the foci in the afford mentioned framework, this framework centers on the importance of engaging in ethical deliberation and decision-making how these processes are shaped by socio-ecological values and cultural practices (Learning in Places Collaborative, 2020b). Here, we emphasize how different nature-culture construals have changed over time in relation to technologies and forms of energy that have become central to human life in different parts of the world. We synthesize research in decision-making science alongside scholarship that suggests that we are now living in an unprecedented time in human history known as the Anthropocene, where human activity is the primary driver of global shifts in climate. Using accessible language, this framework is intended to help educators, learners, and families develop

important ways of thinking about and making socio-ecological decisions. In so doing, we introduce seven dimensions of ethical deliberation and decision-making about socio-ecological phenomena to help educators, learners, and families deliberate about "Should-We" questions or big decisions (figure 2.2). Extended appendices deepen, reinforce, and provide applied examples to support educator practice.

Figure 2.2

Decision-Making Wheel

Extending this focus on how our theoretical frameworks influence and "show up" in designed materials, we move now to take up how we conceive of ethical pedagogical mediation.

Ethical Pedagogical Mediation: 'Wondering With' through Design & Interaction

In this section we explicitly take up axiological considerations not just in the content of our pedagogy, but also in ethically wondering about the relational, pedagogical, and ontological conditions that characterize our interactions with young learners. In ethically wondering about decisions made within our own unfolding pedagogical interactions, our work attends to the social dialectic and semiotic grounds through which interactions emerge (Bakhtin 1981, 1986; Erickson, 2004; Gee, 2014; Goodwin, 2017; Pierce, 1935; Stevens, 2010) through an approach to *ethical pedagogical decision-making* we've come to know as *wondering with*. Foundationally, we understand the educative potentialities of this orientation towards wondering as always taking place *with* others. Even when one is wondering "internally" or seemingly "independently", we locate our work within scholarship in social and cultural activity that recognizing how the conceptual and material ecologies (ideological and placed contexts) that activities emerge from exist first through social activities, interpersonal relationships, and discursive interactions (Vygotsky, 1978; Cole, 1996; Engeström, 1990, 2011; Gutiérrez et al., 1999; Vygotsky 1978). As such, we recognize wondering and related speculative experiences as primarily social phenomena.

Recognizing the ontological primacy of social sensemaking, 'Wondering with' emerged from our work as a dialogic and relational orientation towards both the design of educational activities (Gutiérrez & Vossoughi 2010) and the micro-interactional exchanges that constitute them (Bakhtin 1981, 1986; Erickson 2006; Goodwin 2017). In characterizing our approach to 'wondering with', we draw on John Shotter's conception of "systemic" or *withness* thinking (2005, 2006, 2012, 2015) as an opening towards living out more ethical relations where dignity and educational rights are affirmed through everyday interactions (Espinoza & Vossoughi,

2014). Situated as we are in classroom contexts, we work towards developing the *interpretive power* (Rosebery et al., 2016) that educators rely on to notice and notice and respond to student sensemaking in expansive (Engeström, 2015) and dignity conferring (Espinoza, 2009) ways. Said differently, we intentionally design towards supporting complex onto-epistemic navigations that create possibilities for living and learning beyond Eurocentric pedagogical norms ways of knowing and the harmful relational and disciplinary divides they reproduce (Rosebery et al, 2010; Warren, 2020; Vossoughi et al., 2021). It is with this focus that we take up withness as an interpretive lens to sharpen our engagement with pedagogical mediation throughout this section.

Through *withness,* Shotter addresses relational and orientational problems that implicate our spontaneous responses from within unfolding events as they "just happen". As a systemic perspective, withness supports forms of knowing and being grounded in an understanding of how we live and act as *participants* within unfolding social processes, thereby accounting for our ability to "affect the flow of processes from within our living involvement with them" (2006, p. 585). In contrast to "representational-responsive" understandings, Shotter argues that we arrive at forms of knowledge that are *relationally responsive* when we take up inquiry from within the participatory moment-to-moment of our living relationships from the assumption that we exist as a part of complex and ever-unfolding systems. Like our approach to wonder, withness thinking is also driven by noticings, albeit of a somewhat different sort. Specifically, withness directs focus towards our own attentional habits and how we are disposed to spontaneously respond to others (Shotter, 2012). From within flows of interaction, these noticings represent openings where the next action taken may be different from the usual, thus calling "for reversals in our taken for granted ways of thinking about how inquiries might best be conducted" (Shotter, 2012, p. 4). From within unfolding pedagogical interactions, these openings invite us to consider different

ways of interpreting and responding to student sensemaking and reflect on their mediational role in processes of inquiry.

In part, we mobilize withness through designing opportunities for educators to notice and wonder about how they are interpreting learner sensemaking, including how their in-the-moment pedagogical mediation can produce, affirm, or negate the dignity and educational rights of others (Espinoza, 2009; Espinoza & Vossoughi, 2014). Embodying intentionally expansive orientations towards pedagogical mediation, our design materials strive towards attuning the attention of educators to notice how their mediational strategies as educators are centrally consequential in expanding (or narrowing) opportunities for learning. How an educator models and frames engagement within learning activities communicates more than practical information (e.g., activity procedure, scope, and sequence) but also a host of embodied and affective messaging. Through a relational responsive lens, how educators approach framing and mediation of learning activities in moment-to-moment ways can also reflect limited understandings of particular children or communities and connection to family knowledges. From this, it is our stance that pedagogical mediation should aim towards expanding possible relations between educators, learners, and subject matter through communicating belonging, assumptions of learner agency, and an authentic uptake of student ideas.

Located within the emergent and unfolding flows of discursive activity that characterize social learning, this implicates the pedagogical decisions and micro-interactional moves that cultivate the mind, humanity, and potential of others through meaningful participation, or our "unambiguously effective involvement in socially vital activities structured by dialogic social relations" (Espinoza et al., 2020, p. 2). In parallel with dimensions of participatory design work such as role porosity and critical historicity (Bang & Vossoughi, 2016) 'wondering with' orients

educators towards considering how we can create and sustain more just relational dynamics and forms of sensemaking that desettle normative relations between adult educators and young learners (Bang et al. 2012). Implying important shifts in educator identity, 'wondering with' contributes towards cultivating educators' awareness of the responsibilities they have to distribute facilitative power in ways that recognize *all* participants as teachers and learners and how to design for their authentic and meaningful participation within unfolding activities.

In this sense, authentic and meaningful participation requires *sharing epistemic agency* and *authority* (Damşa & Andriessen, 2012; Damşa et al., 2010; Stroupe 2014; Scardamalia 2002, Heritage & Raymond, 2005) and developing educator's interpretive power (Rosebery et al., 2016) to create conditions of design and interactions where other participants can and do guide paths of inquiry. At this level, the work of refiguring powered relations between educators and learners necessarily involves entrusting and supporting youth to meaningfully co-design their own learning trajectories. We see this stance as offering powerful ways to disrupt dominant approaches that routinely position children as receivers of facts rather than co-creators of knowledge through pedagogical mediations that create openings for more ethical futures and cultivating dignified relations that position youth as historical actors in the here and now (Gutiérrez & Jurow, 2016; Gutiérrez et al., 2019; Espinoza & Vossoughi 2014; Espinoza et al., 2020). In wondering *with* youth, the work of participatory co-design is expanded to include the agentic designs of our youngest participants within the unfolding configuration of the activity itself (Roehl, 2012). That is, the co-design of instruction happens, emerges, and is mediated within moment-to-moment interactions. For us, this stance is central to work that reaches beyond assumptions that children's activity is primarily a practice for some future life, and toward viewing it as constituting life in-and-of-itself within ever-unfolding interactions of the present

moment (Rogoff, 2003; Warren et al., 2020).

We draw on work in *interpretive power* (Rosebery et al., 2016) that places the onus on educators developing the dispositions and habits of mind that enable seeing the intellectual generativity of students' sensemaking (Bang et al, 2017). Starting from the assumption that students are already engaged in sophisticated sensemaking, 'wondering *with'* recognizes learner discourse as emergent sensemaking-in-process which presents opportunities to co-construct and navigate meaning through group inquiry. This orientation to learner sensemaking stands as a corrective to normative logics which routinely interpret discursive contributions of young people (particularly those who come from non-dominant perspectives) are positioned as incorrect, confused, or off-topic (Rosebery et al., 2016). Interpretive power is central to how we understand and position learners' wonderings in ways that desettle long-standing deficit views of children's sensemaking capabilities and the hierarchies they stem from (Bang et al., 2013; Murris, 2013). In understanding learners as engaging from a variety of explanatory models, we understand the interpretive role of educators entangled with to responsibility of practicing "actively responsive understanding" (Bakhtin, 1986) and "relationally-responsive" understandings (Shotter, 2015) in ways that both foster a sense of belonging and create new opportunities for meaningful learning (Bang et al., 2017) through cultivating connections to the cultures and identities of youth.

With such a view, it is the ethical obligation of educators to develop interpretive power, such that their spontaneous interactions with learners confer dignity through a poised and resourceful balance between structure and improvisation (Sawyer, 2011). That is, educators should be responsible for (and supported in) developing their intuitive modes of sensemaking such that they can better recognize the children's capabilities for complex sensemaking and pedagogically respond in ways that cultivate expansive possibilities for wondering and

worldmaking. This means widening the limits of what is considered possible (or acceptable) ways of talking, knowing, and being in sensemaking activities, moving towards a view of learning as a "fundamentally heterogeneous, creative, and multivoiced human activity" (Rosebery et al, 2015, p. 2; see also Warren et al., 2020). This is particularly important when considering our youngest learners, who may more often explain phenomena through constructing hybridized narratives that can be misinterpreted as imaginative digressions.

This orientation encourages educators to continually reflect on and continually develop the intuitive awarenesses they rely upon in the spontaneous and unplanned micro-moments of interaction. Our design supports educators in shifting their pedagogical practice towards greater interpretive power through ongoing learning, applied practice, and reflection on their own pedagogical designs and interactions.

Implications for Design

Following Shotter, we elevate how pedagogical actions are often guided by spontaneous in-the-moment understandings; or "*subsidiary awareness* of certain felt experiences as they occur to us from within our engaged involvement in a particular unfolding process" (2006, p. 586). Indeed, when it comes to taking action and making concrete decisions from within unfolding activities, *intuitive knowledge* guides much how and what we do in relating ourselves to our surroundings. In our approach to design from ethical wondering, we build with Sawyer's (2011) framework of *structure* and *improvisation* to ground design of activities from an understanding of the spontaneous, intuitive, and improvisational nature of social activity (Bourdieu 1977; de Certeau, 1984; Erickson, 2004; Sawyer, 2001).

Resonant with withness and interpretive power, a focus on structure and improvisation focuses on developing educator's abilities to engage in creative and disciplined improvisations

that pedagogically "go with the flow" as noticings and wonderings emerge within unfolding activity (Sawyer, 2011), encouraging creative pedagogical emergence that might better facilitate divergent thinking, critical competence, possibility thinking, and reflective proactivity (Sawyer, 2011 for a deeper uptake of structure and improvisation in creative education). Here, we see Sawyer's uptake of *disciplined improvisation* (2011) as akin to what Shotter (2012) calls "*poised resourcefulness*" insofar as it recognizes how our focal awareness is not primarily responsible for guiding actions in spontaneous moment-to-moment exchanges.

We are applying these perspectives in our socio-ecological-focused learning context through the design of *flexible activity structures* to guide broader arcs of activity, alongside *back-pocket practices* that assist educators in supporting learner sensemaking within activities. It is our contention that routine engagement within the Learning in Places material ecosystem (i.e., using designed materials: project rhizome, educator frameworks, field-based seasonal storyline learning engagements, back pocket practices), educators can develop their capacities to notice and respond to student sensemaking in expansive and dignity conferring ways. With regular practice we intend for supports such as these to come to guide pedagogical decision-making and mediation of activities in more and more intuitive ways. Over time, these tools are designed to develop educator's interpretive awareness such that they become intuitive and spontaneous ways of seeing and responding to student sensemaking – developing enduring dispositions towards interpreting and responding to learner sensemaking in ways that expand opportunities for complex and emergent learning.

As empirical instantiations of the framework described thus far, we offer a brief summary of select *Learning Engagements* from the classroom and family storylines that take up ethical wondering and decision-making, alongside examples of designed Back-pocket practices to

reflect on how they support ethical wondering in the ways we describe throughout this paper.

Learning Engagements. In part, we attend to this through designing *Learning Engagements* (LE). As introduced in Chapter 1, the Field-Based Seasonal Storyline is made up of 10 Learning Engagements (LEs) that represent a semi-linear, place-emergent trajectory of activity grounded in histories of places, phenology, and the wonderings of learners and their families. Designed to be responsive to variations across geographic and ecological contexts, Learning Engagements are flexible activity structures each containing several sub-LEs designed to structure individual activities with varying complementary foci. For example, with our Classroom Storyline, LE 4 consists of 3 distinct sub–Learning Engagements (4.1-4.3), structuring engagement with *Should-We Questions*. Each sub-LE contains an activity overview, connections to the *Rhizome*, and specific learning goals alongside clear alignment with NGSS crosscutting concepts, science practices, and disciplinary core ideas. To further support educators in imagining possible trajectories of LE implementation, we include detailed lesson plans, suggested preparation, and potential instructional sequences.

Coupled with *back-pocket* practices for disciplined improvisation and educational mediation within activities, these materials aim to cultivate educators' interpretive power and educate the subsidiary awareness's that inform our spontaneous responses to learner noticings, wonderings, and places.

Back-Pocket Practices & Sensemaking Supports. Taking up Sawyer's comparisons to jazz, improvisation does not mean "anything goes". Rather, disciplined improvisation requires a great deal of training and practice, including knowledge of "standard compositions" (2011). Taking the musical metaphor seriously, scaffolding structures in our design work act as "lead sheets" that guide educators in developing "licks" or discursive prompts and pedagogical

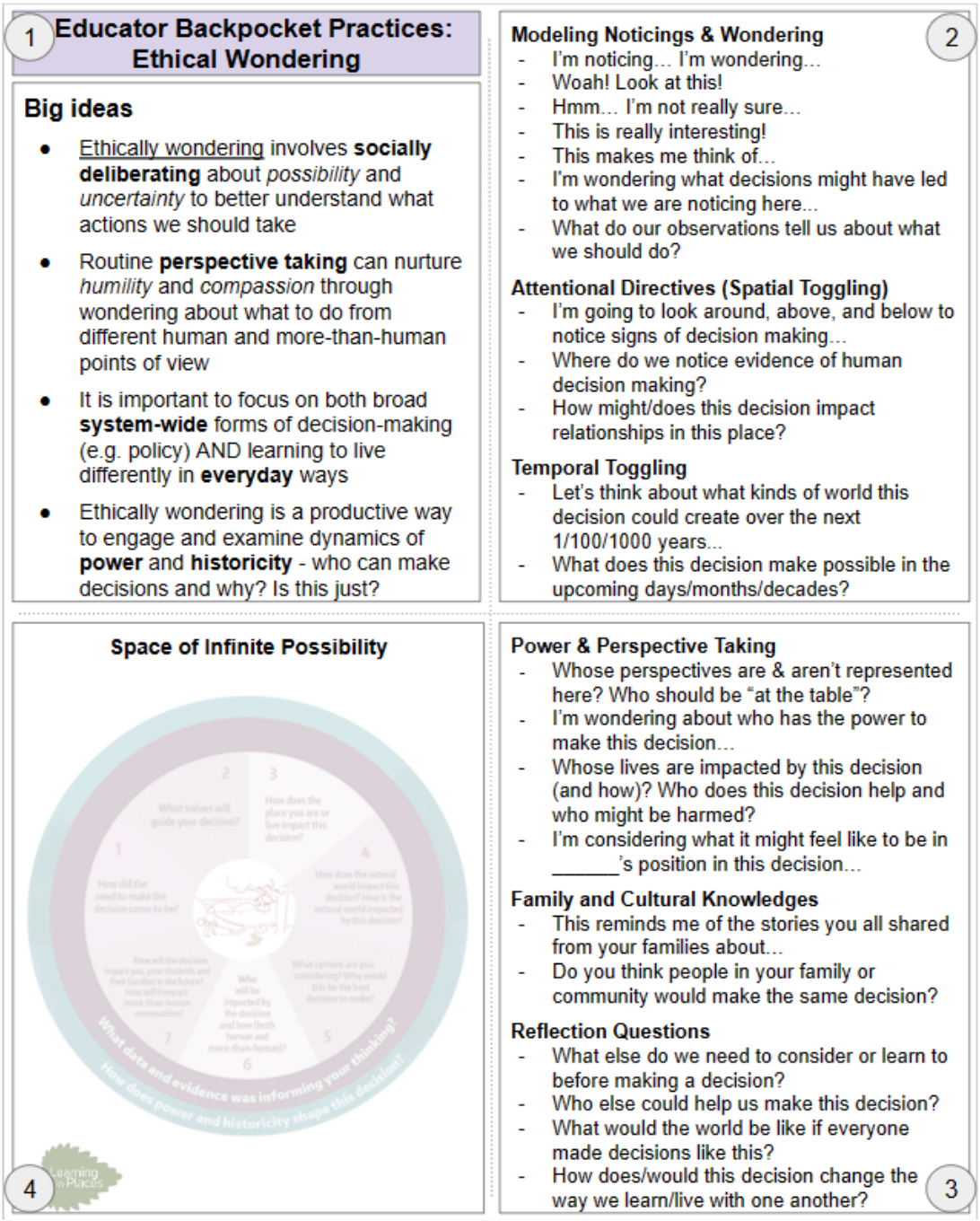
strategies that can be skillfully drawn upon to guide flows of noticing, wondering, and deliberating.

Concretely, we operationalize our commitments to education dignity through withness sensemaking, interpretive power, and disciplined improvisation by designing materials for use in the field. Designed in quadrants to be easily foldable, these tools are intended to be literally kept in a pocket for quick access in the field to support sensemaking within moment-to-moment interactions. With intentional routine practice, prompts on these sheets become more second nature as they facilitate educators experiencing new ways of relating to student sensemaking; the tools as designed to be internalized through use such that they slowly come to guide interactions in more spontaneous and habitual ways.

In this sense, disciplined improvisation is also relationally responsive (Shotter, 2006); it requires being present and actively making sense of the world with others. Like improvisation, disciplined mediation requires being a good listener to learn how and when to contribute in ways that harmonize with, extend, and inform learner meaning making. Our tools aim at developing skills that enable educators to notice present to student sensemaking in ways that enable co-operative sensemaking through disciplined prompts and questions. In part, we understand the shift we after here as an opening to move beyond binaries of adult vs child led learning, and towards understanding pedagogical practices as dynamic processes of joint, intergenerational activity (Vossoughi et al., 2021). As an example, a back pocket guide focused specifically on supporting ethical wondering (figure 2.3).

Figure 2.3

Back-Pocket Practices for Ethical Wondering (front/back)



Quadrant 1 reminds educators of connections to big ideas about ethical wondering – connected to frameworks such as Wonderings and Should-We Questions, Ethical Deliberation Decision-making and Power and Historicity. Building with these core ideas, quadrants 2 and 3 provide a wide range of possible prompts organized under broad categories. While many prompts are questions, we also include other approaches for educators to model the experience of

wonder, awe, and curiosity. These include exclamations, making connections, perspective taking, toggling across scales, and expressing uncertainty. While we have been intentional in our wording throughout these back-pocket practice supports, we encourage educators to take them up as practice-sharpening tools that resource disciplined interpretive fodder to be molded and deployed in response to emergent activity.

Finally, quadrant 4, particular to the focus of this tool, provides educators with a space to be used for whatever they need. In practice, this may be a space for recording emergent noticings and wondering or holding thoughts that emerge over the course of the walk. Within a tool designed to support engagement with expansive possibilities, including a space to hold such possibilities is understood as a proleptic approach to materials design that reinforces our grounding ethics emergence and pedagogical imagining. A faded version of the Should-We question graphic is included in this space to cue connections to framework ideas and questions. This also serves as a reminder that the back side of this document includes a blank copy of the same decision-making wheel graphic (appendix 2a) that can be used to further support engagement with ethical wondering within unfolding activity.

Implications for Practice

Our approach to 'wondering with' suggests fundamental shifts in how educators identify with their role, as well as how they practice their educative identities within and across pedagogical interactions with learners. In recognizing learning as an emergent social process involving the genuine and varying contributions of diverse participants, there can be movement away from inauthentic, unjust, outcome-based learning goals that center linearity, predictability, correct answers. In its place, our designed materials cultivate what we see as a necessary refiguration of the role and practice of educator as one role responsible for guiding and nurturing

processes noticing, wondering, and ethical sensemaking. Rather than a 'sage on the stage' leading learners through predetermined curricular content, *wondering with* positions educators as 'guides on the side' – co-operative collaborators investigating emergent phenomena, questions, and relationships in particular places and contexts. Supporting educators in coming to understand the consequentiality of pedagogical mediation in constructing and reconstructing educational rights and dignity, which are produced, affirmed and negated through everyday interactions (Espinoza & Vossoughi, 2014; see also Espinoza et al., 2020)

In cultivating such reflective awareness through routine engagement with designed sensemaking supports, our work develops educators' interpretive power these by increasing educator's capacities in ethically noticing and wondering about their own pedagogical decision-making in ways that open opportunities to enact more just and participatory educational futures in the everyday. Cultivating the relationally responsive pedagogical ethic we aim at here can be challenging, as it requires that educators relate to learners in ways above and beyond what is normed, supported, or even commonly expected in many systems of education today. Explicitly, this represents is a paradigmatic shift from many approaches that maintain the centrality of an authoritative teacher who is primarily responsible for delivery of linear curriculum taking up student wonderings either in passing or only insofar as they lead back to inflexible and pre-planned pedagogical pathways, divesting youth of educational dignity and opportunities to experience awe in the process.

Through instantiating the axiological commitments we have designed for and from within everyday ontologies of interaction with youth and learners, wondering *with* develops educator interpretive power in ways that offer possibilities to remediate such unjust powered relation between adult educators and youth learners through enacting more equitable and healthful forms

of living and learning within and across everyday activities. More simply, it involves a shift towards supporting educators in understanding their broader pedagogical as connected to expansive forms of learning and living well with youth through modeling genuine interest and positive affect about their ongoing participation in educative pursuits. Bang and colleagues share three principles from which interpretive power may be cultivated: noticing sense-making repertoire, supporting sensemaking, and engaging in diverse sensemaking (2017). As Bang and colleagues elevate "The more you show genuine interest in intellectual and scientific interest in student's sensemaking, the more you expand the space of possible relations among you, your students, and science" (2017, p. 34). Cultivating dispositions towards micro-interactional mediation and pedagogical decision-making through an intentional design for disciplined improvisation with people, place, and more than humans is thus a core facet of our work within Learning in Places.

In the next section, we expand on this uptake of wondering with to also include how educators orient towards facilitating learning at the nature-culture border. In parallel to our emphasis on the agency and dignity of young learners, we work to extend this uptake of shared agency, interpretive power and mediational capacity *with* places as well as the more-than-human beings that we share them with – or the final dimension that bring us to the full formulation of ethical wondering with people, places, and more-than-humans

Disciplinary Contexts: Socio-ecological Sensemaking through Ethical Wondering With Peoples, Places, and More-Than-Humans.

Having traced our approach to 'ethical wondering' and 'wondering with', we turn now to the third major piece of our framework: the *context* in which these ideas are applied. Recognizing how the material, interactional, and ideological landscape of a given context largely

determines how and what one is wondering at, about, and/or with, this section details how the conceptual and designed ecology of the Learning in Places project "prepares the ground" for particular forms of noticing and wondering. Specifically, we are concerned with the design of learning activities and approaches to pedagogical mediation that support ethical *socio-ecological* sensemaking. Through iterative processes of co-design, this focus led to the emergence of a form of 'ethical wondering with' that critically engages nature-culture relations – what we have been referring to as *ethical wondering with people, places, and more-than-humans.*

In designing an ecology of learning materials to focus ethical wondering specifically on socio-ecological contexts, we extend the interactional commitments of 'wondering with' to places and the more-than-human worlds through designs that recognize the dignity of places and more-than-human beings. That is, the assumption that places and more-than-human beings themselves also act as agentic facilitators within field-based activities is woven throughout our design materials in ways that scaffold routine interactional instantiations of reciprocal nature-culture relations. In doing so, we conceive of *ethical wondering with people, places, and more-than-humans* as a desettling pedagogy that can expand normative powered hierarchies among places, youth, more-than-humans, educators, and families through routinely positioning out human selves as placed participants within the rest of the natural world. Within our ecosystems of design and practice, this requires refusing anthropocentric orientations through recognizing lands, waters, and more-than-human beings as active partners within inquiry who can and do share important teachings about the world and our place within it.

Through years of iterative design with people, places, and more-than-humans, 5 key characteristics and commitments have emerged from our work:

1. Reciprocal and non-hierarchical stances towards *nature-culture relations* -

positioning humans as *a part of* the natural world.

2. Recognition of more-than-human agency, dignity, and personhood.
3. Designing *with* places through critical engagement with *histories of places* and *place-designing*.
4. Foregrounding longer timescales of inquiry and through focus on *seasonal change* and *phenological rhythms*.
5. Approaching learning activities through pedagogies of walking, place-based education, and field-based observation.

This section elevates concrete examples of how these 5 foci show up in our ecosystem of designed activity materials and supports.

Nature-Culture Relations

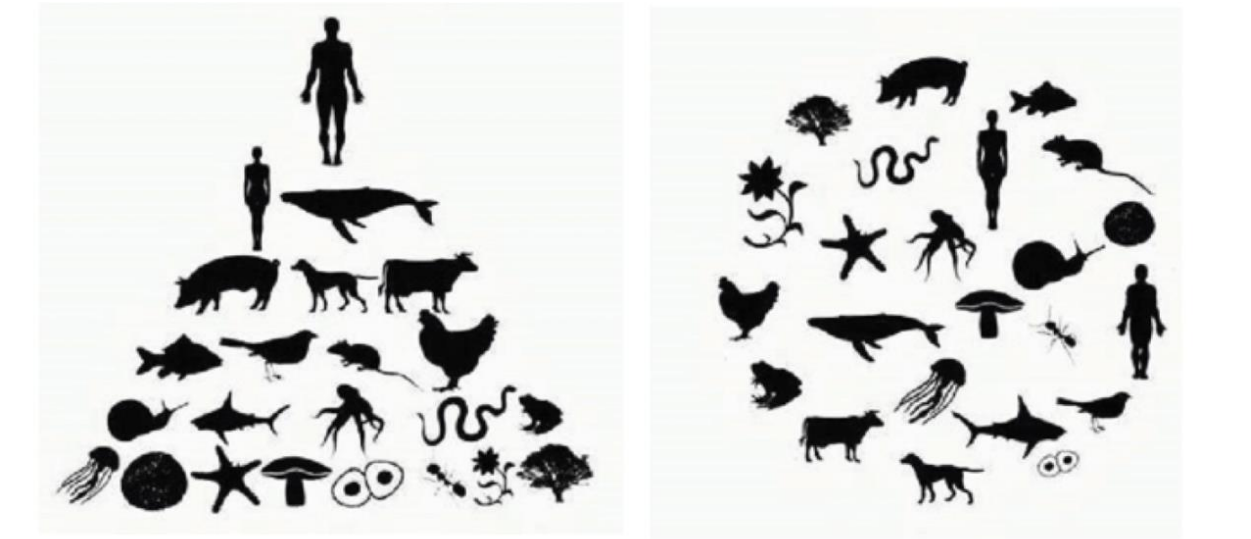
We take up nature-culture relations as a linked construct that describes how humans are positioned respective the rest of the natural world (Learning in Places Collaborative, 2020c). As depicted in Figure 2.4, conceptual models can tend towards some degree of *a part of* and/or *apart from* orientations (adapted from Lehmann, 2010). The left side depicts a separate and unequal arrangement where the (male) human is positioned as separated from, and hierarchically superior to, other living beings: a nature-culture *divide*. Positioning humans as more important than the rest of the natural world, models of division reinforce anthropocentric forms of sensemaking that lack capacity to consider complex system relations between humans and the more-than-human world. These uncritical perspectives can then be mobilized to support decision-making processes that position the natural world as simply inanimate economic resources for the fulfillment of human desire (profit and consumption).

In contrast, the right side depicts a model where humans are positioned as intertwined

with other living beings through complex and mutually constituted systemic relations, what we refer to as a *complementary* nature-culture orientation (Montaño Nolan, in accepted; Bang et al., in prep). Such an orientation facilitates the extension of withness beyond human interaction, as taking a *systemic* approach towards design cultivates recognition of the deeply participatory relationship between natural and cultural worlds. As when one is systemically *with*, "the thinking is self-reflexively *a part of* the systems and takes the *perspective* of a participant or component of the system" (Shotter 2012, p. 3, my emphasis). Towards developing such complementary models, activities in Learning in Places are inextricable from routine outdoor activity. This is a fundamental principle designed to expand possibilities for being and feeling like a part of the natural world; the importance of placing learners within an ongoing nexus of socio-ecological relations themselves to facilitate complex socio-ecological sensemaking cannot be overstated in our work.

Figure 2.4

Core Cognitive Models of Human Relationships with the Natural World



In context of learning, how we construct the relationships between humans and the rest of the natural world within unfolding interactions reflects epistemic, ontological, and axiological orientations towards scientific practices and their role in socio-ecological decision-making. Our materials aim at reimagining and remaking relations among nature and culture, school and family, and between self, other, and land constituted as inherently interdependent systems. From such relational ways of knowing (e.g., Bang, 2015; Cajete, 1999a; Deloria, 1999; Kawagley, 2006; Pugh et al. 2019), our design attends to nature-culture relations through learning activities that support opportunities for youth to develop a sense of their own position within complex socio-ecological systems. Through disciplined and ethical mediation, we hope to engage educators and youth in nurturing a sense of care, awe, and reciprocity with the rest of the natural world through centering experiences of wonder and ethical deliberation.

Two *Learning Frameworks* support the design and implementation of learning activities from such complementary understandings of complex socio-ecological systems.

In the "Relationships in Socio-Ecological Systems" framework (Learning in Places Collaborative, 2020d) we synthesize key ideas around the interdependence of socio-ecological systems. These includes the "quality of social and ecological relationships that expert scientists, policymakers, and communities think about" as well as "the base relationships of species and kinds that undergird interactions in a system". Drawing from our Rhizome, the framework aims at supporting the development of relational habits of mind through routinely sensemaking about interdependent relationships in ways that "support educators, students, and their families develop a language for attending to powered and historicized relationships at the intersections of social and ecological worlds" (framework, p.1; see also appendix 2b).

Complementing this framework is the "Complex Socio-ecological Systems" Framework

(Learning in Places Collaborative, 2020e). Positioning the understanding of how social and ecological systems interact as increasingly important in our present moment, this framework synthesizes key features of complex socio-ecological systems from research literature into more easily digestible forms. A primary role of this framework is in summarizing the "6 Dimensions of Socio-Ecological Thinking" that we connect to in various intentional ways across the FBSS (see figure 2.5). (Species, Kinds, & Behaviors; Relationships; Places, Lands, and Waters; Thinking Across Scales (time, space, perspective); and Human Decision-Making; see also appendix 2c for an example of educator-supporting design from LE 2.3: Introduction to the 6 Socio-ecological Dimensions). Providing more resources to support sensemaking about socio-ecological systems, this framework also introduces different forms of reasoning that are used in sensemaking about complexity, including relational, analogic, perspectival, toggling, abductive, and reasoning with uncertainties (i.e., appendix 2d).

Figure 2.5

Six Dimensions of Socio-ecological Sensemaking

Educators, learners, and families are supported in attending to each of these six dimensions across wondering walks. Representing empirical instantiations of our design towards complementary nature-culture relations, we elevate material from both classroom and family wondering walks designed to support noticing and wondering about nature-culture relationships.

At the level of group activity, *Learning Engagements* also support sensemaking about complex socio-ecological relationships. Following activities introducing the 6 socio-ecological dimensions in LE 2.3, the instructional sequence for LE 2.4 is explicitly structured around noticing and wondering about *relationships*. In these materials, students are encouraged to notice how their own relationships "help us understand the many ways in which everything is connected" (2.4 family walk, appendix 2e). To these ends, the front matter emphasizes "beginning with the premise that humans as part of the natural world, not separate from it" (p. 1), encouraging more than human perspective (beyond just their uses to humans) is positioned as central to equity efforts (p. 2), and the instructional sequence supports relational wondering through reminding educators the many ways in which complementary nature-culture relations can be discursively elevated within activities. Reflecting these approaches in modes of documenting field-based experiences, appendix 2e also includes examples of tools for learning designed to facilitate relational sensemaking through prompting learners and their families to represent and reflect on the phenomena they notice through relational means.

More-than-Human Agency

Deepening reflection on how we orient towards the remediation of anthropocentric nature-culture relations through materials that support ethical wondering with people, places, and more-than-humans, this section highlights how we have designed from commitments to recognize the agency, dignity, and personhood of more-than-human beings (Bang & Marin,

2015; McDaid Barry et al., 2023).

In doing so, this section signals how our approach to nature culture-relations goes deeper than just starting design from the assumption that humans exist as a part of the natural world. As such, we work towards deeper forms of perspective taking that normalize recognition of how more-than-human beings exercise *agentic capacities* (ojalehto, et al; 2017; Bang, Marin & Medin, 2018; Ryan, 2012; Scully, 2018) and have *internal states* that are deeply comparable to our own (Franks & Diament, 2005; Olson et al., 2014; Weber & Johnson, 2009). Alongside conceptually related projects such as the Indigenous STEAM program (Barajas-López & Bang, 2018; Pugh et al., 2019; Pugh, 2019; McDaid Barry et al., 2023; Bruce & Bang, in prep), we work towards approaches to design that recognize more-than-human beings as deeply dialogical partners in life and learning possessing *addressivity* and *answerability* (Bakhtin, 1986; McDaid Barry et al., 2023). That is, more-than-human are also subjects with whom we can dialogue with and expect meaningful responses from.

With this orientation towards non-hierarchical relationships with the natural world, we recognize the dignity, agency, and personhood of more-than-human beings through designing learning materials from the assumption the more-than-human beings can and do exercise agency in ways that facilitate complex and relational forms of learning (Kohn, 2013 Cajete, 1999b; Simpson, 2014; Deloria, 1999; Kawagley, 2006). Such a relational orientation can help educators and learners in coming to understand natural phenomena and kinds as constituted primarily through their relations and agentic activities. This understanding guides how we approach pedagogical designs that communicate how humans share this world with other more-than-human beings whose lives are no more intrinsically valuable than our own. Stemming from this recognition, the material and interactional ecosystem of Learning in Places represents an

unfolding response to the question: “How is sensemaking different when you are wondering with a person, rather than about an object?”

A fragment of this answer is contained within the examples below from our Classroom Storylines which display how we have designed towards more ethical forms of noticing and wondering within the more-than-human world. Appendix 2f shows the instructional sequence and key tools used in Learning Engagement 2.1, “Preparing for Outdoor Learning”. Within the broader storyline of activity, LE 2.1 is the launch of the second series of Learning Engagements, and the first *open* wondering walks.

Launching wondering walks through a scaffolded comparison between what learners and their families need to live healthy lives and what their more-than-human neighbors need to live healthy lives is consequential in communicating the fundamental comparability of the two groups. Necessary for wondering *with* while moving through outdoor places and encountering more-than-human life, it is by design that we scaffold learner attention towards the fundamental relationality of human and more-than-human beings in terms of food, air, water, shelter, and soil. Such a comparison communicates that we share similar sets of fundamental needs required for our well-being, thereby elevating the common ontological grounds necessary for both human and more-than-humans to live healthy lives.

After considering needs, the third student tool in this LE offers opportunities to consider how learners can show respect and care for the more than human neighbors they will encounter within wondering walks. This links the theme of common needs directly to how immediate actions in local places should be guided by deference and respect towards the rest of the natural world. Also by design is the placement of these themes and activities at the beginning (launch) of LE 2 further underscoring the centrality of more-than-human agency as participants prepare for

their first open wondering walks.

Guiding this activity and relational foci, our suggested instructional sequence represents one way that we have designed towards ethical pedagogical mediation by providing a flexible overview of what the activity could look like. The possible prompts, explanations, and activities contained within this instructional sequence reinforces the centrality of learner noticings and wonderings, and pop-out bubbles on the side elevate the rationale behind our suggestions through connections to the project Rhizome. For example, the green bubbles highlight connections to complex socio-ecological systems, such as "Seeing similarities between the needs of their families and the needs of more- than-humans is a way for students to see themselves as a part of socio-ecological systems." In this way, LE 2.1 (and indeed all LEs) further support ethical wondering with people, places, and more-than-humans by providing educators with contextually embedded "just-in-time" resources for disciplined improvisation within structures to direct and organize activity.

The implication here is that by routinely walking in places with particular attentional scaffolds, we can come to see and understand the communicative capacities of places and the more-than-human beings that inhabit them. Moving through places while closely noticing and expansively wondering is therefore a means of addressing places and more-than-human beings directly. In this way, our place-based tools anticipate that places can and do respond to our wonderings as walks become routine and extended over seasonal timescales. Our tools can be interpreted as scaffolding field-based skills that enable educators and learners to converse with places; as structures for learning that help people "see" the dialogic contributions of more-than-human beings by positioning the natural world as teacher and active partner in conversation and inquiry.

At a finer scale of activity, we intend for the assemblage of educative materials we provide to support recognition of more-than-human dignity within moment-to-moment pedagogical interaction through discursive moves that communicate the agency of more-than-human beings. One way we support this is through intentionally referring to plants, animals, and other-than-human kinds as "more-than-humans". In using "more-than-human" we connect with decolonizing methods and Indigenous ethics of care and responsibility towards an inclusive definition of being alive where everything is viewed as having energy and its own unique intelligence and creative process (Cajete, 1994; Kimmerer, 2013; see also Smith, 2012). A form of "border thinking" (Mignolo 2012), we position small discursive moves like this as instantiating our intellectual and political commitment to remediating the epistemic and ontological violence of colonialism. Instantiating small and routine modes of relating to the more-than-human world can rupture normative Western logics that sever human beings from the rest of the living world, and non-Western peoples from humanity itself (Mignolo 2009; Wynter 2003).

Concretized in the tools in appendix 2f (i.e., "more-than-human neighbors"), this underscores our orientation towards other natural kinds as multispecies kin and relatives. We aim for such understandings to manifest in discursive moves across pedagogical interactions, such that plants, animals, and other natural kinds are no longer understood as objects, and towards language practices that reflect the agency, dignity, and personhood of more-than-human beings (e.g., referring to "them" rather than "it"). Working deeply from paradigms that position humans as *a part of* the rest of the natural world, these materials support sensemaking that foreground the fundamental ontogenetic similarities between human and more-than-human beings. Resonating with the uptake in this section, Chapter 3 further explores the impact of our design work in

collapsing nature-culture hierarchies within unfolding micro-moments of pedagogical mediation.

Designing With and In Places through Histories of Places

A third major component of ethical wondering with people, places, and more-than-humans is ongoing engagement with *Histories of Places* and *Place Designing*. We take up "place" in reference to both geographic locations, as well as communities lived experiences with the natural world. Just as different communities of human learners will produce different engage of inquiry, we take seriously how different places themselves facilitate varying forms of noticing, wondering, and deliberation (Simpson, 2014; Deloria & Wildcat, 2001). While "place" necessarily varies across disciplinary, geographic, and experiential contexts, in our socio-ecological context we understand place as "where and how culture and the environment are co-constructed" (Learning in Places Collaborative, 2022, p. 1). This is important because noticings and wondering are always contextualized in places, which are in turn shaped through interdependent and powered relations across local and global scales. So shaped by cultural histories, knowledges, and practices, places we assert that ethical wondering and decision-making are at least incomplete, and often harmful, if lacking consideration of how a place's history continues to impact both the present and future possibilities.

In doing so, we build with Massey's (2005) definition of social space—as the "simultaneity of stories-so-far" (p. 9) to also account for the richness of socio-ecological stories and depth of more-than-human sociality that outdoor places facilitate. More than simply a background upon which learning unfolds, through wondering with places our work intentionally positions lands themselves as dignified and deliberate pedagogical actors who actively facilitate particular ways of knowing and being (Deloria & Wildcat, 2001; Lees et al., 2021; Simpson, 2014). That is, places and the more-than-human beings that inhabit them spontaneously

coordinate attention and continually renewing contexts of investigation. Extending wondering *with* to people, places, and more-than-humans, this entails co-designing with lands themselves towards cultivating interpretive power of places and developing the pedagogical practices needed to share agency with more than just human participants. In Chapter 3 we describe more deeply how we understand places as presenting noticings, provoking wonderings, and teaching expansive ways of living in relation within the natural world.

Histories of Places. Alongside attention to the impact of changing seasonal rhythms (or *phenology*, covered in the next section), "Histories of Places" is fundamental to the launch of the Storyline and remains central to how we design to scaffold and mediate socio-ecological sensemaking. 'History of Places' refers to the multiple, layered, and ongoing socio-ecological trajectories, events, decisions, and future possibilities for particular places. From the very beginning of the FBSS, and rhizomatically throughout our larger ecosystem of design, our uptake of histories of places aims at cultivating the capacities required to toggle across historical scales of time, a central feature of reasoning about complex socio-ecological systems (Learning in Places Collaborative, 2020f).

A primary way that we have scaffolded engagement in this area is through our *Socio-Ecological Histories of Place Framework*. In addition to synthesizing key insights and providing a host of supplemental appendices, this framework introduces six distinct yet overlapping temporal frames used across our materials: hydrogeologic time; plant, animal, & soil time, Indigenous peoples' time; nation-state time, global time, and living ethical responsibilities and possibilities time (figure 2.6). Importantly we explicitly include Indigenous peoples time as a means of presencing the ongoingness of Native communities on their original lands. With resonance with our focus on ethical wondering and the navigation of future possibilities, we

conceive of histories of places as also forward reaching, as the decision made in the past impact our present moment, the possible futures we enacted necessarily emerge through the decisions we make in the present. As further evidence of our approach to iterative process of design, we are currently in the process of incorporating an additional dimension of time, celestial time, that has recently emerged from ongoing co-design.

Figure 2.6

Dimensions of Socio-Ecological Histories of Places

Socio-Ecological Histories of Places diagram, Learning in Places Collaborative 2022

Through Histories of Places, we act from a recognition of how learning about and holding many dimensions of place provides deep context and meaning for learners' noticings, wonderings, deliberations, and proposed decisions. At a finer grain size, appendix 2g shows other examples of how these ideas are woven through initial LE's to support learning about Histories of Places.

Place Designing. A necessary activity of preparing for field-based learning consists in educators spending time intentionally moving through particular outdoor places prior to bringing groups of learners outdoors. Through *place-designing* (see also Bang et al., 2014) educators construct their own relationships with places and become familiar with the features of a place in order to plan in advance on how to guide learning in that specific place. Fundamentally, this involves literally placing educators in immediate proximity to local lands, waters, and more than humans in routine and scaffolded ways to develop meaningful socio-ecological mobilities. As such, 'place designing' moves beyond "classroom-as-container" (Leander et al, 2010) models of education in ways that gradually sharpened educators' mediational skills and pedagogical decision-making with particular places.

A pedagogical focus on place designing is one way that we extend wondering with and recognition of agency, dignity, and personhood to the lands themselves in which activities literally take place. That is, designing and mediating learning activities from the assumption that places and lands themselves are active facilitators of sensemaking (Barnhardt & Kawagley, 2005; Brayboy & Castagno, 2008; Deloria, 1999; Deloria & Wildcat, 2001). Through place designing, educators can be more intentional about how they take up outdoor places as context for learning and living well within socio-ecological systems, a strong counter to prevalent orientations in that foreground the outdoors not just for play, recess, or personal pleasure.

Concretely, the practice of place designing often includes a complementary array of considerations: logistical planning such as what path to take; what learners might notice and wonder about; what phenomena and socio-ecological relationships learners might observe and how; what types of investigations learners could conduct to better understand the complexities of a place; and who might be a good resource to consult and why. Important for our uptake of field-based science learning, outdoor places do not exclusively mean large green spaces and annual vegetable gardens. As quoted from our supporting materials "Field-based learning in place can also happen in a neighborhood park, an alleyway, a forest, or the strip of grass between the curb and the sidewalk." As one project leader has been known to say, "This work began in the concrete alleyways of Chicago".

In addition to intentional planning time with places prior to group engagement, place designing also entails ongoing follow up research to deepen educators' ongoing understandings in locally specific ways. At a minimum, this should include: What peoples are native to this area and how has that relationship been shaped/continuing to be shaped by powered dynamics? What major historical events took place in and around this particular place and how have they impacted the socio-ecological ecosystem?) Within the Learning in Places material ecosystem, we have co-designed attentional scaffolds and observational tools and educator learning frameworks to support designing with places (see appendix 2h; see also figure 2.7 for a graphical representation of how these ideas are woven together).

Figure 2.7

Dimensions of Designing Learning In and With Outdoor Places

As an additional resource, we have developed the Co-Designing Places for Outdoor Learning Facilitation Guide that include 8 *Design Engagements* (DEs) that can be used to "inform collective decision-making for the design of a new outdoor learning site or the enhancement of an existing site" (Learning in Places Collaborative, 2021a, p. 5). Reflecting the rhizomatic domains present across our design materials, the focus of DEs consists of: histories of places; visions and values discussion; place mapping; rhizome mapping; site selection synthesis; designing your site; planning for installations; and sustainability, decision-making, and governance. While deeper engagement with these DEs is beyond the purview of this piece, suffice it to say that the extensive support for place designing throughout the FBSS is a testament to the centrality of this approach across our materials.

Seasonal Change and Phenological Rhythms

Designing *with*, described here as particular orientations and practices that support recognizing the agency and participative capacities of youth, places, and more-than-humans beings, rests on a foundation of learning activities intentionally designed across *seasonal timescales.* In contrast to approaches to science education that deploy predetermined curricular units across the span of days or sometimes weeks, the trajectories of investigative activities we have designed with and within socio-ecological systems are explicitly informed by, and facilitated through, attention to seasonal rhythms and relationships. Formalized through the study of phenology, or how certain biological events exist and change in complex relation to "nature's calendar" (USA NPN National Phenology Network, 2023) attention to seasonal shifts within complex socio-ecological systems is a key focus in launching activity within the FBSS.

Particularly relevant when considering how human-made climate change is altering a range of natural systems (IPCC, 2023), a focus on phenological change supports learners in understanding how species and kinds respond to changes in climate at different spatial and temporal scales. This area of focus is increasingly important to understand how the impacts of unprecedented and unpredictable changes in one rhythm (e.g., via climate change) can cause disruptions in another through "phenological asynchrony", "phenological cascades", and other complex socio-ecological feedback loops (Post, 2017). Connecting to the authentic uptake of learner noticings and wondering across longer scales of time, this focus also reflects alignment with expert practices in field ecology, chronobiology, and the impact of seasonal cues on individual changes and evolutionary selections (Chuine, 2010; Forrest & Miller-Rushing, 2010; Visser et al., 2010).

We ground our uptake of phenology in an understanding of how cultural communities

have made sense of – and exist in close relationship with – seasons and the earth's patterned rhythms since time immemorial. Situated within local places and communities, we argue that an intentional focus on seasonal change can better engage learners' cultural connections to seasons, giving educators the opportunity to scaffold noticings and wonderings involving the interplay of seasonal changes and life cycles in locally relevant ways. As such, we position phenology as a higher-order "meta-phenomena" through its ability to rhizomatically support robust and engaging socio-ecological investigations across seasonal learning engagements.

Concretely, we expect that it takes an entire season (2-4 months) for a learning community to move through any of the storylines we have developed. In school-based learning contexts, this results in multiple multi-month investigations across a typical school year, a sharp departure from typical science curricula where preplanned "units" of instruction typically last only for a couple hours or days at most. With this in mind, we have developed educator frameworks (figure 2.8), family tools, and observation protocols designed to support sensemaking in relation to seasonal change across our material ecosystem (see: appendix 2i). For example, LE 1.6 is designed to bridge home and school contexts by prompting reflection on why seasons might be important to families, while 1.7 focuses specifically on supporting sense-based observations and wondering to gather evidence about what season it is.

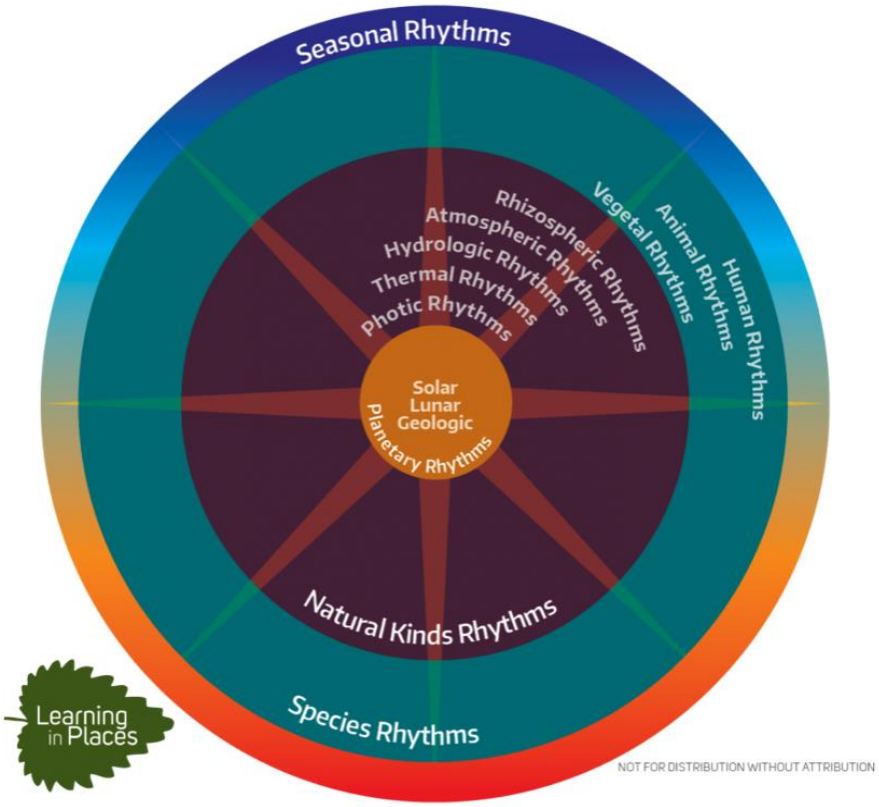
In the same fashion as previously described educator frameworks, we have designed a framework synthesizing the importance of phenology (Learning in Places Collaborative, 2020g). Within these, figure 2.8 depicts the "Phenology Wheel" a visual representation we have created to assist in sensemaking about seasonal rhythms in relation to species, natural kinds, and planetary rhythms. These tools and frameworks are designed to scaffold noticings and wonderings relative to seasonal phenomena, as well as assist educators in developing skills

needed to prompting connections to seasonal impacts in emergent discourse as a form of disciplined mediation).

These tools and frameworks are designed to scaffold noticings and wonderings relative to seasonal phenomena, as well as assist educators in developing skills needed to prompting connections to seasonal impacts in emergent discourse as a form of disciplined mediation (see Chapter 3 for an empirical example). Ultimately, we aim for the focus on seasonal shifts to contribute towards developing opportunities to experience the sense of wonder, awe, and curiosity that attends sensemaking about patterns and cycles of change over timescales within and beyond individual human lifetimes.

Figure 2.8

Wheel of Phenological Rhythms



Field-based Learning: Walking Pedagogies and Naturalistic Observations

Rounding out the select dimensions of ethical wondering with people, places, and more-than-humans highlighted in this piece is routine engagement in field-based learning. Despite its position as the final dimension detailed in this section, it is arguably the most central practice of our work. Spending routine scaffolded time in outdoor contexts holds the larger system of activity together and enables the complementary range of practices we have designed to support socio-ecological sensemaking. Recognizing how observations are the primary means through which data are collected in field-based science (Eberbach & Crowley, 2009, 2017; Smith & Reiser, 2005), our approach towards routine outdoor activities is central to developing epistemic processes central to scientific inquiry (e.g., identifying and naming kinds, generating explanations, finding and evaluating evidence to create a cohesive story about the perceptual field; see also Bang et al, 2015; Massey 2005; Marin 2013, 2020; Marin & Bang, 2018; Ingold 2001).

In our doing, our materials are designed in ways that orient learners and educators to the processes and practices underlying pedagogical activities rather than outcome. Cultivating presence to emplaced phenomena and relationships, the pedagogical significance of repeatedly walking and learning to "read" or "converse" with places and more-than-humans lends itself to the cultivation of awe as participants begin to locate themselves within complex webs of relation that become visible only through extended observation over seasonal timescales. Mirroring expert science practice, it is common for field-ecologists often spend days, months, or even years observing the same place in different seasonal conditions and over time. During these extended outdoor activities, learners repeatedly observe the structures, functions, & behaviors of places, species, & kinds in ways that support building personally meaningful relationships with local

places and kinds, a foundational dimension of complex socio-ecological sensemaking. Thus, we position moving through outdoor places while closely noticing and wondering as a means of being in dialogue with places and the more-than-human beings that call them home, a fundamental orientation we see as necessary to observing in increasingly complex ways over the course of the storyline.

The fundamental centrality of field-based learning is rhizomatically woven throughout every aspect of our materials. Far from exaggeration, literally every tool, framework, learning engagement, and pedagogical support in the Learning in Places material ecosystem is premised on spending routine time noticing and wondering outdoors with supporting foci. While indoor activities are still important and complementary components of learning activities, our materials work to decenter classroom-based activities as the default contexts for learning to routinely position humans outdoors. Rather than a primary focus on abstract, this literally places participants within the complex socio-ecological places and unfolding relationships we are aiming to understand.

Concretely, we have designed for at least 23 walks to be taken between educators, classes, and families across our storyline. Table 2.1 reports on each of these walks, including the Learning Engagement, walks title or focus, and recommended number of walks. These include place-designing walks taken by educators, school-based walks with varying foci, and family walks designed to bridge home and school sensemaking. While any walk can be taken more than once, for some walks it is necessary to engage in multiple walks with similar foci (for example collecting data at different times in LE 5 or conducting investigation walks in LE 7).

Table 2.1

Range of Walk-Based Engagements in the FBSS

LE	Walk Title / Focus	# of Walks
1.1	(Educator) Place Design Walk(s)	2-4
1.1	History of Places Walk	1
1.2	Family Histories of Places Walk	1
1.3	Sharing Places Walk	1
1.4	Family Learning Across Places Walk	1
1.7	Evidence of Seasons Walk	1
2.2	School Wondering Walk(s)	1-3
2.2	Family Wondering Walk(s)	1-2
2.3	5 Socio-ecological Dimensions Walk	1
2.3	Thinking Across Scales Family Walk	1
2.4	Relationships Wondering Walk	1
5.1a	Family Focused Wondering Walks	3
5.1b	Walk to Observe Focal "Should We" Phenomena	3
7.1	(Educator) Place Mapping Walk(s)	1-2
7.1b	School Field-Based Investigation Walk(s)	2-4
7.1d	Home Field-Based Investigation Walk(s)	2-3

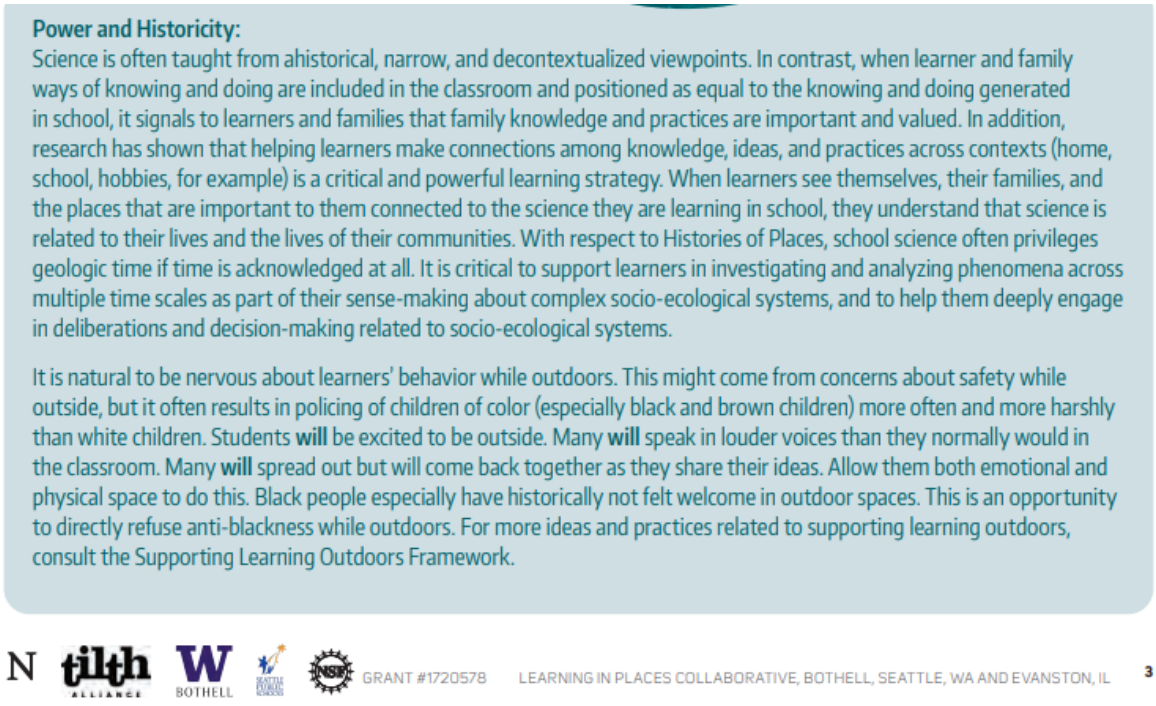
In related scholarship, members of the Learning in Places team have conducted more focused studies analyzing the relationships between school and home walks, noting shifts in nature-culture construals and movement away from human-centric sensemaking while outdoors (Montaño Nolan, 2020). Within school contexts, observational data provides rich resources that educators can use to elevate connection and build with student and family cultural experiences and wonderings. Building with this, empirical analysis of moment-to-moment noticing and wondering during wondering walks is further explored in Chapter 3. Chapter 4 then reviews data from a large sample of wondering walks that speaks to other important implications in terms of indoor/outdoor, as well as progression of walks over time and from open walks in LE 2 to more focused walks in LE 5

Throughout our materials we provide support for educators to reflect on how dimension of power and historicity are present within emergent sensemaking (Learning in Places Collaborative, 2021b). This includes attending to how historically contextualized power dynamics involving race, ethnicity, socio-economic status, and diverse cultural ways of knowing

are relevant while moving through and learning with outdoor places. Being explicit about how stereotypes, hegemonic norms, and cultural values can show up in learning activities is one means that we support educators in the reflective work necessary to enact dimensions of 'wondering with' with learners in outdoor places. Figure 2.9 shows an example of such supporting text within Learning Engagements.

Figure 2.9

Embedded Supports for Sensemaking about Power and Historicity



Through routinely wondering about possible decisions as places within an interdependent web of socio-ecological relationships, learners are afforded opportunities to ethically speculate in ways that require and reinforce scientific sensemaking. In this way, outdoor activities can support perspective taking across natural kinds and temporal scales, scaffolding learner sensemaking about how particular socio-ecological values and decisions may afford or constrain particular kinds of futurities.

Implications and Conclusions

Ultimately, we position design and practice from *ethical wondering with people, places, and more-than-humans* as a desettling pedagogy that can open new relationships of power, knowledge, and interaction beyond adult, human, and school supremacism.

However, as wonderful as wonder is, wonder alone is not enough to meaningfully shift teaching and learning. Wonder requires some narrative context, some social, emotional, and/or cognitive landscape on which to grow and propagate into particular kinds of questions. That is, how we frame and respond to wonder has implications for what kinds of attitudes, awareness, values, and commitments populate our educational contexts. The educational and moral potential of wonder is inextricably connected to the social, material, and ideological contexts in which such wonder is manifest (Schinkel, 2018). This is consistent with Bianchi's focus on activity, context, and response in *wonder-rich* science education (2013) where "rich" activities are characterized as involving multimodal hands-on engagement, social collaboration, and occurring in authentic science contexts (e.g., field-based learning) supported by high-quality responses that build from learner wondering by making thinking visible.

Through design, Learning in Places "prepare the ground" for ethical wondering with people, places, and more-than-humans by supporting educator learning through structures of activity that promote conditions for the emergence and sustenance of particular forms of sensemaking and pedagogical mediation over time. Sustenance of wonder is particularly important here as we work towards encouraging the development of enduring and dispositional forms of ethical wondering with people, places, and more-than-humans, not just on occasion, but as "woven in the texture of one's awareness of the world…as a permanent tone in the background, always ready to come to the fore" (Schinkel, 2018, p. 47). Providing rich context for

observation and speculation, our designed ecosystem scaffolds the development of dispositional forms of wonder, awe, and curiosity through means that shift the spontaneous and intuitive ways we interpret the world to be better attuned to and aligned with axiological considerations that expand beyond school, adult, and humans-centric logics.

The changes we articulate here are both epistemological and ontological, for if we change our spontaneous and embodied responses to the world—if we change the ways we see and act within the world—we change the very notion of who we are (Shotter, 2006). So positioned, the quality of 1pedagogical encounters and environments for learning co-constitutes our sense of self and meaning in the world. This pedagogical orientation shifts activity design from designing *for* learners to designing *with* learners. Educators still maintain key facilitative roles, but these roles are conceptualized and practiced as porous; educators are also learners and learners contribute meaningfully to guiding activities, investigative foci, and the processes through which these activities unfold.

Through wondering with people, places, and more-than-humans we also ground learning in orientations and assumptions that recognize how we are necessarily dialogic participants within sets of complex social and ecological systems. Cultivating both systemic sensemaking skills within complex systems (e.g., toggling across temporal, spatial, and population scale), but also towards forms of pedagogy and perspective that cultivate awe, humility, gratitude, and compassion. This orientation towards speculation, deliberation, and decision-making thus honors the educational rights of other humans (adults, children, educators, families, researchers, etc.) while also recognizing the dignity and agency of people, places, and more-than-humans as partners in life and learning. In so doing, we move beyond narrow and decontextualized epistemic foci in science education (e.g., “How do I know about a natural phenomenon?”),

towards more holistic and applied scientific understandings (e.g., “How can we live well with our human and more-than-human relatives”).

Ethical wondering with people, places and more-than-humans is thus understood as a set of interconnected ontological innovations that reframe epistemic processes through foregrounding axiological considerations towards more ethical forms of socio-ecological sensemaking. Beyond just a theoretical concept, ethical wondering with people, places, and more-than-humans is an empirically designed instantiation of the conceptual and philosophical premises that guide our work to facilitates ethical wondering, expansive pedagogical mediation and recognition that humans exist as a part of complex socio-ecological systems. As described throughout this paper and across this dissertation, we see this orientation as crucial in our current historical moment where enacting new possibilities for worldmaking and cultivating hope and compassion are key to remediating discourses of despair and apathy in the face of complex socio-ecological challenges such as climate change.

Chapter 3. Paper 2: "Let's Keep Walking and See": Wondering With People, Places, and More-Than-Humans as a Context for Ethical Socio-Ecological Sensemaking in Early Science Education

Introduction and Key Framing

We are living in times of rapid socio-ecological change, systemic destabilization, and sociocultural unrest. Changing climates, environmental degradation, linguistic and cultural genocide, and unsustainable nature-culture relations necessitate new and imaginative ways of seeing, knowing, and relating to the rest of the natural world (Berkes, 2017; Bang & Marin, 2015; Bang et al., in prep; Whyte, 2018). These challenges present opportunities and responsibilities to collectively notice, wonder about, deliberate on, and make decisions to enact more healthful and sustainable socio-ecological futurities. In considering how we might prepare ourselves and future generations for productive engagement with the complex socio-ecological challenges that characterize our present moment, this work focuses on the re-mediation of nature-culture relations towards more ethical forms of deliberation and decision-making. Indeed, the social, cultural, and scientific processes that mediate pedagogical activities are key sites for developing just and sustainable socio-ecological sensemaking practices (Bang et al., 2013; Rosebery et al., 2010; Warren et al., 2020).

In the field of cognitive studies, knowledge and interaction about the natural world is dominated by models that position humans as separate from, or superior to, other natural kinds. Following from this, educational scholarship tends to situate the natural world as a largely inconsequential background to human sensemaking (Bang, 2015; Preston, 2005; Tuck et al. 2014). These positionings between humans and the rest of the natural world are enacted within and through everyday activity in ways that reflect, reify, or transform normative epistemic,

ontological, and axiological dimensions and commitments. Narrow study of learning at the nature-culture boundary not only reduces what we can know, but also constrains how we imagine, design, enact, and analyze learning activities and relationship making with the natural world within educational spaces.

The fact that human-centric relational construals are not a given–but developed through participation in cultural practices (Medin & Atran 2004; Medin & Bang, 2014)–highlights the need to develop more just and sustainable practices of reasoning and decision-making towards model that position human beings as a part of larger complex socio-ecological systems. In this space, expanding and re-making nature culture relations becomes necessary towards a more just and thriving future where humans can enact more reciprocal understandings of socio-ecological systems towards more ethical nature-culture relations. This involves both expanding methods of analysis in novel ways that more adequately account for the pivotal role of the natural world in facilitating learning.

In our work, we have pursued this line of inquiry through designing system for activity grounded in what we call *ethical wondering with people, places, and more-than-humans* – a particular orientation towards teaching and learning whereby inquiry is launched and mediated through routine noticings and wonderings in outdoor places. In addition to expanding nature-culture construals beyond anthropocentrism, this pedagogical orientation also seeks to remediate adult-centric curricular logics through beginning processes of inquiry with the noticings and wonderings of youth towards positioning learners as authentic and dignified co-designers of their learning trajectory. In doing so, we assert that our collective capacities to ethically notice, wonder, and deliberate with youth and the more-than-human world are deeply implicated in the kinds of futurities we can imagine and enact. Grounded in context of science education, we also

forward this orientation as a productive means of generating emergent and personally relevant engagement in core disciplinary practices through routine field-based inquiry, thereby expanding opportunities to make sense of complex socio-ecological systems, an increasingly important capacity in contexts of global climatic shifts.

Central to this work is considering the ways in which culture, wonder, and field-based learning are conceptualized and designed for in learning environments. We work from the contention that humans should have a right to learning landscapes characterized by wonder and awe in ways that expand affective possibilities for life and learning. In pursuit of more ethical futures, we see educators as having a moral obligation to nurture that sense of wonder through activities and interactions that invite imaginative consideration of possibility. This is especially true in the face of large and complex socio-ecological challenges that can provoke fear, anxiety, and despair. In deliberating about possible social futures, this work elevates the importance of engaging wonder towards awe, curiosity, hope, and compassion in contexts where prevalent socio-ecological discourses too often foreground decay and mourning through 'scorched earth' narrative, rather than centering possibility thinking and opportunities to build and rebuild worlds towards more healthful and livable socio-ecological futures.

This paper reports on work emergent from the Learning in Places project designed to remake socio-ecological relations through engaging youth in routine outdoor activities grounded in ethical wondering with people, places, and more-than-humans. Through analysis of design and purposefully sampled transcripts (Merriam & Tisdell, 2016) gathered from wondering walks in the pilot year of implementation, this work offers a deep qualitative analysis of emergent interaction and sensemaking to characterize how educators and learners enacted core dimensions of ethical wondering with people, places, and more-than-humans. Towards these ends, the next

sections outline key theoretical commitments and methodological processes that frame subsequent analysis of interaction across five major dimensions we see as central to ethical wondering with people, places, and more-than-humans: disciplined socio-ecological improvisation; emergent place-facilitated inquiry; focus on the patterned structure, function, and behavior of places, species, and kinds; expansive and embodied perspective taking; and complementary nature-culture positioning.

Nature-Culture Relations, Ethical Wondering, and Field-Based Learning

Nature-Culture Relations. Scholars in the field of science education are increasingly making sense of how culture, identity, and power are intertwined and reflected in epistemic, ontological, and axiological orientations to everyday pedagogical activity (Cajete, 1999b; Bang et al., 2013). Understood as socially and culturally situated, science education is historically saturated in hierarchical orderings and dominant logics that reflect anthropocentrism, adult-centrism, and other colonial features (e.g., Grosfoguel 2011; Mignolo, 2009, Smith, 2012; Wynter, 2003;). As a consequence of these long-standing assumptions, humans are often positioned as apart from–and superior to–the rest of the natural world; pedagogical activities frequently center questions predetermined by adult educators and rote curricular materials; and scientific phenomena are commonly presented as isolated from the complex systems of relation in which they actually exist. Attendant to these concerns, we posit that engaging in socio-ecological sensemaking in outdoor places and from particular design commitments can remediate nature-culture relations across axiological ontological, and epistemic dimensions towards more sustainable and reciprocal futures (Deloria, 1999; Simpson 2014; Kawagley 1995; Burkhart 2019).

We understand practices of noticing, wondering, and deliberating as an important entry

point into imagining, designing, and enacting more reciprocal nature-culture relations. In our work, we have developed an interconnected array of ideas and practices to support what we call *ethical wondering with people, places, and more-than-humans.* This orientation to design and interaction emerged from our co-design work as multidimensional framework with several interconnected dimensions. These include: grounding in a particular uptake of wonder as related to curiosity and awe (i.e. Chapters 1 and 2); 'ethical wondering' involving asking about normative questions about should be done in a particular situation or context; 3) an ethical orientation towards pedagogical mediation characterized by relational responsivity (Shotter, 2006), shared agency (Damşa et al., 2010), interpretive power (Rosebery et al., 2016), and designs that support disciplined improvisation (Stevens & Hall, 1998; Sawyer, 2011); as well as a particular disciplinary context (i.e. Learning in Places as a context for socio-ecological sensemaking, see Chapters 1 and 2)

Taking science education as an important site of socio-ecological intervention, our works aims at refiguring nature-culture relations (Cajete, 1999a; Kawagley, 1996; Medin & Bang, 2014) towards relational orientations that start from the assumption that all things are related in complex, interactive, dynamic, and reciprocal relations (see also: Tallbear 2011; Latour 1993). This relational approach to activity aligns with work in complex systems education, where making sense of emergent and webbed levels of relation requires forms of learning that support skills such as perspective taking (Medin, et al., 2006; Medin & Bang; 2014; Unsworth, et al., 2012), and toggling across spatial and temporal scales (Jacobson, & Wilensky, 2006; Wilensky & Resnick, 1999; Wilensky & Reisman, 2006; Yoon et al., 2018). These understandings are reflected in our work through a principled commitment to designing and mediating learning in ways that position humans as *a part of* nature, nested within complex socio-ecological relations

extending backwards and forwards across time (Bang et al., 2014; Burkhart, 2019; Cajete, 1999a; Deloria & Wildcat, 2001; Pierotti, 2010). From such an understanding, we position places and other natural kinds as beings we should show deference to, rather than resources we should strive for dominance over; a web of mutually constitutive and reciprocal relationships in which we are deeply embedded, rather than an economic resource ripe for human exploitation. In describing how we understand and design for scientific sensemaking that positions humans as a part of the natural world, we build with research in science education (e.g., Chin & Osborne 2008; Reiser et al, 2017; Bang et al, 2017) and learning as contextualized within the everyday lives and routines of students, families, and the places they inhabit (Rosebery et al. 2010; Bell et al., 2012; Bricker & Bell, 2014; Warren et al., 2020).

Ethical Wondering. We draw on educational perspectives on wonder (e.g., Hadzigeorgiou, 2013, 2016; Schinkel, 2017, 2018; Silverman, 1989; Scardamalia & Bereiter, 1992; Chin & Brown, 2002; Egan et al., 2014) in characterizing ethical wondering with people, places, a more-than-humans as a desettling (Bang et al., 2013) onto-epistemically expansive pedagogy (Warren et al., 2020) that supports considering "big" questions that "engage the whole person" (Opdal, 2001, p. 332) across cognitive, affective, and existential level. Grounding wonder in a field-based socio-ecological context, we elevate how wonder can open up the conditions under which anthropocentrism, school-centrism, and adult superiority can be productively engaged and refigured in everyday interaction, recognizing wondering as a necessary precondition to the collective imagining and enactment of alternative possibilities for human learning and relations with the rest of the natural world (Espinoza, 2009). Recognizing wonder as an open or "floating" signifier (Lévi-Strauss, 1987, pp. 63–64; Hall, 1997), whose meaning is made particularly sensitive to the which it is manifest and through the way it is

framed, directed, and facilitated within educational activities (Schinkel, 2018) - we explicitly ground our understanding of wonder in outdoor, field-based learning contexts to support socio-ecological sensemaking.

A major strength of designing learning activities from this view of wonder is an intentional focus on open-ended and emergent processes that allow for learner-generated questioning to authentically guide flows of activity. Through centering the noticings and questions of learners, authentic designs from wonder share and distribute epistemic agency with learners in ways that position their sensemaking as the origin and motivator of emergent inquiry. Emergent from immediate experience, we understand wonder as necessarily infused with personal relevance about why the world appears the way it does (Lone & Burroughs, 2016). Through imbuing incoming information with affective-emotional and cognitive-motivational qualities, wonder generates epistemic momentum, ontological mobilities, and axiological interest in ways that better supports learners navigating uncertainty through speculative discourses that reflect greater depth of engagement than "known-answer" questions commonly posed within educational activities (Long & Soto, 1983; see also Cazden, 2001; Mehan, 1979 & O'Keeffe et al., 2007). Throughout our work we understand the pedagogical potential of wonder in its ability to cultivate a combination of awe at one's place in the world, alongside a curiosity to know more, tempering and enriching the analytic drives of curiosity within the holistic and humble overtones of awe.

From such an uptake of wondering, our work is concerned with internationally scaffolding socio-ecological sensemaking towards *ethical wonderings*; or those that pose normative questions about what we 'should' or 'ought' to do in a given situation. Through social process of deliberation, such ethical speculation supports sensemaking from multiple

perspectives to consider how varied values and priorities may lead to different courses of action (i.e., decisions). These ethical capacities for perspective taking support the skills required to make sense of natural phenomena from within socio-ecological systems themselves. Elevating complex relationality inherent in socio-ecological systems, ethical wonderings works to de-center and contextualize–to situate–individual phenomena within layers of ongoing history and relational reciprocity.

Speculative activity is thus situated within the holistic experience of being a small, yet important, part of socio-ecological systems many magnitudes greater than our individual and collective human worlds. Both emergent and mediated within unfolding activity, such wondering can engender engagement with a range of affectively vital experiences, including awe, amazement, curiosity, gratitude, and humility from within our own lived experience of the world. In ethically wondering about our own existential situations, we can become aware of both the extreme potentiality and fragility of life, an experience that nurtures compassion for self and others (Hepburn, 1980).

Ethical wondering thereby engages axiological and existential terrain through addressing dynamics of power at the core of our fundamental relationality with the rest of the natural world. That is, what beings are recognized as agentic and intrinsically valued, as well as whose lives and perspectives are prioritized within processes of socio-ecological decision-making. We see wondering as morally significant through how it supports the development of cultivates "other acknowledgement" (Vasalou 2015). Though the "other" in this formulation is often conceptualized as human, we draw on Indigenous points of view which extend this recognition towards to include natural kinds and more-than-human beings as kin and relatives with whom we share this world (Bang et al, 2014; Cajete, 1999a; Burkhart, 2019).

In our design work we support sophisticated scientific inquiries in ways that nurture senses of awe and amazement through the understanding that we (humans) exist within complex systems of socio-ecological relations with countless more-than-human beings whose perspectives deserve to be taken into consideration by building skills in wondering from and with the perspectives of more-than-human beings in ways that recognize the agentic capacities of other beings and places themselves. Within this, we take seriously how sense of wonder can impel us to act respectfully in the world, encouraging us to "see life as something to which we owe respect and care" (Moore, 2005, pp. 273), or as Fuller summarizes, "No other emotion so readily kindles a reverence for life" (2006, p. 158). Our work, in part, is the result of wondering about how wondering can shift socio-ecological inquiry through positioning the rest of the natural world is positioned as a subject to wonder *with* rather than an inanimate resource to dominate or wonder *about.* We take this orientation towards wonder into our approach to field-based (outdoor) learning.

Field-Based Learning: Co-Operative Action, and Spatial Indexing. As the primary means through which data are collected in field-based science practice (Eberbach & Crowley, 2009, 2017), a focus on noticing and observation can help us understand salient semiotic resources implicated in activities structured around ethical wondering with people, places and more-than-humans. As such, we draw on routine noticing, wondering, and deliberating with/in outdoor places as key practices designed to support ethical socio-ecological sensemaking through cooperative field-based learning where pedagogies of walking and reading land support and develop the capacities and attunements needed to coordinate attention and observation between humans and more-than-human beings (see also, Marin 2013, 2020; Bang et al., 2015; Bang & Marin, 2018; Kawagley, 2006; Lees et al., 2021).

In characterizing the importance of moving through, attending to, and thinking with outdoor places, we build with scholarship that speaks to the important role of place and movement in field-based experiences in the development of scientific expertise (d'Alessio, 2012; Dyment, 2005; Fisher, 2001; Maltese, Balliet, & Riggs, 2013; Mogk & Goodwin, 2012; Windschitl et al., 2007); including field-based science learning (Eberbach & Crowley, 2009, 2017; Smith & Reiser, 2005), movement and mobility in STEM learning (Hutchins & Renner, 2012; Lee, 2015; Lee & Drake, 2013; Ma, 2012; Stevens, 2012; Taylor & Hall, 2013, Marin & Bang, 2018), and Indigenous perspectives that recognize the pedagogical capacities of lands and more-than-human beings for knowledge making through relational practices of walking and reading land (Marin & Bang, 2018; Bang et al., 2014, p. 8; Marin, 2013, 2020). Understood through an interactional lens of co-operative action (Goodwin, 2017) and spatial indexing (Pugh et al., 2019; Pugh, 2019) we describe how our design for ethical wondering approaches pedagogical mediation *with* (Shotter 2005, 2006) people, places, and more-than humans through a micro-interactional approach to designing for dignified worldbuilding (Espinoza 2009; Espinoza & Vossoughi, 2014; Escobar, 2018).

Because every day observational practices reflect and support culturally variable ways of attending to the world (Correa-Chavez & Rogoff, 2009; Rogoff, 2014; Gutiérrez & Rogoff, 2003; Bang et al., 2015) and what we are able to attend to and observe is culturally mediated by existing knowledge structures (Eberbach & Crowley, 2012; Hmelo-Silver et al., 2014; Smith & Reiser, 2005), we conjecture that routine engagement in emergent, semi-structured, socio-ecologically-focused activities assists in developing foundational epistemic capacities (e.g., identifying and naming kinds, generating explanations, finding and evaluating evidence, etc.. When adequately supported (i.e., via disciplined mediation, see Chapter 2), this paper

demonstrates how such activities can cultivate an ethic of relational reciprocity from the understanding that humans exist within systems of complex socio-ecological relation. Understanding how routinely linking noticings and wonderings in field-based science contexts can expand relationships between and among learners, educators, and the natural world (Beery & Jørgensen, 2018), we position this work as a critical area of research for insights into how learners initiate ethical sensemaking to engage with complex phenomena in concrete ways (Bang et al., 2007; Assaraf, et al. 2012; Assaraf, & Orion, 2010; Roehl, 2012).

In investigating the interactional impacts of field-based design for and from ethical wondering with people, places, and more-than-humans, we draw on frameworks of co-operative action (Goodwin, 2017) and spatial indexing (Pugh et al., 2019; Scollon & Scollon 2003). *Co-operative action* refers to frameworks developed by Charles Goodwin (2017) for studying how people collaboratively create shared knowledge and opportunities for action by transforming and re-using resources inherited from earlier actors, or how we "inhabit each other's actions" through interdependent use of language, the body, and historically shaped contexts. Because we are interested in the affordances of field-based design grounded in learner wonderings, Goodwin's framework helps us understand how the layering of semiotic resources over time (talk, gesture, movement, environment, etc.) provides opportunities for the transformation of action and learning (2000; 2017, see also: Melander, 2012). Through co-operative action, we explore how routine field-based wondering walks can afford possibilities for enacting expansive onto-epistemic relations between and among people, places, and more-than-humans.

We emphasize the importance of *spatial indexing* in cultivating and coordinating attention in ways that support reading the land through temporal, spatial, and relational models associated with complex socio-ecological systems (Pugh et al 2019; Bang & Marin 2018; Marin

2020). We draw on Scollon and Scollon's (2003) conceptualization of geosemiotics to understand how the meaning of a sign depends on its placement in the world. A historically human-centered approach, we extend geosemiotic frameworks towards also understanding the semiotics of the natural world (e.g., Kohn, 2013) via spatial indexing. Defined by Pugh and colleagues, spatial indexing refers to:

> "a form of meaning-making in which a phenomenon that is spatially present (located in the perceptual field) is immediately discursively connected, via sense-making, to a different phenomenon that is not explicitly present. This associated sense-making indexes phenomena on either a different locative, temporal, or relational scale." (2019, p. 429).

Because we are interested in how our orientation towards open-ended field-based inquiry can mediate towards complementarity nature-culture construals, a methodological focus on spatial indexing can make visible how routine moments of emplaced socio-ecological noticing and wondering can afford or constrain opportunities for co-operative action between people, places, and more-than humans towards desettling normative hierarchies between and among learners, educators, places, and more-than human beings.

Situated in particular places, times, and relational configurations, this approach to co-operative action and spatial indexing resonated with our phenomenological approach to design and interaction concerned with nurturing attention towards socio-ecological noticing, wondering, and ethical deliberation. That is, we are interested in moments of spatial indexing wherein attention is cultivated towards socio-ecological complementarities, instantiating place-based enactments of our design commitments towards unfolding pedagogical mediation. As an embodied practice, this includes focus on how mobility attunes attention to space through the active facilitation of places and more-than-human beings. Spatial indexing and co-operative

action help us understand the ways in which field-based learning continually renews contexts of investigation as participants notice and wonder through embodied movement within outdoor places. In this paper, we elevate profound richness of semiotic resources and relational data that becomes available "seeable" and "noticeable" when outdoors, highlighting the holistic forms of learning that become possible when regularly moving within outdoor places, outside of "classroom as container" models so prevalent in education today (Leander et al., 2010).

These practices involve the coordination of attention between humans, places, and more-than-human beings towards facilitating sophisticated inquiries involving identifying and naming kinds, generating explanations, and finding evidence to create a story about the perceptual field (Bang & Marin, 2015; see also Massey 2005; Ingold 2001). While many researchers recognize the centrality of coordinating of perception, attention, and motivation through movement and learning (e.g., Grotzer & Tutwiler 2014; Taylor & Hall 2013; Ma, 2017; Taylor 2017), a central commitment in our work rests on the fundamental claim that land and more-than-human beings themselves, as never static and always becoming, are semiotically relevant to complex sensemaking as agentic social actors (Marin & Bang 2018). Taking up relational ways of knowing at the center of our ontological assumptions (Cajete, 1999a; Kawagley, 2006), we work from an understanding of how lands, waters, and more-than-humans play essential roles in facilitating learning and development (Bang & Marin 2015). This stance marks a significant departure from the majority the educational study in human culture, learning, and development, and by the with Indigenous communities we worked with, as well as broader contributions within fields of Indigenous scholarship (e.g., Barnhardt & Kawagley 1998; Deloria 1991; Cajete, 1999b; Kimmerer, 2013; McCarty & Brayboy, 2021).

Through orientations to co-operative action and spatial indexing, the analysis below

characterizes design-based micro-interactional practices that can support emergent wondering with peoples, places, and more-than-humans through the lamination of diverse interactional practices semiotic resources. In so doing, we elevate how power is enacted to make and remake socio-ecological relationships. To wit, we detail how participants engaged in extended investigative activities that reflect key dimensions of ethical wondering with people, places, and more-than-humans, including how design-commitments are taken up to mediate emergent sensemaking alongside the active role of places and more-than-human beings in facilitating trajectories of everyday learning in consequential ways. This paper is thus an emergent and open-ended response to questions such as:

- *What shifts in pedagogical interactions when humans are positioned as a part of the natural world through practices of disciplined mediation (wondering with)?*
- *What is different about learning when place and more-than-human beings are recognized as partners (situated subjects) in life and learning, rather than decontextualized resources for epistemic domination and material extraction?*

Project Overview and Study Methodology

The data used in this analysis comes from Learning in Places, an National Science Foundation funded participatory co-design project aimed at developing and refining innovative forms of transdisciplinary science learning with children, families, educators, and community members that supports their well-being and world making. Through iterative participatory processes, Learning in Places cultivate equitable forms of complex socio-ecological systems sensemaking and sustainable decision-making practices with people, places, and more than humans that seriously engage dynamics of power, historicity, and relationality (Bang et al., in prep; Montaño Nolan et al., accepted).

This project focuses on engaging early-grade children, educators, and families in complex socio-ecological sensemaking through an array of materials and activities designed within the Learning in Places "materials ecosystem" (e.g., Project Rhizome, Educator Frameworks, Field-based Science Storyline, Learning Engagements, etc.). Following from our focus on routine engagement with ecological systems, outdoor activities are foundational components of the LiP ecosystem. Through iterative cycles of co-design, the practice of *wondering walks* emerged and was designed as a foundational component within the Field-Based Science Storyline (FBSS, see Figure x). This study characterizes the emergence, structure, and function of noticing, wondering, and deliberation emergent within *wondering walks,* a central activity of Learning in Places (see Chapter 2).

Study Design

The data in this paper comes from wondering walks taken by students and educators in the pilot year of storyline implementation. During these engagements, classroom groups walked within places around their schools (e.g., neighborhoods, parks, school gardens) to notice, wonder, and deliberate on the social and ecological phenomena they encountered. Situated within the storyline of activities, initial wondering walks are intentionally open-ended – there is no predetermined focus apart from collectively walking, noticing, and wondering in particular places (e.g., LEs 1-2). Over time, these routine walks become focused as observations, wonderings, and questions concerning particular relationships and phenomena recur and are progressively shaped within various learning activities (LEs 3-5), such as the development of a "should we" question. Through the latter half of the storyline, the should-we question generates investigation questions that are explored through developing and revising models, collecting and interpreting data from the field before constructing and sharing empirically-grounded

explanations that inform decision-making processes (see Chapters 1 and 2 for more in depth uptake of the Learning in Places material ecosystem).

Data Collection

The data for this analysis were collected between December 2018 and March 2019 during the pilot year of Learning in Places FBSS implementation. This paper draws from a secondary data set comprised of video data collected during outdoor wondering walk activities that were a part of the FBSS in our pilot year of co-design and implementation. In this paper, we present an interactional and ethnographic case study of a wondering walk taken by Ms. Poppy's 2nd grade class. Ms. Poppy's class went on 10 walks over a period of 7 months in our pilot year, with each walk lasting from 20 min to 1.5 hours. During this time, randomly selected youth participants recorded their activities using small wearable cameras, the GoPro Hero 5. Cameras were worn on chest-mounted harnesses and captured how participants' bodies were oriented (see fig 3.1). The wide-angle setting (~170 degree angle) was used to maximize video view of interactions occurring from the participant's perspective.

Figure 3.1

Chest-Harness GoPro Use on Wondering Walks

The cameras did not capture eye-level, as our initial tests with head and shoulder

mounted arrangement caused undue distractions. We found that positioning the cameras at chest-level was both less distracting and foregrounded movements of the whole body, including interactions where participants are touching, holding, or otherwise interacting with materials in front of them. Multiple camera perspectives allowed us to analyze the same walk from the view of different participants, allowing for more holistic analysis of unfolding activity and interaction. Attending to participants embodied movements, coordination of attention, and multimodal noticings, we designed data collection procedures that enabled us to observe individual and joint experiences as they moved through particular places (e.g., Goodwin, 2006; Marin and Bang, 2018). Importantly, these methods utilized across the data set afford analysis of both social and physical context of learning (Anderson, Adey, & Bevan, 2010; Marin, 2020). Following from our ethical commitments to design, the approach to data collection and analysis used here reaches towards ethics of relationality and away from uses of video recording and data collection as forms of surveillance through co-authored process of asking, learning, and knowing (Vossoughi & Escudé, 2016).

Analytic Approach

Interaction Analysis. This analysis proceeded using an adapted two-phase model of Jordan & Henderson's (1995) approach to content logging and open coding. In construction of grounded codes **(**Glaser & Strauss, 1967) based on analysis of conversation (Goodwin & Heritage (1990) were analyzed through application of techniques and methodologies used in analysis of interactions gathered as video data (Cobb & Whitenack, 1996; Derry et al., 2010; Erickson, 2006; Goffman, 1967, 1983; Goodwin 1994, 2017; Hall, 2000; Kendon, 1990; Powell et al. 2003; Stevens & Hall, 1998). As such, this analysis is informed by the analytical commitments of *interaction* analysis, including focus on data that allows for repeat analysis of

interaction occurring within naturally occurring events (Hall & Stevens, 2016) and attention to phenomena such as member relevance (Schegloff, 2007) and procedural consequentiality (Raymond & Heritage, 2006).

Attention to the sequenced order in which interactions unfold enabled analysis of how layers of interactional sequences result in semiotic laminations of interactional histories that afford and constrain forms of sensemaking (Goodwin, 2017). Making sense of the interaction order itself (Goffman, 1967, p. 14) was particularly important in coming to understand how the micro-interactional unfolding of events is implicated in everyday constructions of meaning for participants (Erickson, 2004). Through attention to the temporal triad of interaction (the now moment, the immediate past, and immediate future), alongside repeat viewing of longer interactional stretches, we constructed progressively more refined interpretations of how participants come to constitute interactional environments for each other (McDermott, 1976, p. 36) through a social ecology of mutual adaptation that underlies and enables the very interactions being analyzed (Erickson, 2004, pp. 4-5).

In attending to the physical, gestural, affective, and artifact-mediated dimensions of experience, interaction, and learning (Hall & Nemirovsky, 2012; Goodwin, 2017; Marin & Bang, 2018) we focused on how embodied ways of wondering, knowing, and being are always situated in complex relations infused with both pedagogical and ethical values (Vossoughi et al. 2020; Marin, 2020). Analysis thus takes seriously how meanings are carried by the formation and orientations of bodies in space (Kendon, 1990), and accounts for the role of place and embodied interactions as central components of learning (Leander et al. Phillips, & Taylor, 2010; Ma, 2017; Shapiro & Hall, 2017), including how movement and mobility itself is linked to historical dynamics of place (Taylor, 2017; Taylor & Hall 2013; Marin et al, 2020) that reflect particular

epistemological, ontological, and axiological orientations towards land and the natural world (Bang et al., 2014; Tuck et al., 2014; Marin & Bang, 2018). Alongside a focus on spatial indexing (Pugh et al, 2019), attention to the interactional complexities emergent within wondering walks makes visible how our design-based orientations towards nature-culture relations are present within unfolding semiotic and relational configurations.

Grounded Analysis. In the *first* round of analysis, we reviewed all wondering walk data from Ms. Poppy's class using design-based codes (developed a priori from key project commitments, see: Bang et al., in prep; see also Chapter 2, this volume) alongside grounded categories emergent within analysis (Glaser & Strauss, 1967). Through repeated viewing and logging of walk data we identified routine forms of discourse and activity that participants engaged in while on wondering walks to characterize how ethical noticing and speculation unfold through interaction within outdoor places. For example, these practices include disciplined socio-ecological improvisation, place-facilitated inquiry, sensemaking about the structure, function, and behavior of emplaced phenomena, perspective taking, and foregrounding complementary nature-culture relations. Together, these constitute the central dimensions of wondering with people, places, and more-than-humans that this case study focuses on.

Initial high-level findings were used to develop progressively more refined questions, interpretations, and hypotheses (Engle et al., 2007; Derry et al. 2010). Through this constantly comparative "zigzag between conjectures and refutations" (Glaser & Strauss, 1967, p. 224), we identified rich points (Agar, 1996), hot spots (DeLiema et al., 2015), and critical events (Powell et al. 2003) that characterize concepts and practices associated with our design from ethical wondering with people, places, and more-than-humans. In addition to constructing a more refined coding scheme, this first phase of analysis identified several streams of particularly rich

data. Here, richness was defined as data with high-degree of design-salient codes (e.g., socio-ecological noticing and wondering, practices of ethical pedagogical mediation, instantiations of complementary nature-culture relations). As with other top-down and bottom-up approaches to analysis (e.g., Erickson 2004; Sipe & Ghiso, 2004), the entire data corpus was reviewed before empirical claims were generated.

Case Study Segmentation: Quantification and Ethnographic Accounts. In the *second* phase of analysis, we selected one particularly rich walk from Ms. Poppy's class and employed methods of conversation and interaction analysis within Dedoose and Microsoft Excel to construct quantitative and qualitative characterizations. In this phase, data were bounded by semiotic episodes (Bang & Marin, 2018), determined through changes in contextual configuration (Goodwin, 2000) as indicated through shifts in discourse, eye gaze, bodily orientation, and gestures that spatially index varied geosemiotic referents (Pugh et al, 2019; Scollon & Scollon, 2003). Specifically, each new "segment" was determined through shifts in the focal topic or phenomena that oriented participant's attention. For example, in excerpt 8 children comment on seeing a squirrel in the trees before attention shifts towards discussion of outdoor rules and expectations in excerpt 9. Excerpt 10 is then initiated through an adult facilitator modeling outdoor noticing and wondering. This process resulted in 70 total semiotic segments, varying from 1 to 78 turns-at-talk, over the approximately 1-hour walk.

Segmenting data based on focal phenomena is a methodological innovation that affords insights into how places, more-than-human beings, and other focal phenomena mediate onto-epistemic process within place-based activities (Marin, 2013; Taylor, 2013; Pugh et al, 2019; Pugh, 2019; Jordan & Henderson, 1995; Nxumalo, 2019; Gruenewald, 2003; Tuck & McKenzie 2015a). Methodologically consequential, this positions land and more-than-human beings as

relevant and agentic actors (e.g., Bang et al. 2014; Tuck & McKenzie 2015b) within the interactional unit itself (Goodwin, 2013; Kohn, 2013; Marin & Bang, 2018). This analytic ethic thus works to recognize how lands and more-than-human beings actively facilitate inquiry through contribution of semiotic resources that develop and sustain ongoing engagement in epistemic, affective, and axiological ways. More specifically, analysis of activity unfolding over the course of this walk affords insights into how "seedpods" generate spontaneous noticings and wonderings that facilitate trajectories of scientific investigation. Within this framing, close examination of talk-in-interaction is used to make sense of how observation, speculation, and movement mediate emergent sensemaking with the natural world (Bang & Marin, 2015; Marin & Bang, 2018; Marin, 2013, 2020).

As an exploratory step in analysis of this case study, qualitative data were quantified in several ways within segments (Chi, 1997). Each utterance was coded for spatial indexing, placed observational practices, discursive markers of a 'wondering landscape', and a range of other epistemic practices described below. Placed observable practices included linguistic directives such as 'look' 'see' and 'notice', as well embodied displays including 'showing' and 'pointing'. Markers of the 'wondering landscape' were operationalized through coding for explicitly speculative statements (e.g., "I wonder...", "What if…?"), and through attention to speculative markers (maybe) and use of process-based or open-ended questions (in contrast to procedural, clarification, or yes/no questions). Epistemic processes were highlighted through coding for particular question formations (e.g., 'generative' and 'constructive'), as well as observation-linked wondering (speculation and question that reference immediate observational data).

Observational practices were quantified through attention to embodied and linguistic markers that signal placed attentional directives such as pointing. This included compiled lexical

counts of coordinative observational discourse (e.g., ‘look’, ‘see’, ‘notice’, ‘show’, etc.) as well as coding for forms of sensemaking that explicitly require emplaced observation (place emergent, extracted, abstracted, and/or speculative observations: Pugh, 2019). Finally, segments were coded in relation to the Disciplinary Core Ideas (DCIs) and Crosscutting Concepts put forth in the Next Generation Science Standards (NGSS, cite) for 2nd and 3rd grade. These include attention to inquiry concerning patterns, cause and effect relationships, interdependent relationships in ecosystems, biodiversity, variation of traits, growth and reproduction of organisms, the role of water in Earth’s surface processes, and the structure, function, and properties of matter (see appendix 3a for examples of coding representation across segments).

While the primary thrust of this paper tends toward more qualitative and ethnographic logics, it is worth noting how initial analysis suggests that both adults and children engage in a range of observational coordination through language and embodied movement. Further, these initial findings suggest that field-based noticing and wondering supplies the semiotic resources from which sophisticated scientific investigation emerges and is shaped through pedagogical mediation. This emerging finding is reinforced by the analysis of knowledge and interaction in the latter half of this paper, as well as by the broad quantitative analysis described in Chapter 4.

In addition to quantitative counts, we worked to create an ethnographic account of activity unfolding over the course of this walk by analyzing talk in interaction (Goffman, 1983; Erickson, 2004). Attention to the sequenced order in which interactions unfold enabled analysis of how layers of interactional sequences result in laminations of interactional histories that afford and constrain forms of sensemaking (Goodwin, 2017). Within this framing, close examination of talk-in-interaction was used to make sense of how observation, speculation, mobility, and spatial indexing mediate emergent sensemaking with the natural world. Across these interactional

sequences we focus on emergent forms of activity that characterize central dimensions ethical wondering with people, places, and more-than-humans as they are empirically reflected in a wondering walk taken by Ms. Poppy's class.

The Context of Wondering Walks in Ms. Poppy's Class

During this particular wondering walk, children were loosely divided into four groups based on the grouping of phenomena that emerged from the first set of school and family walks (slugs, trees, leaves, mushrooms). Participants were each equipped with clipboards and observational scaffolds prompting them to look and attend to relationships above, around, and below their focal phenomena. These tools also drew their attention to the weather and seasonal evidence, prompting them to investigate what happens to their focal phenomena during the winter. Additional data collection tools (magnifying glasses, thermometer, trowels, etc.) were distributed between groups. Aside from their broad focus on a particular phenomenon and use of particular tools, students were not constrained in how they chose to investigate the outdoor space so long as it was respectful to others. Throughout the walk adult participants explicitly modeled wondering, questioning, and the use of observational directives.

Over the course of the walk, participants walked through a local park investigating a range of phenomena. The data analyzed below comes from a student-worn camera worn by a student (Jiah) in a group who had decided to focus on leaves and other "fallen plant parts". This particular group begins by observing leaves and pine needles (excerpt 10) before gradually focusing on a diverse range of seedpods. Jiah is the first to bring these seedpods to the group's attention as she then begins to collect them on her clipboard and speculate on the variations she is noticing. Over the course of the activity several other children and educators co-participate in the Seedpod investigation; central to this walk was the participation of Ms. Dalia (an adult

facilitator and project co-designer) and Sash (a 2nd grade classmate)

Analysis and Findings

High-Level Themes

During this walk, several interconnected themes emerged that characterize our conception of ethical wondering with people, places, and more-than-humans. These include: disciplined socio-ecological improvisation; emergent place-facilitated inquiry; focus on the patterned structure, function, and behavior of places, species, and kinds; expansive and embodied perspective taking; and complementary nature-culture positioning. Across these segments of interaction, we also note additional emergent themes concerning: recognizing the personhood and agency of more-than-human beings; practices of place designing; dynamics of power and historicity; and implications for learner culture and identity through connections to family & community knowledges. While these themes are presented in analysis below as distinct categories, it is important to elevate how we see these elements as always coexisting – the distinctions here are purely heuristic, we suggest there is significant overlap and rhizomatic synchronicity between these elements - as follow from the conceptual framework for ethical wondering with people, places, and more-than-humans introduced through Chapters 1 and 2.

We now move on to provide a more detailed thematic account of discourses-in-interaction within 10 selected excerpts to illustrate salient dimensions of ethical wondering with people, places, and more-than-humans. Taking up both the socio-ecological content of activities as well as the mediational ethic used by educators in micro-moments of interaction, we attend to the socio-semiotic work that focal participants engage in, including how field-based noticings, wonderings, and questions coordinate attention and participation within emergent processes of inquiry. In doing so, we demonstrate how key dimensions of wondering with people, places, and

more-than-humans support ethical forms of socio-ecological sensemaking. We close analysis with a vignette detailing how the wonderings, interactions, and focal phenomena emergent in this walk contributed to processes of ethical deliberation and decision-making developed in future learning engagement as Ms. Poppy's class moved through the pilot model of our FBSS.

Design-Disciplined Socio-Ecological Improvisation

To engage in design-disciplined pedagogical improvisation is to mediate emergent learning at the micro-interactional level in ways that creatively draw upon designed materials and semiotic resources emergent in activity to support complex socio-ecological sensemaking. We draw on Sawyers (2011) conception of structure and improvisation alongside interpretive power (Rosebery et al. 2015) and withness orientation (Shotter, 2005, 2006, 2015) to characterize the mediational ethic we design from to support ethical pedagogical interactions. Designed as cultural and interactional artifacts intended to mediate between theories of teaching and learning and moment-to-moment interactions, designed materials are structural resources aimed at guiding pedagogical mediation through unfolding, in-the-moment interactions. Importantly, these structures do not rigidly anticipate or require a strictly linear approach, but are responsive to particular emplaced pedagogical situations in which educators apply and refine their own emerging socio-ecological expertise. In doing so, this approach recognizes how educators make spontaneous facilitative judgements largely based off of qualities that unfold in the course of action in ways that creatively respond to the unique contingencies and semiotic resources of a given situation through a disciplined balance between structure and freedom (Sawyer, 2011; Eisner, 1979).

Through routine engagement with designed materials, alongside opportunities to practice linking structures of design to in-the-moment interaction, we see this approach as central to

developing educator's capacities to see student sensemaking in expansive ways (i.e., interpretive power (Rosebery et al. 2015) and mediate towards heterogeneous forms of socio-ecological sensemaking (Bang et al., 2017, Warren et al 2020). In our work, this involves both expansive attunement to learner sensemaking as well as building capacities to improvise with the semiotic contributions of places and more-than-humans. In practice, this involves design-disciplined mediations such as spatial toggling, enacting relational epistemologies, connecting with bigger FBSS concepts such as seasonal rhythms in ways that positioning people, places, and more-than-humans as agentic participants in unfolding co-operative activity. As a routine practice we position design-disciplined improvisational mediation as a relationally responsive ethic that takes seriously our ability to guide flows of interaction from our own unfolding participation within them (Shotter, 2005, 2006, 2015) from an understanding of how education rights are produced, affirmed, and negated in everyday interaction (Espinoza & Vossoughi, 2014).

Excerpt 1: Segment 10 "I'm noticing… I'm wondering… How do you know?". This first excerpt takes place near the beginning of the walk as the class is moving from the school grounds and into a nearby green space. The interaction is initiated (lines 1-4) as participants come to a pause and Ms. Dalia re-orients them to their focus on fallen plant parts through modeling how to construct a wondering from noticings using a series of discursive moves designed to support emplaced noticings across spatial and temporal scales (a key component of complex systems sensemaking, Wilensky & Resnick, 1999). Through design-disciplined pedagogical mediation, we see a line of inquiry emerge as Ms. Dalia poses open-ended questions, spatially indexes through embodied gestures, and makes improvisational connections to broader socio-ecological phenomena. This move is occurring at the beginning of the walk and during the first stop in movement, we argue that these moves are procedurally consequential

(Raymond & Heritage, 2006) and play a critical role in shaping the interactional context that contribute towards framing, tone, and goals of this walk as it continues to unfold (Goodwin & Heritage, 1990).

1	Ms. Dalia:	I'm noticing lots of leaves in the ground *[looking down]*,
2		I'm noticing leaves up in the trees *[looking up]*,
3		I'm noticing leaves on plants *[looking around]*,
4		I'm wondering, how do you know that it's winter?
5		When you think of leaves, when you look at leaves, what makes
6		you think it's winter?
7	Kirk:	In winter, basically, leaves fall. *[looks up]* Not all leaves fall.
8		Those don't fall. *[pointing at tree]*
9	Ms. Dalia:	These don't fall? *[looks down]* Huh.
10	Kirk:	Only their little sticks.
11	Ms. Dalia:	But I see so many on the ground. *[pointing to the ground]*
12	Jiah:	But lots of them falled at my house.
13	Ms. Dalia:	Oh yeah? What do you mean? Like-
14	Jiah:	These kinds. *[pointing at an evergreen tree]* And Kirk said they
15		don't fall.
16	Ms. Dalia:	So … when you're walking along your house, do you notice,
17		are they kind of like these? [picks up browned pine needle]
18	Jiah:	Yeah.
19	Ms. Dalia:	Yeah?
20	Jiah:	But some of them are green, just like that.
21	Ms. Dalia:	Some of them are like this?
22	Jiah:	Mm-hmm (affirmative).
23	Ms. Dalia:	What do you think makes them do that?

In this interaction, student noticings and practiced mediation invite others into emergent inquiry as they deliberate on the relationships between seasonal change and different types of "leaves". Drawing upon their present noticings in place observations as well as those recalled from other personally relevant contexts (i.e., home), the group deliberates on what makes some leaves fall, but not others. By the end of this excerpt, we see Jiah noticing patterns of colors, a mode of inquiry she continues to build from as the walk progresses. Drawing on her engagement with designed materials and activities, Ms. Dalia enacts a series of improvisational moves that we see as central to facilitating ethical socio-ecological sensemaking (see lines 1-6, 9, 11, 13, 16-

17).

For example, her use of open-ended questions (lines 4-6, 13, 23) is a practice we have designed as a means of supporting learner wonderings and guiding inquiry forward across time and place. Characteristic of our approach to improvisational mediation grounded in design principles, Ms. Dalia's discourse repeatedly expands possible semiotic closures through disciplined reframing towards open-ended, processual, and relational orientations that move the inquiry forward both conceptually and physically. For example, in line 13 Ms. Dalia responds to Jiah's cross-place observations by asking her to clarify her meaning, thereby extending the interactional exchange towards cross-place noticings. Similarly, in line 23 Ms. Dalia reframes a possible discursive closure by posing a processual question. We also note how frequent bids for clarification (lines 9, 13, 16-17, 19, 21) position youth as agentic and dignified participants in inquiry through displays of genuine interest that contribute towards the sharing of facilitative power within micro-moment of interaction. Though specifically highlighted here, interactional moves like these are present across the excerpts presented here, suggesting the routine nature of their use during walks.

Aligning with core dimensions of our project's design goals, Ms. Dalia's interactional improvisation in this excerpt toggles from a focus on isolated phenomena to relational construals as she spatially indexes immediately observable phenomena, thereby positioning nearby "plant parts" as participants in inquiry that can teach them about their phenomena of interest through close observation. In launching epistemic activity through wondering about immediately observable phenomena (leaves) in relation to broader socio-ecological phenomena (seasonal change) (lines 1-6), Ms. Dalia guides group attention towards the relational synchronicities between their place-emergent noticings and broader phenological rhythms. This is a pedagogical

capacity that we have explicitly infrastructured for in our design work through creating structures for learning that engage educators in ongoing learning about broad concepts such as phenology (Learning in Places Collaborative, 2020g), while also providing them with examples of how opportunities to make such connection might manifest in moment-to-moment interaction.

Additionally, we have developed and refined a series of "back pocket practice" designed to be creatively drawn upon within activities such as wondering walks (see Chapter 2). Embedded within particular learning engagements, this series of expansive discourse practices is intended to be literally kept in educator's pockets to prompt routine use in the field. Through repeated use and practice across varying learning activities, tools such as these act as means of disciplining the subsidiary awareness of educators that determine their spontaneous responses to unfolding sensemaking. Alignment of material tools and ideological resources (design commitments) are designed to support relationally responsive pedagogical mediation in ways that cultivate educator interpretive power. Concretely, preparation for such a role includes practices such as place designing or moving through local places and building an immediate and ongoing experiential relationship with the place to better identify the affordances and constraints for learning by collaborating with particular places prior to implementing the FBSS (Learning in Places Collaborative, 2022; see also Chapter 2 for a deeper uptake of place-designing).

Emergent Place-Facilitated Inquiry

As is suggested by the formulation of the terms ethical wondering with people, places, and more-than-humans, this orientation towards learning and teaching recognizes the agency of the more-than-human world, including how places and lands themselves are active facilitators of sensemaking (Barnhardt & Kawagley, 2005; Brayboy & Castagno, 2008; Deloria, 1999). That is, lands and the more-than-humans the inhabit them are not simply assemblages of semiotic

resources awaiting human engagement and interpretation, they themselves are deliberate social and pedagogical actors who actively facilitate particular ways of knowing and being (Simpson, 2014).

Supported by movement within places, spatial indexing, and disciplined pedagogical mediation, our design positions places themselves as spontaneously coordinating attention and continually renewing contexts of inquiry. We foreground the role of place in recognizing how lands themselves are active and agentic facilitators of inquiry, including how educators can recognize lands, waters, and more-than-human beings as participants and co-teachers who can and do contribute to speculative and deliberative processes through directing noticings, modeling open speculation, and elevating relational dynamics (see also, Lees et al., 2021). Across the following 3 segments we see the interactional manifestations of our aim to design field-based learning in ways that foreground spatial and relational epistemologies within the facilitative capacities of place. In so doing, we demonstrate how Ms. Dalia and the place itself act as co-facilitators of inquiry alongside Jiah and the rest of their group through open-ended inquiries that necessitate ongoing engagement with various more-than-human beings they encounter as the walk unfolds.

Excerpt 2.1: Segment 21 "Oh! What are these?". This excerpt occurs as children have begun to notice, wonder, and ask questions about a range of fallen plant parts. Some notice a large chunk of bark with a slug crawling along it, others ask questions about the structure and function of thorns on the blackberry vines. A focal participant in this analysis, Jiah, begins encountering "seedpods". Mediated by educators *and* places, seedpods are positioned as dialogic partners in sensemaking alongside Jiah, Ms. Dalia, and the rest of their group. As a seed of another sort, these observations come to prompt and inform investigative trajectories that are

carried forward throughout (and beyond) this walk.

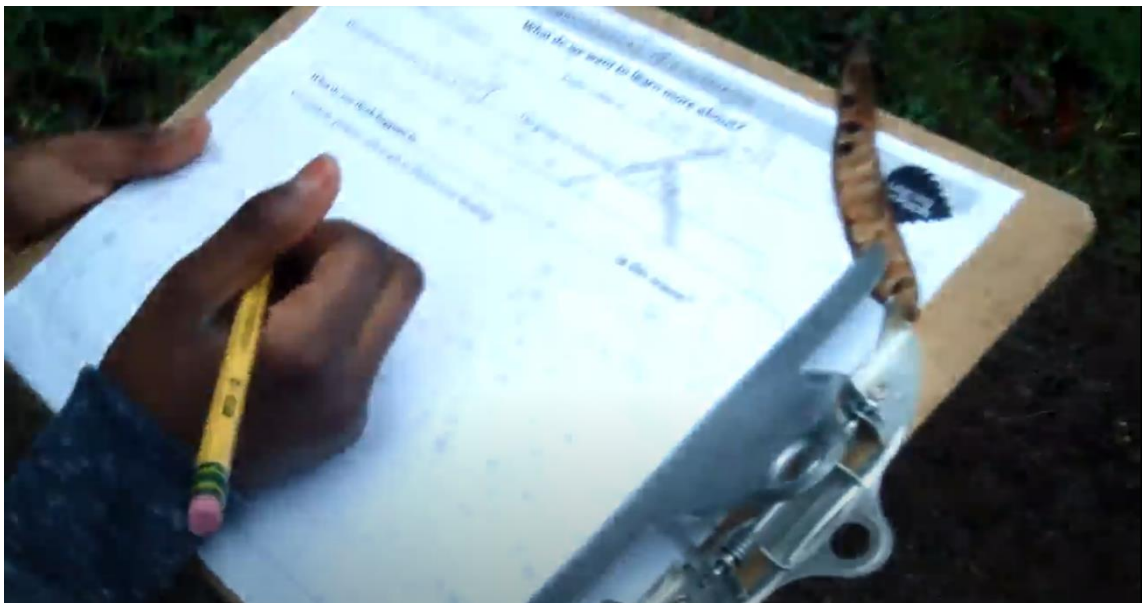
1	Jiah:	Oh! *[crouches down to pick up Seedpod]*
2		What are these? *[shows Seedpod]*
3	Ms. Dalia:	That looks like what you were looking at before doesn't it?
4	Jiah:	Mm-hmm (affirmative).
5	Ms. Dalia:	I think that's something we might want to draw…
6	Jiah:	Okay. Did that come from a tree?
7	Ms. Dalia:	You know, I'm wondering if it did.
8		That would be pretty exciting.
9		I wonder what kind of tree it would come from…
10		I'm, you know what… I'm curious...
11	Jiah:	Down- Down by the helicopter tree, I think it came from that.
12	Ms. Dalia:	That's a good, that's a good hypothesis.
13		Look at this one. *[pick up another Seedpod]*
14		*[both looking at Seedpod]*
15	Ms. Dalia:	Here, I'll hold it as we walk, okay?
16	Jiah:	Mm-hmm (affirmative).
17	Ms. Dalia:	So you're seeing that there's something similar about this?
18	Jiah:	Mm-hmm (affirmative).
19	Ms. Dalia:	Here. You know what we can do? *[clips pod onto clipboard]*
20		Is that okay?
21	Jiah:	Yeah.
22	Ms. Dalia:	So how do you think this and trees are related?
23	Jiah:	Because these ones I saw on a helicopter tree and I thought they
24		were related, but I was not sure.
25	Ms. Dalia:	Yeah?
26	Jiah:	I'm pretty sure they like the water.
27	Ms. Dalia:	You pretty sure they like water? Was it floating?
28	Jiah:	Mmm - Mm-mm (negative).
29	Ms. Dalia:	There was it? Oh, so what makes you think it likes water?
30	Jiah:	Mmm. I don't even know.
31	Ms. Dalia:	Well, let's keep our eye out for more of them. And you know
32		what we could do? If we think they come from trees we could
33		look up in the tree and see if there's any still hanging there.
34		Don't you think?
35	Jiah:	Yeah.

The beginning of this transcript excerpt comes after Jiah has moved away from the group in search of other fallen plant parts. After a brief pause, she accelerates towards something she's noticed. An affect of wonder and excitement attends her exclamation "Oh!" as she crouches down to pick up what the place has facilitated into her attention –a "seedpod" (line 1). She then

approaches the group and asks, “What are these?”. Focusing on seedpods in isolation, Jiah’s taxonomic request tacitly assumes a more expert other will respond with a categorical response (“These are X”), and likely anticipates a discursive closure upon being provided the “correct” answer. Instead, Ms. Dalia toggles backwards in time connecting this moment to Jiah’s prior observations (line 3). This move is expansive insofar as it locates Jiah’s immediate wondering within an unfolding process of inquiry, which she then uses as a pivot towards representational activities (i.e., drawing) designed to attune Jiah’s attention towards more focused modes of noticing (line 5).

Figure 3.2

Multimodal Representation with Seedpod



It is important here that Ms. Dalia suggests a possible way forward, rather than demanding representational compliance (i.e., filling out the observational tool in a prescribed way). Using the tentative and provisional language of “I think” and “might” (line 5), Ms. Dalia frames her statement as a recommendation rather than a directive that requires compliance. This move contributes towards a flattening of her adult authority in the activity, instead recognizing

Jiah and Seedpod's own agencies in how they might pursue the work of getting to know one another better through suggesting another mode of interaction (drawing). Although it is Jiah who would be drawing Seedpod, in using "we" rather than "you" here Ms. Dalia communicates that this possible mode of representation is one of joint activity between at least Jiah, Seedpod, and herself; Jiah may hold the pencil, but the activity itself arises and carries forward only through the joint participation of Jiah, Ms. Dalia, and Seedpod together (Goodwin, 2017). Through these moves Ms. Dalia temporally extends the interaction into the past and future, while ceding decision-making within the inquiry to Jiah in ways that expand activity through joint activity where seedpods and the place itself are treated as agentic contributors.

Following an acceptance of Ms. Dalia 's suggestion, Jiah also toggles backwards in time as she takes up a more relational lens in questioning the origins of the Seedpod (line 6). Jiah continues to position Ms. Dalia as a more expert other, but shifts the forms of her question from a taxonomic request (what kind) to closed "binary" or "polar" question (one that anticipates a simple yes or no). Instantiating core design principles in interaction, Ms. Dalia resists moves towards epistemic enclosure through responding with a processual reframing via wondering (lines 7 & 9), excitement (line 8), and curiosity (line 10). Ms. Dalia casts the inquiry forward in both time and place, motivating continued engagement with the Seedpod and prompting speculative claims that necessitate continued walking and reading land with Seedpod (line 11) (Marin & Bang, 2018).

As the investigation shifts towards focusing on the origin of seedpods, Ms. Dalia repeatedly coordinates group attention towards more focused forms of noticing and wondering as foundational to their inquiry process (e.g., lines, 5, 13, 17, 31-34). Though spatial indexing Ms. Dalia positions Seedpod as an important partner in conversation and agentic participant (lines 14,

19, 29, 31) in the unfolding inquiry who, through close noticing and wondering, can teach them about their role, relationships, structure, and function in this particular place.

Of consequence for how this interaction develops across the wondering walk as a whole is Ms. Dalia's moves bring Seedpod with them as they continue to investigate (lines 13, 15, 19). This move positions Seedpod as an agentic conversation partner that can and will assist the group in noticing similarities and differences. The improvisational move to put Seedpod on Jiah's clipboard (line 15) turns out to be deeply consequential: it positions Jiah in a direct physical and dialogic relation with Seedpod over the duration of the walk (decentering of Ms. Dalia's facilitative centrality) while simultaneously expanding the representational capacities of Jiah's clipboard in ways that recognize the centrality of Seedpod themselves in facilitating inquiry. That is, seedpods themselves are understood as mediating emergent representational comparisons rather than centering human mediation. This is exemplified in lines 31-34 when Ms. Dalia again expands a possible discursive closure through attuning group attention to forms of noticing directly connected to Jiah's emerging hypotheses (lines 11, 23-24, 26).

This excerpt represents how Seedpod is facilitated into emergent inquiry through agentic capacities of the place itself alongside design-disciplined mediation at the micro-interactional level. The following excerpts build on this theme through further highlighting the facilitative capacities of places and more-than-human beings within open-ended pedagogy enacted through mobility within and through places themselves.

Excerpt 2.2: Segment 32 "Maybe we should keep walking and see…". This excerpt takes place approximately 12 minutes after excerpt 2.1. In this time, co-operative activities of place, Jiah, and Ms. Dalia have situated seedpods as the focal phenomena and more-than-human conversation partner in more and more durable ways. Jiah has continued to collect seedpods on

her clipboard and organize them into loose groups intended to make similarities, differences, and patterns easier to identify. In the time between segments, these activities have drawn several other students into the unfolding inquiry as they collectively notice patterns in seedpods with an increasing affect of excitement, awe, and curiosity. The epistemic and affective momentum gradually builds as each new Seedpod encountered offers an exciting opportunity to clarify, complicate, or otherwise inform complex socio-ecological sensemaking about the roles, relationships, structure, function, lifecycles, and species diversity of various seedpods. This excerpt represents a characteristic example of the activities happening during this time that empirically reinforce the major points developing in this section.

1	Sash:	Look a tiny one.
2	Ms. Dalia:	That is a tiny one.
3	Sash:	I found a tiny one
4	Jiah:	That's really cool. But this one is tinier. *[shows seed]*
5	Sash:	Yeah
6	Jiah:	Haha! Wow my thing is so cool.
7	Sash:	This one is salmon colored. Like it's this color on this side, and
8		*[flips pod over]* then it's like that. *[flipping pod back and forth]*
9	Ms. Dalia:	Yeah. Do we have any guesses?
10	Sash:	I don't know.
11	Jiah:	Yeah, me too.
12	Sash:	Maybe we should keep walking and see if we can find any more-
14	Jiah:	Oh! I found it again!
15	Ms. Dalia:	Ok, let’s keep walking
16	Sash:	-Or if they just like stop here

Here we see additional evidence that suggests how movement within places expands opportunities for more-than-humans themselves to facilitate noticings that can give rise to wonderings about the nature of what human participants are encountering. Specifically, by this point in the walk the group is engaged in more detailed noticings with regard to difference in form and structure (size, shape, color) of seedpods (lines 1-5, 7-11). Attended by an ongoing affect of excitement and genuine interest within the process of inquiry (e.g., lines 1, 4, 6, 14) Ms.

Dalia continues to encourage speculative sensemaking and open wonderings about what they are noticing (line 9).

Of particular interest here is how principles of design are gradually being taken up by youth who are not directly familiar with formal co-design processes. Specifically, Sash's response to Ms. Dalia's prompt (line 12) reflects our designed focus on speculative and processual inquiry that necessitates ongoing interaction with more-than-humans. We take Sash's suggestion that "maybe we should keep walking and see if we find any more" as evidence of how he is internalizing and enacting an orientation toward how ethical wondering with people, places, and more-than-humans can guide socio-ecological inquiry. That is, after only 3 wonderings walks (he was absent for 1), and in only a few short minutes with this group, he has picked up on and is running with Ms. Dalia's facilitative ethic towards the open-ended and processual nature of field-based inquiry within wondering walks.

Excerpt 2.3: Segment 37 "Can you show me what you mean?". These themes continue to develop in excerpt 2.3 where Sash proposes a more focused line of speculative inquiry through putting natural kinds into conversation with one another (i.e., direct comparison). These represent further enactments of key design principles through foregrounding the semiotic capacities of place and necessity of more-than-human participation in moving inquiry forward.

1	Sash:	Maybe that can give us a clue, like, we could find on each tree
2		we see. *[referring to seedpods found attached to small twig]*
3	Jiah:	Oh look, look. This is just like this one.
4		Sash said, if we see a tree we should like-
5	Sash:	-test it on every tree we see. Like this, you could test it on that
6		tree.
7	Ms. Dalia:	Can you show me what you mean by test?
8	Sash:	Like we could take this and then put it on the tree and see if it
9		works… *[holds up twig to nearby tree]*
10	Ms. Dalia:	Oh I see what you're saying. So if there's similar…?
11	Sash:	Yeah because this one's really thin and bendy.
12		Let's keep walking and see if we can find one that has like more

13		than one on it.
14	Ms. Dalia:	I know, so we've been looking down. I'm wondering if we
15		should try looking up...
16	Jiah:	There's lots of V's and then helicopter seeds.
17	Ms. Dalia:	Yeah. Oh my gosh, guys! *[moves to tree, looking up at branch]*
18	Sash:	What? That might be it.... no.
19	Ms. Dalia:	These are slightly different.
20	Sash:	Yeah. Those are like pinecones.
21	Ms. Dalia:	They are like little pinecones.
22		I don't want to pull it off the tree because I'm worried...
23		It'll let go when it's ready, but I'm seeing tons of them!
24	Sash:	Yeah!
25	Jiah:	What?
26	Sash:	Or maybe like they're covering the pinecones when it's too big
27		they break out?
28	Jiah:	Sash did you ever touch them?
29		*[holds out clipboard and all 3 touch Seedpod]*
30	Sash:	Hm, those are like beans...
31	Ms. Dalia:	Oh wow. So you've got to look up, you've got to look down.
32	Sash:	Another one! I know, there's lots of them, yeah!
33		There's a bunch right here.
34		They're different - these ones are different.
35		Maybe they're growing... Jiah!
36	Jiah:	There's one right here.
37	Sash:	Jiah! We found like baby ones

Figure 3.3

Co-Operative Action between Jiah, Sash, Ms. Dalia, and Seedpod

In this excerpt we give an extended example of how place continues to present opportunities to compare species and kinds. Through such facilitation, the physical and conceptual trajectory of investigation as noticings and wonderings emerge, collide, and are woven together in an affect of awe and excitement through embodied activity and skillful pedagogical mediation. Continually supported through Ms. Dalia's use of design-disciplined improvisational discourse (e.g., lines 7, 14-15, 17, 31), Sash and Jiah orient to the facilitative capacities of place as they propose numerous spatially situated trajectories through which they might understand more about Seedpod's role in this place (lines1-6, 8-9, 11-13, 18, 28-30, 32-27).

In so doing, this excerpt highlights how our work aims to expand the development of interpretive power (Rosebery et al., 2016) beyond application to human sensemaking towards an understanding of how places themselves support particular forms of sensemaking. Acting from this expansive uptake of interpretive power requires a deep trust in the intellectual capacities and facilitative agency of young people, places, and more-than-humans kinds; an understanding that their contributions to emergent learning trajectories come already infused with sophisticated socio-ecological themes and potentialities. Cradled within a relationally responsive orientation towards field-based inquiry (Shotter, 2012), this excerpt evidences how such a stance generates opportunities for truly participatory complex socio-ecological sensemaking emerge through repeated noticings and wonderings that that recognize the agency of youth, places, and more-than-humans in investigating the structure, function, and behaviors of seedpods within this place.

Structure, Function, & Behavior of Places, Species, & Kinds

Through disciplined pedagogical mediation and expansive forms of participation with place and more-than-human beings, we see the emergence of an increasingly sophisticated

scientific inquiry into the structure, function, and behavior of seedpods placed in relation to other species and kinds. Noticing and wondering about patterned variance in color, size, and behavior of seedpods while moving through this place opens up spontaneous opportunities for inquiry that cascade forward through resulting in sustained engagement with concepts, criteria, techniques of categorization, and other disciplinary ideas core to methods in field-based science (NGSS 2013/2017). Evidencing this more concretely, the following excerpts elevate interactions where human participants speculate on emergent patterned relationships through improvised experimentation, thereby instantiating fundamental claims of epistemic and ontological categories within expert scientific practice.

Excerpt 3.1: Segment 30 "Let's see if they get darker or lighter as we walk"

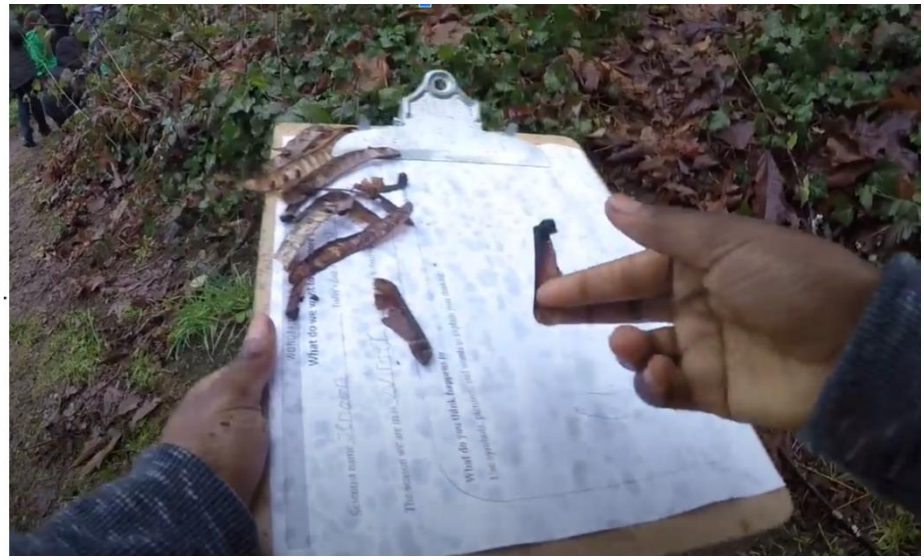
1	Sash:	Look at this one! *[showing seed]*
2	Ms. Dalia:	Oh that one still has a seed in it?
3	Sash:	Looks really dead, but…
4	Sash:	But this one's really light, if you flip it over. *[turns Seedpod*
5		*over]* It's really light.
6	Jiah:	And wow this one *[pointing]* is really dark.
7	Ms. Dalia:	And that one's *[pointing]* really dark.
8	Sash:	Like this one… *[pointing]*
9		[Jiah picking up many more]
10	Ms. Dalia:	So I'm wondering, so as we walk, let's see if they get darker or
11		lighter as we walk. Or as we walk if we notice that some of the
12		lighter ones are like on something different.

As the group continues to collect and compare a of seedpods, they begin attending to structural traits of various seedpods (lines 1-2). Thinking with more and more seedpods, this leads to speculation on the relationships between stage of life and apparent difference in form and color (lines 3-8). Even in this short excerpt, we see the central role of spatial indexing used by Jiah, Sash, and Ms. Dalia in directing attention towards noticings particular similarities and differences (lines 6, 7, and 8). This catalyzes continued tactile engagement with seedpods in the

moment (line 9), which carries forwards through disciplined reframing (line 10-12) that positions emergent noticings and wonderings part of mobile and embodied investigative processes. That is, Ms. Dalia models speculation on how through movement and close noticing might reveal differences in relationships between place and the structure of seedpods.

Figure 3.4

Collecting, Comparing, and Contrasting the Characteristics of Seedpods



Following from our broader conception of ethical wondering with people, places, and more-than-humans, we understand interactions like these as procedurally consequential in how they laminate key orientations to investigations together in ways that afford deeper engagement in future interactions through elevating a broader range of semiotic resources. In segment 3.2 we see how these spatially situated investigative trajectories bring the group into place-facilitated interactions with increasing variance of seedpods that they continue to excitedly compare and experiment with as the investigation deepens.

Excerpt 3.2: Segment 32 "Can I try something…"

1	Jiah:	Look how many things we found!
2		There's lots of helicopter trees over there…

Ms. Dalia: Uh-huh
Jiah: … in the bush hiding. Oh Sash almost stepped on one.
[all crouch down around clipboard]
Ms. Dalia: You know what I find really interesting? Is that… These seed pods. *[picks one up]* So these have spaces for lots of seeds whereas this one only has the one seed…
So, I wonder why some plants...
Sash: And it's like dark here. [shows seed]
Ms. Dalia: And then lighter right there. Yeah.
Sash: Yeah. Or it's like super dark cause then it gets a little lighter.
Ms. Dalia: Can I do something? Can I try something? I'm going to try dropping this from up high to see what happens. Okay?
Sash: Okay.
[Ms. Dalia drops seed]
Sash: Doesn't look like a helicopter seed… Let's try a hel...
Ms. Dalia: Yeah… May I try this one?
Sash: Yeah.
[Ms. Dalia drops seed]
Ms. Dalia: Huh. That one just kind of dropped too.
Sash: Yeah.
Ms. Dalia: Didn't really do what I was expecting.
Sash: Helicopter?
Ms. Dalia: Mmhmm (affirmative). I'm wondering if maybe the rain...
Sash: Oh double! [shows seed]
Ms. Dalia: Oh that's cool! You found a double one!
Jiah: That makes a V.
Ms. Dalia: A V?
Jiah: Yeah it looks like a V. I found one that's light and dark.
Ms. Dalia: I wonder... So one of my questions is like why are they shaped differently?
Jiah: I don't even know.
Ms. Dalia: Why do some of them have more seeds or no seeds?
Jiah: Why is there a light one on the bottom and a dark on the top?
Sash: Yeah, it's like a gray. Or something.
Ms. Dalia: So we think that color might be important?
What do you think the color might be important for?
Sash: Maybe like, to camouflage itself? Like, like
Jiah: I think that's the thing that Akan had... Oh no. Wow. Oh these orange things are just like this, but orange.
Sash: Yeah. Maybe they're like rotten ones.
Ms. Dalia: Rotten ones? Because they've been on the ground for a while? So kind of how the leaves turn kind of a darker brown color?
Sash: Look this one has a brownish color *[pointing]*
[Jiah gathering more]
Ms. Dalia: So maybe…Maybe it tells us on how long they've been on the ground?

49	Sash:	Maybe…
50	Ms. Dalia:	So maybe, so one thing is maybe the longer they've been on the
51		ground the browner they are?
52	Jiah:	[Gasp!] Oh I found another dark and light one.
53	Ms. Dalia:	Another dark and light one?
54	Jiah:	Yeah. Like this and like that. And they also have the kind of
55		bean things on it.
56	Sash:	Yeah maybe it's like a source of beans?
57	Jiah:	Two! I wonder how, why they're not the same like amount of the
58		things? That one has one, that one has two, and that one has one.

Figure 3.5

Ms. Dalia Drops Seedpod while Group Observes

In both excerpts 3.1 and 3.2 we see how places themselves present variations in traits that youth spontaneously notice and wonder about. Specifically, this group is wondering about the semiotic and relational relevance of variations they are noticing in the structure and function of seedpods (i.e., the meaning shape, color, and number of seeds relative to Seedpod origin and immediate conditions). That is, what complex ecological relationships cause these varying characteristics to be in the first place? Toggling across temporal scales, the tacit assumption that

to understand seedpods, we must understand how they come to be the way they are now. In this excerpt, this toggling is carried out, in part, by an improvised experiment that replicates Seedpod's journey from tree to ground (lines 13-25).

As seedpods accumulate on Jiah's clipboard and various spatial trajectories emerge, Ms. Dalia makes a series of pedagogical moves which elevate noticings, wonderings, and Seedpod themselves (lines 6-9) Launching through her routine practice of asking for consent before taking action, Ms. Dalia moves to performing an emplaced experiment with Seedpod (lines 13-14). Designed from emergent noticings and wonderings, we understand this kind of field-based experimentation as disciplined form observation with more-than-human beings that shares epistemic agency through positioning seedpods themselves as teachers. In dropping varied seedpods from an elevated height, Ms. Dalia places seedpods into direct conversation with air and gravity, supporting opportunities for seedpods themselves teach about their structure, function, and/or behavior in this place (lines 16 & 20). As a form of embodied improvisation with places and seedpods, this experiment spatially indexes Seedpod relations across temporal scales through partially recreating the relational dynamics that guided Seedpod from their place of growth to the ground they now lay upon.

These emplaced experiments open up discursive space in which participants begin to speculate on the (unanticipated) results to make sense of why neither seemed to spin (lines 17, 21-25). As Ms. Dalia is posing a potential explanation (line 25) the place presents Sash with an exciting and novel noticing in the form of a "double seedpod" (two pods that appear attached to form a V-shape), a variance in structure that the group has yet to encounter (lines 26-28). Improvising again with these emergent noticings, Ms. Dalia elevates key scientific concepts in wondering aloud about why this variation in structure occurs in the first place (lines 31, 34, 37-

38). Elevating multiple noticings via wondering in this way works to attune attention and focus sensemaking through weaving together semiotic resources developed through ongoing noticings and recent experimentation. Indeed, such experimentation provides new forms of evidence to make sense of relations between places and more-than-human beings, resulting in speculative explanations for structural and behavioral variations that account for more a more complex range of Seedpod's relations (lines 38, 42-51). Of consequence for future actions, we speculate that this form of improvised experimentation with places and more-than-humans contributes to Sash's proposed experimental trajectories analyzed above in excerpt 2.3.

The mediated emergence of such complex scientific reasoning within the open-ended structure of wondering walks in segments like these has deep implications for our design work. For example, common approaches to the design of learning activities begin with relevant science standards as a means of isolating particular learning goals, pre-determining process of inquiry, and settling on specific learning outcomes before implementation of such activities has occurred. In contrast, while we do attend to content standards in our design of learning activities, they do not lead design processes from the outset. Rather, we lean into a logic of emergence and a 'trust in the processes' of place-based inquiry as grounded in key project principles and supported through disciplined pedagogical mediation with people, places, and more-than-humans. While educators certainly are involved in ongoing development of the skill sets (building skills in disciplined pedagogical mediation see lines 6-9, 13-21, 31-34, 43-44, 47-51) needed to improvise with the array of emergent semiotic resources, we foreground designing structures that support educators in recognizing the capabilities of children, more-than-humans, and places to generate and sustain sophisticated complex socio-ecological systems reasoning over any particular set of content standards

This is because we view predetermined curricular paths designed from content standards as overly constraining in ways that tend towards squashing genuine awe, wonder, and curiosity out of learning activities. Counterfactually, the routine emergence of such sophisticated scientific sensemaking in this walk evidences how engaging in the activities, processes, and forms of sensemaking supported through the Learning in Places ecosystem (i.e. wondering with people, places, and more-than-humans) can result in consequential opportunities for complex socio-ecological learning that still engages learners in a broad range of scientific content standards. That is, what emerges through 'trusting in the processes' of design and implementation through Learning in Places is expansive opportunities for personally relevant socio-ecological investigation via more authentic and contextualized means. In contrast to rather than in learning arrangements where educators have already decided on key phenomena, questions, and investigative trajectories prior to implementation of activities, learning in and with places in the way we have described often occurs in more preferable, relationally-responsive social arrangements through the authentic participation of youth, places, and more-than-human beings.

As additional evidence to this point, and building on the methodological innovation introduced above, we coded all interactional segments in this walk for engagement with NGSS DCIs for 2nd and 3rd grades to demonstrate how alignment with content standards emerges without the need of rigid, linear, or wholly teacher directed pedagogy (see coding and segmentation examples in appendix 3a). Specifically, we note the comparatively higher degree of DCI engagement around emergent phenomena, seedpods in particular. Collectively, we assert that such a pedagogical orientation lays the groundwork for ethical socio-ecological deliberations that come into focus as movement through the FBSS progresses.

Expansive Embodied Perspective Taking

Informed by our grounding in research on culture, cognition, and complex systems reasoning, we explicitly designed learning activities in ways that support noticing, wondering, and deliberating about phenomena from multiple perspectives. *Perspective taking* (Medin, et al., 2006; Medin & Bang; 2014; Unsworth, et al., 2012) was instantiated through considering varying socio-ecological situations from the perspectives of other natural kinds (e.g., plants, animals, fungi, water, etc.), as well as processes and relations to space and time (e.g., Pugh et al., 2019). Design for such perspective taking was intended to support thinking (toggling) across spatial and temporal scales in ways that support relational orientations towards the world (Cajete, 1999a) necessary for complex systems thinking (Wilensky and Resnick 1999; Olson, 2015). Attendant to our focus on desettling normative nature-culture relations (e.g., Bang et al., 2013), our design supports routine perspective taking to facilitate recognizing reciprocal relationships between and among people, places, and more-than-humans. In so doing, we take seriously how understanding the many ways in which human activities exist within webs of socio-ecological relations is a significant indicator of complex systems thinking and socio-ecological decision-making that requires toggling between multiple human and more-than-human perspectives.

Throughout the FBSS, and within this walk specifically, participants engage in varying forms (and levels) of perspective taking that contribute to developing relational orientations that recognize the agency of more-than-human actors within unfolding inquiry. We argue that routine noticing and wondering from more-than-human perspectives is not only necessary for complex ethical deliberation and decision-making, but also can contribute towards the cultivation of mental models and sensemaking landscapes where humans are recognized as a part of the natural world. Specifically, we highlight moments of pedagogical practice where participants ascribe

intentional states and agentic decisions to more-than-human beings through spatial indexing, embodied displays, and dialogic modes of co-operative discourse that foreground the fundamental relationality of humans, places, and more-than-human beings.

Excerpt 4.1: Segment 19 "I wonder if snails do the same thing". Emerging in parallel to the group focusing on seedpods, the following segment illustrates an instantiation of embodied perspective taking relative to noticing a snail on a fallen piece of tree bark. In line with the analysis above, we again see how noticings are first facilitated into attention by place, then improvisationally mediated by Ms. Dalia through an affect of wonder. Through this orientation, an interaction emerges wherein Ms. Dalia takes the perspective of Snail to support emergent speculation on their inner psychological and emotional states.

1	Kirk:	It's a snail! It's a snail!
2	Ms. Dalia:	Whoa. I wonder if that one's a snail. I wonder if when they're
3		curled up like that-
4	Ms. Amy:	Oh Samuel, I love how gentle you're being.
5	Ms. Dalia:	Yeah.
6	Kirk:	That is so tiny.
7	Ms. Dalia:	Have you guys ever been so afraid of something, and you curl up
8		really tight and go like this *[crouches bringing head down and*
9		*arms in]* and then emerge like this *[reverses movement and*
10		*expands body outward]* when you're feeling more comfortable?
11		I wonder if snails do the same thing…
12	Jiah:	Yeah.
13	Ms. Dalia:	I wonder-
14	Akan:	Slugs do the same as snails…
15	Jiah:	I think He already did it. I think He already did it. *[pointing]*

As this group is observing Snail, Ms. Dalia enacts a design-disciplined improvisation intended to bridge nature-culture relations through use of her own body (lines 7-10). Through embodied recognition and speculation on a Snail's inner state (fear) based on noticings of Snail physicality (being curled up), Ms. Dalia models the beginning of an affective relationality between the living form of humans and more-than-humans towards pedagogical ends. Using her

own physical form as a spatial and relational index for "tiny" Snail (figure 3.7), Ms. Dalia closes the perceived distance between human and more-than-human forms of being through foregrounding the ontological relationality of their bodies. Taking the perspective of Snail in this way laminates diverse semiotic resources (e.g., gesture, emotions, speculation, and size alongside the physical forms of Snail and Ms. Daliah) into the attentional field, thereby amplifying meaning making at the nature-culture boundary – blending the corporeal and the conceptual to nurture expansive forms of socio-ecological sensemaking.

Figure 3.7

Ms. Dalia Uses Body as Index for Slug

Though this particular pedagogical support was not planned, it was no accident either; support for perspective taking is built into our work by design, to be drawn on in spontaneous moments in place-facilitated instruction. Across our materials (learning engagements, frameworks, etc.) are prompts and scaffolds that encourage participants to routinely consider multiple perspectives in expansive ways. For example, participants might be encouraged to "follow the path of water" and consider "who do you meet on your journey?" or they might "imagine what it would be like to be [a particular] tree" and "what stories might that tree tell us from its life living in this place?". Adequately supported, routine perspective taking cultivates

psychological closeness with the rest of the natural world associated with greater attention to the contextual and relational complexities of ecological systems (Medin & Bang, 2014; Pugh et al., 2019).

Over the course of engagement with the FBSS, it is our design intention that perspective taking activities such as contribute towards normalizing a sensemaking landscape in which humans are positioned as a part of the rest of the natural world. In recognizing more-than-human beings as having relatable agentic capacities and emotional landscapes to our own, the undeniable interconnectedness of our ontological similarities resources experiences of awe and wonder as stitched into the substrate of semiotic unfoldings; not always the primary focus, but always a guiding orientation stitched into the background of collective activity. We would want a much larger creature to be gentle with us (line 4), thus praise for being treating another body delicately and with care aims at reinforcing reverence to more-than-human beings, building with our core assumptions that beings such as trees, snails, and seedpods have relatable psychological and physical states. Thus, it makes sense to compare fundamental qualities of experience (fear, comfort, belonging, etc.), in ways that desettle affective hierarchies between human and more-than-human beings. These themes carry forwards as the group goes on to deliberate about the best place to leave the slug where they can be safe and comfortable (i.e., excerpt 6). The next section of analysis build on these empirical accounts of deference to more-than-human beings, or what we have characterized as *complementary* orientation toward nature-culture relations (Bang et al., in prep; Bang & Marin, 2015; Montaño Nolan et al, accepted, see also Chapter 2).

Complementary Nature-Culture Relations

Nature-culture relations reflect particular epistemic, ontological, and axiological orientations that are consequentially implicated in processes of deliberation and decision-making

(Bang & Marin, 2015; Bang et al, in prep, Montaño Nolan, accepted; McDaid Barry et al., 2023). How we understand the relationships between humans and the rest of the world is a determining factor in who is considered knowledgeable, whose perspectives are valued, and whose lives and well-being are prioritized within social processes of deliberation and decision-making. A fundamental design principle in our work is concerned with desettling and re-making nature-culture relations towards landscapes of sensemaking that recognize humans as a part of the natural world through supporting complex socio-ecological sensemaking (Bang et al., 2014, Bang & Marin, 2015). That is, we design systems of activity and mediate emergent interactions from a principled understanding of how noticing, wondering, and investigating about and within complex socio-ecological systems supports the understanding that we are all related in reciprocal webs of relationality.

Throughout the data reviewed thus far, we see how Ms. Dalia's improvised pedagogical mediations tend towards those that recognize more-than-human beings as dignified participant in inquiry as they investigate emergent patterns through routine walks. For example, in excerpt 2.3 Ms. Dalia recognizes the dignity and agency of Pinecone when she verbalizes and acts from a sense of worry about pulling them from a tree, noting how "It'll let go when it's ready" (line 23). Suggesting how design principles are being taken up by youth, we also see instantiations of similar orientations towards the agency of more-than-human beings when Jiah suggests trees and seedpods are actively hiding among the bushes both in excerpt 3.2 (line 4), and again below in excerpt 5.1 (line 7). Similarly, the improvised moments of perspective taking analyzed in the previous section (excerpt 4.1) reflect this socio-ecologically expansive ethic insofar as the more-than-human beings and places are assumed to exercise agentic capacities and possess relatable states of being. Building with analysis so far, excerpts in this section demonstrates the

development and deployment of a more powerful and explicit nature-culture reframing through improvised comparisons between seedpods and humans that indexes their fundamental ontogenetic relationality.

Excerpt 5.1: Segment 21 "They almost look like little babies, don't you think?".

1	Jiah:	What are those? Are those slugs?
2	Ms. Dalia:	No. Look, they're attached to the pod. *[pointing]*
3	Jiah:	Oh.
4	Ms. Dalia:	What do you think-
5	Jiah:	Oh, there's more over there. *[pointing]*
6	Ms. Dalia:	There's more over there?
7	Jiah:	Yeah, just hiding. Are they little beans?
8	Ms. Dalia:	Oh, that's a good thought. Little beans. They do have-
9	Jiah:	What's that line attached to them? *[pointing]*
10	Ms. Dalia:	I'm going to hold this down so you can see it on there.
11	Jiah:	Yeah.
12	Ms. Dalia:	They almost look like little babies, don't you think?
13	Jiah:	Yeah. Like-
14	Ms. Dalia:	Like a little baby?
15	Jiah:	Mm-hmm (affirmative).
16	Ms. Dalia:	I wonder if this little, little, tiny baby is going to grow up into a
17		big, big tree. Maybe three big trees.
18	Jiah:	That are attached!
19	Ms. Dalia:	That are attached?
20	Jiah:	Mm-hmm (affirmative). And I think I know it's winter, oh
21		maybe that tree that Akan has came from these ones.
22	Ms. Dalia:	Like this? *[pointing]*

Connecting temporally across the walk, Jiah orients group attention through recalling previous observations (slugs) as interpretive framing to wonder about the latest seedpod that she has encountered (line 1). Though Ms. Dalia's response reads initially as a discursive closure ("no"), she then directs attention to the relationship between seed and pod to positions them able to contribute towards answering Jiah's question (line 2). Deferring to Seedpod, she suggests that closer observation of Seedpod would give insight into their structure, behavior, and relations with other kinds (they have *answerability:* see Bakhtin 1986; McDaid Barry et al., 2023).

Recognizing Seedpod as answerable to Jiah's noticings and wonderings thus simultaneously contributes towards the normalization of complementary nature-culture relations and dignified educator-learner relationships through reducing onto-epistemic hierarchies and promoting axiological shifts among adults, children, and more-than-human beings.

Potentially reflecting how design principles are increasingly guiding youth sensemaking, A similar orientation towards the agency of seedpods is also evident in Jiah's discourse as she then toggles to include more seedpods further instantiating seedpods as dialogic pedagogical partners capable of agentic decisions (i.e., to hide, line 7). Toggling back to a detailed focus on a single seedpod, Jiah then asks about the line connecting them (line 9). Supporting more focused observation, Ms. Dalia helps her get a better look (line 10), before then making a direct comparison between seedpods and babies (lines 12-17). Jiah then playfully speculates on how they might all grow up attached (line 18) before re-engaging and earlier trajectory of investigation (lines 20-21), thereby renewing the focus on local evidence of seasonal change as it has developed over the recent observations. The group goes on to speculate about Seedpod's relationship to seasonal rhythms while students continue to collect and catalog various seedpods on Jiah's clipboard.

In a similar reengagement of earlier investigative trajectories, the connection between seedpods and babies emerges again 20 segments (approximately 18 minutes) later in the walk. In the following excerpt, attention is again drawn to the connection between seed and pod in ways that expand opportunities for more ethical socio-ecological sensemaking.

Excerpt 5.2: Segment 41 "That's the tree's womb".

1	Sash:	I think as you go on they get longer and longer.
2	Ms. Dalia:	They do?
3	Jiah:	Oh they're all apart.
4	Ms. Dalia:	Whoa.

5	Jiah:	Wow that's lots.
7		[crosstalk: other group walking by]
8	Ms. Dalia:	Jiah can we look at one of these real quick? Let's see if we can
9		find one. *[picks Seedpod up from clipboard]*
10		See how the little seeds are connected?
11	Sash:	Oh yeah.
12	Ms. Dalia:	You know what it reminds me of?
13	Jiah:	A line?
14	Ms. Dalia:	So I have two kids. And when they were in my tummy there was
15		a cord that connected them. And when they came out we had to-
16	Jiah:	Cut the cord
17	Ms. Dalia:	Cut the cord - and so it makes me think of these as like the...
18	Jiah:	Little babies?
19	Ms. Dalia:	The trees. That's the tree's womb. And then these little babies
21		ones are-
22	Ms. Amy:	Alright guys. Time to come back up now.
23	Jiah:	Look how many seedpods we found.
24	Ms. Amy:	That's amazing you guys.
25	Sash:	Helicopter seeds, and these other seeds that we don't know
26		about.
27	Ms. Amy:	Oh I wonder if you can find out what they're called?
28		Wow that is so cool.
29	Sash:	Look at them. Seeds like when somebody's in your belly you
30		have something attached to them and then seeds that they have
21		something attached too-
32		*[Ms. Amy walks away]*

As the group is moving through place and drawing tentative conclusions about the form and function of Seedpod (lines 1-5), Ms. Dalia again asks for consent (see also segment 2.1 and 3.2) to pick up a seedpod Jiah has collected before highlighting variations in how different seeds are connected to their respective pods (lines 8-10). Of key interest here is how, grounded in her own experience as a mother, Ms. Dalia makes a direct comparison between seeds and babies (lines 14-19). More than just a passing remark, our enacted framework makes visible how recognizing the fundamental ontogenetic similarities between Seedpod and womb creates discursive moments and opportunities in which normative hierarchies between humans and the rest of the natural world are ruptured and a new possible ethical landscape becomes instantiated

(see also Kimmerer, 2013). If seeds are as babies, and womb is as Seedpod, then the fundamental relationality between more-than-human beings becomes the axiological grounds from which particular ontological practices and epistemic assertions becomes relevant, and even possible, in the first place.

Here we can clearly see the interactional manifestation of our design from complementary nature-culture relations emerge through routine practices with people, places, and more-than-humans. We contend that interactional moments like these shift the landscape of sensemaking in important ways that more accurately reflect the socio-ecological reality that humans do exist as a part of the natural world, and are thereby conducive to the development of dispositions towards ethical noticing, wondering, and deliberation. Small moments like these, reiterated over numerous learning engagements across a seasonal investigation, layer with and reinforce one another to progressively desettle and remake the axiological, ontological, and epistemic assumptions from which investigative activities unfold. Thus, it is our contention that such interactional manifestations of reciprocal and complementary nature-culture relations are central places where nature-culture relations are remediated in ways that offer expansive possibilities for sensemaking and decision-making towards more just and sustainable nature-culture relations.

Increasingly apparent across excerpts is an affect of playful and low-stakes intellectual engagement through open-ended noticing and speculation supported through movement within places. Through this dynamic, the inquiry gradually picks up interactional and investigatory momentum as a path of inquiry is facilitated into emergence through joint activity. This is particularly relevant in (and beyond) this excerpt as Ms. Dalia, Jiah, and Sash's deep co-participation as mediated by Ms. Dalia in relation to the place itself – they are literally finishing

each other's sentences and movements by this point in the walk, evidence of shared or intersubjective perceptions of reality within interactions supported in our design.

Of note, this segment occurs at what we consider to be a critical juncture in the activity: it is just before the group turn around to start making their way back to the classroom, and right as youth are working to synthesize and represent their varied observation and wonderings on the material scaffolds carried along on their clipboards (see Chapter 2). Over the approximately 40 minutes of walk so far, the fluxes and flows of place-facilitated and educator-mediated activity have slowly gained significant semiotic and epistemic momentum as noticings abound and wonderings have become more complex and nuanced. However, this momentum is cut a bit short as Ms. Amy's mediation bluntly redirects the group towards more pragmatic ends (line 22).

In just a few turns at talk, it becomes evident that Ms. Amy is either not as familiar with mediation from the core design principles of Learning in Places, or is otherwise more concerned with managing student behavior towards more pragmatic ends. Held alongside the disciplined improvisational skills of Ms. Dalia, Ms. Amy's responses to student sensemaking read as somewhat shallow. Perhaps ignorant of the profundity of the unfolding interaction, Ms. Amy's spontaneous responses represent hasty enclosures towards shallow taxonomic wondering and representation. This orientation is apparent in her surface-level engagement and feigned awe (lines 24 and 28), reinforced again by her physical movements away from the group while Jiah and Sash are still sharing their sensemaking with her. In so doing, Ms. Amy's engagement with people, places, and more-than-humans seems to reflect a lack of interpretive power (Rosebery et al., 2016) insofar how she wholly prioritizes getting the group back indoors at the expense of maintaining engagement with student sensemaking. While it is uncertain how the interaction would have unfolded differently, we wonder what could have been different if Ms. Amy had

more intentionally balanced deep engagement with sensemaking while also initiating pragmatic actions to get back to the school building. While Jiah and Sash continue their investigation with some support from Ms. Dalia as they make their way back, eventually finding a tree with "helicopter seeds" on and around it, we interpret this as a missed opportunity to developing this investigative trajectory with other groups while walking back.

As suggested across these segments, it is also interesting to consider the ways in which nature-culture stances built into the LiP material ecosystem become present in interaction via educator designers within activities, and then how these orientations get taken up by children. For example, though this is only the 4th walk of the pilot year we see surprisingly developed characteristic of ethical wondering with people, places, and more-than-humans in youth activity. For example, Sash's ease of joining the activity in the first place; children initiating pedagogies grounded in noticing and wondering and children indicating recognition of the agentic capacities of places and more-than-humans. To these ends, Chapter 4 begins to narrate an emergent developmental trajectory for engaging in ethical wondering with people, places, and more-than-humans suggested by empirical analysis of ~98 hours of wondering walk data collected in the following school year (the first year of full FBSS implementation).

Vignette

Excerpts used in this analysis were drawn from a walk taking place earlier on in the storyline where noticings and wonderings are slowly focused through routine "open" wondering walks. As such, a limitation of such deep analysis of a single walk is that it cannot deeply attend to how phenomena and questions emergent in this walk ply forward to impact sensemaking as Ms. Poppy's class move through subsequent learning engagements in the FBSS. In this last section of analysis, we further contextualize this case study walk through short vignette that

describes salient aspects of this class's future engagements as related to the questions and phenomena emergent in this walk.

Through "open" wondering walks (e.g., LE 2), learner noticings, wonderings, and questions are gradually focused through routine walks and thematically organized on the class's "wondering wall" (LE 3) towards the development of a "should we" question (LE 4). A should we question supports ethical deliberation and focus wonderings (LE 5) through investigation questions which then guide cycles of data collection and analysis (LE 6-9). Data, analysis, and other resources used to inform deliberative processes used to determine what decision should be made in a given socio-ecological situation (LE 10; see Chapters 1 & 2).

This particular walk is of added interest as we see the first emergence of a "should-we" question (a 'wondering whether') that would come to guide subsequent investigations is Ms. Poppy's class as educators and children wonder whether they should remove more-than-human beings from the place they were found.

Excerpt 6: Segment 19 "Should we take this with us?" "I can't. it has to live in the wild".

1	Devon:	It's a baby sluggy!
2	Ms. Amy:	It does look like a baby slug.
3	Kirk:	I think it's a rock. Where do you think all these lines and-
4	Ms. Dalia:	Oh, look. There's another one right here.
5	Ms. Amy:	There's two.
7	Ms. Dalia:	Should we take this with us?
8	Ms. Dalia:	Oh my gosh you guys, how cool.
9	Akan:	I can't. It has to live with the wild

Ethical wondering on line 7 reflects Ms. Dalia's knowledge of LiP design and upcoming activities. Understanding that asking ethical questions based on noticings and wonderings comes into greater focus through future walks, her interactional improvisation here is guided by a sense of the investigation's future trajectory. Not necessarily the exact question or investigations they

will need to answer it, but the general outline of "should we" question development. She is using this design knowledge in the field to prime students to think not only about what something is (is it a slug?), but how we ought to interact with it as she encourages them to consider what decisions we should (or shouldn't) make in light of our current observations. Noting an affect of deep and sustained interest throughout this segment, we see how Akan already has a sense that it shouldn't be removed because it "has to live in the wild" (line 9).

Near the end of the walk, Sash poses a similar question to Jiah in reference to the seedpod collected on her clipboard when he asks, "should we take these seedpods back to the classroom?". After some deliberation, they come to the decision to leave the seedpods base of a tree along the trail near the entrance to their school ground. In future walks we see Jiah, Sash, and other students check on the seedpods they left behind and verbalize noticings about how they have become much darker in color which leads them to wonder about related phenomena such as decomposition. The repeated return to similar emplaced phenomena over time is suggestive of one of the design goals of LiP where inquiry occurs over longer scales of time, and not always in linear ways. As such, noticings and wonderings are positioned as entry points into lines of inquiry as developing relationships with places and more-than-humans as opposed to single instantiations of inquiry aimed primarily at committing decontextualized scientific facts to memory.

Over the course of these wondering walks, and in conjunction with family wondering walks and a developing wondering wall, Ms. Poppy's class maintains a focus on fallen plant parts through a should-we question that asks: "should we remove fallen plant parts from the ground". To explore possible answers to this should we question, Ms. Poppy's class takes up numerous lines of investigation aimed at better understanding key relationships and phenomena

implicated in their deliberative efforts. For example, in coming to understand why it is that some plant parts fall they learn about: the effects of seasonal rhythms on the life cycles of plants in their area; why some plants parts fall and other don't; and how relationships between fallen plant parts, soil, fungi, and the broader ecosystem via decomposition and nutrient cycling.

As their investigation proceeds over subsequent weeks and months, processes of inquiry increase in complexity as the class begins attending to more nuanced relationships between various fallen plant parts and the different ground types they might fall upon. Specifically, and through design-disciplined pedagogical facilitation, they investigate how differences in particular kinds of fallen plant parts and particular grounds might inform (and complicate) their should-we question. For example, their processes of deliberation and decision-making require different kinds of investigation questions to understand the contextual and socio-ecological differences between different plant parts that have fallen in different places and times (e.g., leaves fallen on a grass lawn, branches fallen on a hiking trail, or seedpods fallen in the local park). Along with this facilitated focus on different relational configurations across related phenomena in different contexts, students were supported in a range of perspective taking opportunities within these investigations to deliberate on their should-we question from different positionalities to support the understanding that what decision (action) we "should" make is inseparable from the roles, relationships, and values that are prioritized. In so doing, they explore how differing values and socio-ecological arrangement underly everyday practices such as raking and removing leaves from grass lawns, as well as socio-ecological dynamics of power and historicity that have resulted in glass lawns in the first place.

Seedpods, as one of many kinds of "fallen plant parts" (focal phenomena) encountered on future walks as the investigation unfolds, continue to be agentic contributors to understanding

what should be done in their specific situation. That is, “should we remove seedpods from the park grounds” is a situated pedagogical example that re-emerges in various forms in least four additional learning engagements between this walk in late January and completion of the FBSS pilot implementation in mid-May. That Seedpod continues to recur within interactions over the following weeks and months suggests that activities such as these produce durable experiences that continuing to guide inquiry throughout this classroom’s participation in the field-based storyline. That is, the semiotic durability of noticings and wonderings with focal phenomena that emerge through ethical wondering with people, places, and more-than-humans push back against deficit claims concerning the capability of young people to meaningfully remember scientific experiences (Zimmerman & Bell, 2014). The activity of this class beyond the focal walk analyzed above begins to demonstrate how spontaneous continued interest over longer scales of time suggests that children’s ability to remember isn’t the core issue. To the point, it is the conditions of engagement that afford or constrain young people’s ability to hold an experience and pull it forward into longer storylines of inquiry.

Discussion and Implications

Within the broader ecosystem of Learning in Places materials, ethical wondering with people, places, ethical more-than-humans implies paradigmatic in how we understand the role of teaching and learning, including important shifts in educator identity. Rather than a “sage on the stage” whose role is to deliver settled content in linear and predetermined ways, this orientation refigures the role of educator to that as a “guide on the side”. Decentering content knowledge, outcome, and standards-based priorities in educational design and interaction, the work of educators in this paradigm is to notice, build with, and nurture student sensemaking through expansive pedagogical mediation that cultivating attention to socio-ecological relationships

across multiple scales. This is evidenced in the mediation of Ms. Dalia, who is not expected to have all the answers, but whose design-disciplined pedagogical decision-making guides, connects, and elevates unfolding inquiry processes. In Sawyer's conception, this mirrors pedagogical mediation of the most experienced educators, who often use more structures, but also improvise more (and thereby need less time planning) (Sawyer, 2011).

Indeed, educator preparation looks very different through ethical wondering with people, places, and more-than-humans as it becomes not only about content standards and reaches towards continual development of one's own interpretive power, socio-ecological expertise, and personal relationships with particular local places (e.g., though place designing, see Chapter 2). The work of teaching thus comes to resemble more of an improvisational art form that is emergent from and facilitated alongside the semiotic contributions of youth, places, and more-than-human beings. Building from this shift, materials in Learning in Places encourage and equip educators with conceptual and material support that gradually build capacities needed to see and improvise with and the contributions made by learners, places, and more-than-humans with activity towards sophisticated complex socio-ecological sensemaking. Grounded in such relationally responsibility, learning is thus recognized as joint activity via porous roles between people, places, and more-than-humans where each is afforded opportunities to be a dignified and agentic co-operative collaborator in unfolding ethical inquiries.

By tracing conversations and interactions across place, analysis of this walk characterizes particular methodological approaches, modes of socio-ecological sensemaking, and approaches to disciplined pedagogical mediation within places that are characteristic of ethical wondering with people, places, and more-than-humans. Following the emergence and development of inquiry with seedpods, actions on subsequent walks suggest the. In analyzing this walk as

situated within a broader scope of unfolding inquiry, we argue that the activities and foci characterized here are enactments of emergent and ethical complex socio-ecological inquiry. Following from this, we assert that ethical wondering with people, places, and more-than-humans represents as an important orientation and set of values to guide analytic method, activity design, and pedagogical mediation towards more just and thriving forms of teaching and learning. Within implications for both educator and learner identity, this suggest that we can, at least in part, meet the socio-ecological challenges and opportunities of our time through intentionally designing and facilitating learning experiences that cultivate sensibilities to act from a sense of awe and wondering, carefully notice and observe, consider relational complexity, deliberate from multiple perspectives, and take actions grounded in reciprocal nature-culture relations.

As a final thought experiment, we invite the reader to consider what may have been different about such an inquiry without an intentionally designed orientation towards on ethical wondering with people, places, and more-than-humans. "Business as usual" in science education takes place in an indoor, lab-based setting. Teachers (or the curriculum they follow) may have determined the plant growth and development is important content knowledge for students to learn about at a particular age or grade. As part of a preset curriculum, fallen plant parts such as seedpods may have been made available for students to observe indoors. Perhaps stored for weeks, months, or years before the lesson, it is easy to imagine a container with varying seedpods scattered across a lab table for children to interact with. Students may have opportunities to hypothesize on their observations, or to attempt to create explanatory models of relationships in pursuit of a correct, uniform, or otherwise "gapless" explanation (Windschitl et al., 2018). Their own personal interests, wonderings, or cultural practices may be more or less

engaged, but do not authentically drive the decisions to focus on seedpods, or the trajectories of activity that grow from this present focus. Rather, pre-sequenced materials provide the singular pathway through which to engage scientific content for all learners regardless of their relevance to the lived experiences of them and families.

In this paradigm of simulated science practices, students are presented with an inauthentic "simulacra" of science populated with examples that are too often idealized, over-simplified, and decontextualized (Lemke, 1994). Not only are their contributions prevented from meaningfully guiding the content and trajectory of investigations, but this over-constrained approach mutes and excludes learner's ontological and affective selves through linear and lockstep curricular processes that necessitate rapid dissemination of content knowledge in order to move to the next predefined unit. This short example highlights the reality of science education for most learners, and stands in sharp contrast to how we have described ethical wondering with people, places, and more-than-humans throughout this work

In sum, to ethically wonder with people, places, and more-than humans is to navigate socio-ecological uncertainty through engaging in emergent place facilitated speculation grounded in a sense of awe and curiosity. Designing learning activities and mediating learning within activities from the framework of ethical wondering with people, places, and more than humans involves recognizing the pedagogical power of place, the facilitative agency of more-than-human beings, and design-disciplined forms of improvisational mediation that nurture student sensemaking and educational dignity. Through the FBSS, open ethical wondering is gradually focused through routine walks, noticings, and ethical deliberations emergent from *within* our unfolding and participatory (relationally responsive) involvement with particular people, places, and more-than-human beings. Pedagogically, such a focus on wonder is aimed at

developing conceptual models and habits of mind that support complex socio-ecological sensemaking through a deeply relational ethic of reciprocity and complex complementary between humans and the rest of the natural world.

Chapter 4. Paper 3: Speculative Socio-Ecological Sensemaking in Places and Over Time: A Quantitative Analysis of Wondering Walks

Introduction

The challenges of the 21st century provide opportunities to imagine and enact more healthful forms of teaching and learning. Particularly in the context of climate change, this generation of educators are tasked with designing novel forms of activity that might better prepare learners for rapidly shifting social and ecological landscapes (Bang et al., 2016; Berkes, 2017; Whyte, 2018). This is, at least in part, a matter of rekindling orientations towards the natural world that recognize the deep relationality between humans and other forms of life (Bang, 2015; Cajete, 1999a; Deloria, 1999; Kawagley, 2006; Marin & Bang, 2015; Medin & Bang, 2014). Remaking relationships between humans and the rest of the natural world involves teaching and learning that nurtures a sense of awe and hope about our collective futures within approaches to sophisticated socio-ecological inquiry. Building with the framework and evidence presented in earlier chapters, the analysis offered in this final paper is grounded in the stance that learning about, marveling at, and spending routine time within the natural world is vital to our capacities to wonder and act upon expansive opportunities for more ethical relationships between humans and the rest of the natural world.

Our work in the Learning in Places project contributes to this space through designing place-based and outdoor forms of teaching and learning grounded in understandings of complex socio-ecological systems that support educators and learners in developing capacities to conduct routine field-based scientific inquiry. In this paper, we are interested in understanding the relationships between shifts in place-based practices and components of socio-ecological systems sensemaking. Pursuing this, we present a broad and layered analysis of activities designed to

support noticing, wondering, and investigation facilitated through routine outdoor activity and disciplined educator mediation (see Chapters 2 and 3). Together, these layers of analysis substantiate consequential shifts in routine practice-based orientations and demonstrate important shifts in engagement with core design principles of design between contexts and over time.

Nature-Culture Relations & Place-Based Inquiry

In our work we are trying to better understand how to design learning from a recognition of how humans exist as a part of complex socio-ecological systems (Cajete, 1999a; Medin & Bang 2014; Bang & Marin, 2015). Taking up science education as a key point of inquiry, we draw upon work demonstrating how construals between social and ecological systems impact decision-making practices (Medin & Atran, 2004). How we construe the relationships between and among natural and cultural systems has implications for sustainable decision-making. For example, "a part of" models, which position humans as existing within socio-ecological systems, are linked with psychological closeness more conducive to more sustainable socio-ecological decision-making (Medin & Bang, 2014), as well as to supporting perspective taking capacities associated with greater attention to the relational complexities of socio-ecological systems (Medin et al., 2006; Pugh et al., 2019).

Reaching beyond "classroom as container" models so prevalent in education today (Leander et al., 2010), we recognize scientific sensemaking as embodied, interactional, and embedded in particular places and contexts (Hutching & Renner, 2012, Mogk & Goodwin, 2012). From this stance, we have designed to support socio-ecological learning through spending routine time outdoors engaged in place-based inquiry (Pugh et al 2019; Gruenewald, 2003) Rather than positioned as the largely inconsequential background of activities, we position places and more-than-human beings as facilitators of sensemaking whose active participation

contributes directly to unfolding inquiry (Pugh, 2019; Nxumalo, 2019). Elevating the affordances of outdoor places for socio-ecological inquiry, this work addresses the relative dearth of robust and sustained empirical engagement with outdoor learning environments through analysis of routine forms of outdoor activity designed for in Learning in Places.

Emergent within outdoor places and guided through the design-disciplined mediation of educators, we have designed activities such as 'wondering walks' to support the transformation of human-centric decision-making through routine opportunities to be and think with the outdoor world. Growing from place-based noticings and wonderings, our design work scaffolds more complex and reciprocal understandings of complex socio-ecological systems, while also reaching towards educational dignity through authentic collaboration with people, places, and more-than-humans. As such, we assert that grounding sensemaking about nature-culture relationships in an understanding of complex socio-ecological systems is an essential capacity in the cooperative work needed to cultivate more healthful futures for life on this planet.

Through our design work we have synthesized key area of scholarship in complex systems sensemaking (Olson et al., 2014; Wilensky & Resnick, 1999) to elevate 5 dimensions central to sensemaking in complex socio-ecological systems: Species, Kinds, & Behaviors; Relationships; Places, Lands, and Waters; Thinking Across Scales (time, space, perspective); and Human Decision-Making. Grounded in critical uptakes of power and historicity, these dimensions are rhizomatically woven across our ecosystem of designed materials to support and guide complex socio-ecological sensemaking through Learning in Places. Grounded in the noticings and wondering of learners, engagement with these key dimensions of complex systems sensemaking is designed to develop the capacities of educators and learners in more ethical deliberation and decision-making processes.

Wonder

A pedagogical focus on wondering holds immense possibilities for supporting the ethical navigation of complex dynamics involved in everyday learning and living. Because wondering is central to navigating uncertainty, considering possibilities, and speculative problem solving, designing for and from a multiplicity of learner wonderings can expand opportunities for dignified pedagogical interactions between and among youth, educators, more-than-humans, and the places they live within. Through both wondering about and wondering at (e.g., Goodwin, 1994), wondering braids together embodied, cognitive, and affective dimension of learning in ways that can cultivate socio-ecological awe, curiosity, and care. In contrast to normative paradigms of science education which prioritize generating quick curiosity about largely de-placed phenomena via "wondering about", our design from place-based "wondering at" aims to transform both the conditions and the experience of science teaching and learning through expanding opportunities for wonder, awe, and joy as essential to meaningful learning.

In our focus on ethical socio-ecological sensemaking, we elevate a third category of speculation that Goodwin (2001) calls - wondering *whether*. These kinds of wonderings elevate questions of ethical deliberation and decision-making that implicate values, priorities, and perspective taking through asking normative questions such as "Should I do this?", "Must I do this? "Is this right?, and "Why is this important?" (Bianchi, 2013). Attendant to our core focus on dimensions of human decision-making in nature-culture relations, a pedagogical focus on "wondering whether" and asking "should-we" questions is central to how we support processes of ethical deliberation and decision-making through routine field-based inquiry. Emphasizing these dimensions of wonder, and grounded in the framework built through previous chapters above (e.g., Goodwin, 2001; Hadzigeorgiou 2016; Schinkel, 2017 Shotter, 2015; Stolberg, 2008;

Vasalou, 2015) this paper rounds out the three paper model pursued in this dissertation.

Paper Organization

From such a stance on nature-culture relations, place-based inquiry, and wondering, this paper reports on the initial findings of a broad and comprehensive analysis of video data gathered during *wondering walks*, key activities in the Learning in Places Field-Based Seasonal Storyline. Building with the design-based analysis in Chapter 2 and complementing the deep qualitative analysis presented in Chapter 3, this paper is primarily concerned with analysis towards quantitative breadth. Methodologically, this analysis investigates the representational density of socio-ecological coding categories to produce comparable measures of key practices and commitments of the Learning in Places project across field-based implementations. Specifically focused on the relationships between noticing and wondering relative to socio-ecological sensemaking and nature-culture relations, this paper reports on the processes of applying and refining an analytic coding framework for *socio-ecological sensemaking* and *speculation in places* to approximately 98 hours of wondering walk data collected in our pilot year of storyline implementation.

Towards these ends, this paper is organized as follows. Contextualizing the coding scheme used in analysis, I first give a brief conceptual review and synthesis regarding design for ethical socio-ecological sensemaking through *wondering with people, places, and more-than-humans*. Situating the work within the Learning in Places project, I then describe the methods used to segment, log, and code the data set. Finally, I share analytic findings in 3 complementary layers: a descriptive overview, measures of code co-occurrence, and comparative analysis of representational density across key codes of interest.

Through sharing total quantities and distributions of data across school, grades, educators

and other relevant descriptors, descriptive analysis contextualizes the data set in ways that inform subsequent layers of analysis. Next, analysis of co-occurrence reports on statistically significant relationships emergent from the data set. In particular, we elevate the triangulation of core forms of sensemaking that informs and reinforces our understanding of how outdoor place-based inquiry supports the co-constitution of sophisticated scientific inquiry with experiences of wonder and awe. Finally, the following sections provide a comprehensive report on select categorical variables chosen to compare sensemaking between learning engagements 2 and 5, as well as across indoor and outdoor learning contexts. Making up the bulk of analysis in this paper, in this section we elevate key findings and explicate their relation to key themes present within our ecosystem of design and practice. We conclude by summarizing how the main themes and notable limitations of this analysis inform our ongoing design work and approach to future analysis of wondering walks.

Project Context

Learning in Places

This paper analyzes data collected within the Learning in Places (LiP) project. LiP is a participatory design-based research project (Bang & Vossoughi, 2016) focused on iterative co-design of materials to support complex socio-ecological systems learning and field-based science practices. Our approach is fundamentally grounded in nurturing reciprocal nature-culture relationships and cultivating more ethical forms of socio-ecological systems through engaging youth in routine outdoor place-based activity (Gruenewald 2003; Nxumalo, 2019; Pugh 2019). Since 2017 we have been partnering with educators, families, children, and community-based organizations to design models of outdoor learning premised on the interconnections between culture, learning, and identity (e.g., Nasir et al. 2006, Warren et al 2020).

Key feature of our ecosystem is the Field Based Seasonal Storyline, a semi-linear activity system of indoor (classroom-based), outdoor (field-based), and family (home-based) Learning Engagements (LEs) designed to support socio-ecological sensemaking and ethical decision-making. Relevant to this analysis are select indoor and outdoor LEs in the first half of the storyline, where wonderings are mediated within the ecosystem of activity from *open* walks (e.g., LE 2) to *focused* walks (LE 5) which are guided through a communally constructed "should we" question (see also Chapters 1 and 2).

Marking an important distinction in how wondering walks are conducted, the first wondering walks in the FBSS are *open* wondering walks. In this intentionally under-constrained space, the activity is flexible – open to whatever emerges as learners wonder and ask questions about what they are noticing. Over the course of these initial walks, learner wonderings are gradually compiled, frequently revisited, and thematically organized through use of a *wondering wall* (LE 3). Using the wondering wall, learners and educators relationally organize wonderings as they emerge, eventually selecting a smaller number of phenomena and relationships to focus on as they move forward in the FBSS. This serves as a conceptual and practical pivot in activity, where the group begins to move from *open* to *focused* wondering walks (e.g., LE 5) as patterns, changes, and relationships become more evident in emergent phenomena of interest. Characteristic of more focused walks, attention is guided towards particular phenomena of interest for deeper investigation. This practice results in the creation of a "should we" question that drives lines of collective investigation and analysis designed to inform what *should* (or shouldn't) be done in response to a specific socio-ecological situation (LE 4 and beyond).

Year 3 Wondering Walks Secondary Data Set

The data analyzed in this paper was collected during our first full year of FBSS

implementation. Following the analytic focus of this work, a secondary data set was constructed through compiling all video data collected in LEs where participants engaged in *Wondering Walks* (both *open* walks in LE 2 and *focused* walks in LE 5). In total, this set includes just over 98 hours (98:08:43) of video data from a total of 38 wondering walk implementations across 10 classrooms and two schools. Video data was collected during indoor classroom activities (approximately 10 hours and 55 minutes of activity *launches* and 10 hours and 34 minutes of synthesis) using a tripod-mounted camera, and during outdoor activities (wondering walks, LE 2 and LE 5) using chest-mounted Go-Pro cameras (see table 4.1 for total times in hours: minutes: seconds).

Table 4.1

Total Sum of Data Collected Across Activity Structure and Participants

Total		**98:08:43**	
Indoors		**Outdoor**	
21:28:59		**76:39:44**	
Launch	**Synthesis**	***Adult***	***Child***
10:55:15	**10:33:44**	***22:19:59***	***54:19:45***

Methods: Data Segmentation and Coding

In the early stages of analysis, researchers independently coded the same segments of data and noted emergent moments and themes for discussion which progressively sharpened the coding scheme detailed below. This approach is both practical and meaningful, serving the dual purpose of data processing and organization (e.g., content logging at 5-minute intervals) and simultaneously indicating the presence or absence of key codes. This enriches the process of data logging by weaving dimensions of conceptual analysis within already necessary organizational processes. In prioritizing analytic methods that were not overly cumbersome to implement alongside our existing logging framework, this study added analytic dimensions to existing

logging processes resulting in meaningful interpretive depth despite the pragmatic constraints of knowledge and interaction analysis across such a large and complex data set.

Data Segmentation

Aligning with our approach to logging and coding for presence or absence of focal phenomena across 5-minute segments (e.g., Dorsey et al., 2018), measures of time in hours and minutes to 5-minutes segments were necessary to maintain methodological continuity throughout analytic steps. Plainly, the unit of analysis used to generate the descriptive, correlational, and representational analysis below is the 5-minute segment. While this prevents claims about the density *within* 5-minute segments, this analysis is well-positioned to make claims about the *representational density* and *co-occurrence* of codes *across* segments based on the total number and distribution of coded segments associated with given head and child codes.

While there is some nuance lost in this approach, it is an analytically effective way to empirically consider the distribution of what is often called "hot spots", “rich points”, or “critical events” in interactional analysis (e.g., Agar, 1996; DeLiema et al., 2015; Powell et al. 2003; Goodwin, 2017). Used across such a large data set, this approach helps to see patterns in significant activity that inform our understanding of wondering walks in a broader sense.

These processes of segmentation resulted in a total of 1170 coded 5-minute segments from 98 hours 8 minutes and 43 seconds of data.

Codebook Development and Application

Developing from, and in parallel with, the conceptual framework outlined in previous chapters, we created a series of analytic codes that were refined through application to data alongside processes of content logging. These codes were refined through grounded engagement with video data, our direct participation in project design and classroom storyline

implementation, review and synthesis of relevant literature, and ongoing consultation with various project partners including children, families, educators,

A priori codes developed in relation to overarching project commitments (e.g., LiP rhizome, ethical wondering, socio-ecological sensemaking, nature-culture construals, etc.). These initial coding categories shifted and were progressively refined through processes of data processing alongside methods in grounded analysis (Glaser & Strauss, 1967) to progressively refine conceptual categories (Engle et al., 2007; Derry et al. 2010). To ensure inter-coder reliability, these early stages of the project moved gradually to allow regular time to compare code applications and refine conceptual categories. This process was repeated until the coding categories began to stabilize, and we achieved 90% reliability in 90% of code applications over multiple iterations using both the *socio-ecological sensemaking* and *speculative practices in places* coding schemes detailed below.

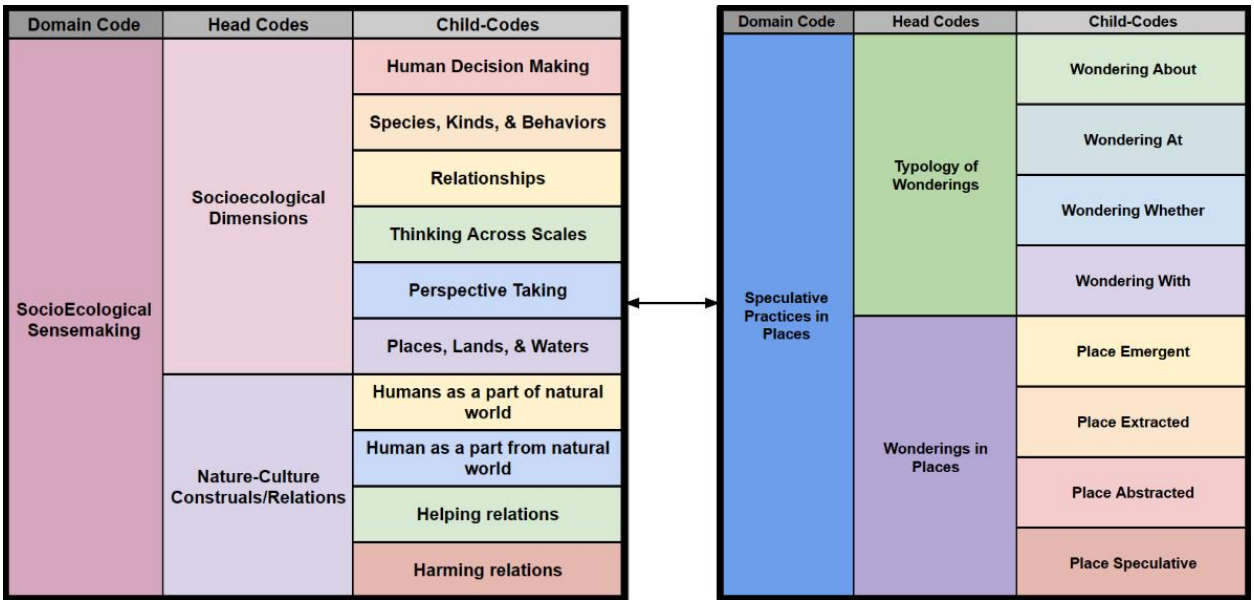
Our approach proceeded by opening relevant video files and viewing them while using the coding scheme in a separate window. While watching, we attended first to codes for socio-ecological sensemaking, including "socio-ecological dimension" and "nature-culture construals/relations". Additionally, we attuned ourselves towards noticing a range of speculative activities. This noticing prompted us to include a "speculative note" concerning what prompted our shift into the speculative framework. We would then code the speculation activity using the "typology of wonderings" and the "wonderings in places" codes. At the end of the 5-minute segment we would often briefly pause to provide a 2-3 sentence description highlighting the general flow of activity (participants, place, movement, etc.) along with any salient elements of interaction pertaining to the socio-ecological sensemaking coding scheme. If a subsequent section was less than 2 minutes, it was logged as a part of the previous interval.

Within 5-minute intervals, these codes were allocated as present or not present. Rather than coding for discrete quantities of a particular code within segments (i.e. within-segment "weight"), this prioritizes methodological focus on *synchronicity* of codes. Following from a unit of analysis at 5-minute segments, we use "code density" to mean the *representational likelihood* of distinct code applied rather than to a depth of any one 5-minute segment in particular. Examples of blank code book logs are included in appendix 4a for reference.

Presented below is the general overview of each code as used to log the wondering walks secondary data set. Detailed definitions and discursive examples are included in full below for reference.

Table 4.2

H*ead and Child Codes for Socioecological Sensemaking and Speculation in Places*



Typology of Socio-ecological Sensemaking

This typology consists of six broad socio-ecological dimensions as well as four primary nature-culture relational construals woven through our design work in Learning in Places. For brevity and analytic focus, child codes for nature-culture construals are not discussed in depth in

this analysis. Larger versions of all focal codes can also be found in Appendix 4b.

Socio-ecological Dimensions. The socio-ecological dimensions represented in our coding scheme included: 1) human decision-making; 2) species, kinds, and behaviors; 3) relationships; 4) thinking across scales; 5) perspective taking; and 6) places, lands, and waters. As analysis moved forward, we collected sets of discursive examples for each code to illustrate how each manifested in interaction. This process also assisted us in continuing to hone our interpretations of each code. The six child codes are presented below alongside the working definition developed through the aforementioned analytic approach.

Table 4.3

Child Codes and Descriptors for Socio-ecological Sensemaking

Socio-ecological Dimensions	Human Decision-making	Discussing or observing human decisions in the past, present, or future. Considering the rationale behind certain decisions, the impact of particular decisions, and/or what should or shouldn't be done within a nature-culture relationship.	"What should we do?" "What would happen if we picked up all of the worms?" "The settlers decided to take the land for themselves"
	Species, Kinds, & Behaviors	Noticing, discussing, or otherwise differentiating between particular species or kinds of phenomena (kind of spider, type of tree, etc.) and/or sensemaking via the behavior of particular phenomena (spiders build webs, trees make pollen)	"These thorns look different from these ones over here…" "Why do mole dig holes and leave dirt on the surface here?"
	Relationships	Identifying relationships between and among phenomena, including humans, more-than-humans, lands, waters, or other natural kinds.	"Does the ivy help or hurt the tree it is growing on"
	Thinking Across Scales	Toggling across temporal (past, present, future), spatial (perspectival, e.g., home & school, indoor & outdoors), and/or agent-aggregate (population) scales	"What looks different from the last time we were here?" "I see leaves above and below us" "What if we considered all the worms here?"
	Perspective Taking	Sensemaking from the positionality of another: people, places, and/or more-than-humans. Can also be embodied. Can involve reasoning from assumptions of affective states or agentic capacities to more-than-human beings	"How would you feel if you were a bird in that situation?" "What stories to you think this tree could tell us from its time in this place?"
	Places, Lands, & Waters	Noticing how observed phenomena are connected to particular places. (May be accompanied by "here" or "this", indicating specific focus on a particular kind of phenomena).	"This tree right here is just the one I was looking for!" "Do these kinds of bird only live here?"

Typology of Wondering in Places

Typology of Wonderings. Drawing upon our frameworks for wondering, (as well as the

literature review in Chapter 2, e.g., Goodwin, 2001; Schinkel, 2017 Shotter, 2015; Stolberg, 2008) we coded for four basic modes of wondering: wondering *about*, wondering *at*, wondering *whether*, and wondering *with*. Though the first three are explicitly derived from existing literature, *wondering with* is a novel formulation derived from the intersection of this literature with the design principles and commitments of Learning in Places. The four child codes are presented below alongside the working definition developed through analysis.

Table 4.4

Child Codes and Descriptors for Wondering

Typology of Wonderings	Wondering About	"Reflects the activity of scientists" and involves epistemically forward questions designed to "know more" about phenomena such as: How does it work? What would happen if? Why? When? What next? - Associated with curiosity, to finding out more within a particular framework. (A known unknown-attending to yet unknown facts) (Sometimes chained in succession)	"What kinds of worm is that?" "Why do worms come out when it rains?" "How do birds find worms to eat?"
	Wondering At	"Reflects the human response to discoveries and understanding", and to "our capability to wonder at all" Pertains to exclamations and "affective sparks". Can manifest in ontologies of amazement, or the ineffability of experience via extended awe or puzzlement/aporia. Wondering that suggests a new framework for understanding is needed (unknown unknown, not just new facts).	"Wow! I see so many worms!" "Oh! That water is cold cold cold!" "Woooah, that's SO beautiful" "That's so cool! I don't even know how they do that"
	Wondering Whether	Wondering about possible actions: What to do, what one could do, what one shouldn't do. Reflects speculative discourse and questions that engage axiological considerations involving values, moral and ethical judgements: (e.g., Should I do this? Must I do this? (Can reflect value judgements: Why is this important? What is the right thing to do? May imply concepts of good/evil, right/wrong, reward/punishment.	"What is the right thing to do?" "I don't think we should do that…" "Should we move the worms back into the grass"
	Wondering With	Speculative activity that attends to human-nature positioning (dominance/deference), positioning humans as a part of nature. Sensemaking about complex interdependence. Assuming agency of natural kinds, sometimes via pronoun use (e.g., "them" vs "it". Nature is not objectified. Signals axiological stances.	"What do you think worms can teach us about their relationships in this place?" "The slug will be lonely if we take it away from its family here in the forest"

Wonderings in Places. The final series of codes applied to these data during logging and analysis are derived from the work of Pugh and colleagues (2019; 2020) work on spatial indexing in outdoor learning environments. Importantly, these do not refer to any or every time that places were visible in sensemaking, rather, we took care to apply these codes only when

relations to places occurred within an already speculative frame of reference. That is, a code for wondering necessarily preceded a place-based code as a matter of coding protocol to ensure fidelity to our broader focus on the relationship between speculative practices and the places of their instantiations. The four child codes are presented below alongside the working definition developed through analysis.

Table 4.5

Child Codes and Descriptors for Wondering in Places

Wonderings in Places	Place Emergent	Speculative activity via observations directly located in, or emergent from, place; sensemaking about, at, whether, with something in the sensory or perceptual field / surrounding environment. Can also include the lack or absence of something expected if triggered by immediate observations in place.	"Look over there! I wonder what that is…" "Why are there so many trees on this side of the river?" "Are the squirrel and the crow playing with each other over there?"
	Place Extracted	Wondering about emplaced phenomena that was/are either extracted from places and thus in a transformed context (e.g., holding a berry or leaf that is removed from where it was found, e.g. picking up or collecting. Showing documentation or representations as removed from places (photographs, drawings).	"This seedpod is dark on one side, but light on the other." "What looks different from this picture I took when we we're last here"
	Place Abstracted	Wondering about abstracted places and kinds not presently co-located. General ideas and/or concepts about phenomena relative to, but not immediately present in, a particular place. A generalized view/sensemaking from "nowhere" in particular – distanced	"What kinds of relationships do forests usually have" "I wonder where the snail we found is now"
	Place Speculative	Speculation and/or anticipation about was or will be done or perceived in a particular place – not in present moment. Recalling past or speculating on future events and/or phenomena in particular places. Wondering about origins or destinations, where something came from or where it is going. What happened/will happen in past/future.	"What was here 100 years ago?" "Where did these seedpods come from?" "I wonder what this will look like next month."

Overall Descriptive Statistics of Data

Sums of Segments Coded by Categorical Variables

The categorical variables of interest for this analysis follow from our conceptual focus on the shifts in sensemaking between Learning Engagements (open to focused wondering walks; LE 2 to LE 5), as well as comparing the representation of code applications across learning environments (indoor and outdoor). To frame this focus within the broader data set, we first report on broad descriptive data. While not the primary focus of this analysis, descriptive

findings reported on in this section contextualize subsequent analytic layers through tracking the variance in segments coded across educators, grades, and places (schools). Table 4.1 displays these variables together alongside categorical variables of interest.

Table 4.6

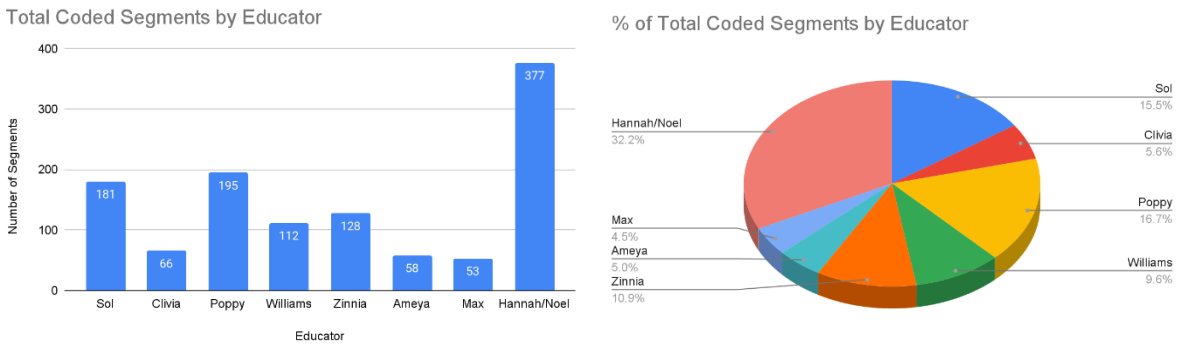
Count of Segmented Data by Focal Descriptors

Educator(s)	Place	Grade	Engagements	*LE 2*	*LE 5*	Segments	*Indoor*	*Outdoor*
Max	Creek	3	2	*1*	*1*	53	*13*	*40*
Clivia	Creek	3	1	*1*	*0*	17	*2*	*15*
Sol	Creek	2	9	*2*	*7*	181	*56*	*125*
Poppy	Park	2	5	*2*	*3*	195	*39*	*156*
Williams	Park	2	3	*2*	*1*	112	*14*	*98*
Clivia	Creek	2	2	*1*	*1*	49	*15*	*34*
Zinnia	Creek	1	5	*2*	*3*	128	*48*	*80*
Hannah & Noel	Park	K	8	*1*	*7*	377	*49*	*328*
Ameya	Creek	K	3	*2*	*1*	58	*19*	*39*

Educator. Figures 4.1 reports on coded segments by educator in terms of total count and percent respectively. Of note, because Hannah and Noel always implemented wondering walks by combining their kindergarten classes and co-teaching, there were frequently additional recording devices were used to gather data from activities of the larger combined classes.

Figure 4.1

Total Count and Percentage of Segments by Educator

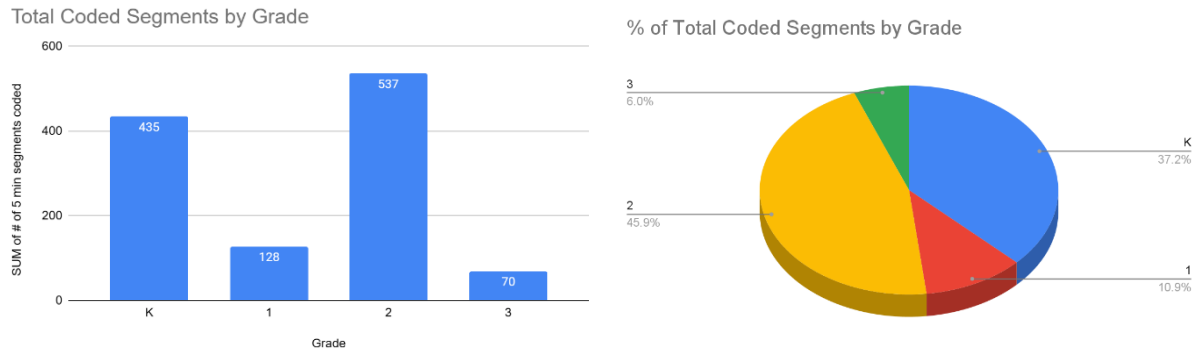


Grade. Depicted in figure 4.2, the majority (81.3%) of the wondering walk secondary data

set consists of segments drawn from kindergarten (37.2%, n=435) and 2nd grade (45.9%, n=537) classrooms.

Figure 4.2

Total Count and Percentage of Segments by Grade



Place (School). The distribution of coded segments was relatively balanced between the two schools (Creekside Elementary and Parkview International School) where video data was gathered from wondering walk implementations.

Creekside Elementary school serves grades PreK-5 and is situated above a 200-acre park, Arroyo Park. Key features of this place include a riparian creek, temperate forest, cultivated apple orchard, and intertidal beach. This area includes multiple natural and human-managed ecosystems and is the site of significant restoration efforts over recent decades to recover the salmon run and spawning grounds, and increasing biodiversity in the forest and wetlands. During the time of implementation in 2019-2020, Creekside Elementary was predominantly White (51.7%) and Hispanic/Latino (15.1%,) (Black 10.2%, Asian 8.6%; Native[1] 1.5%; two+ races 13.6%) (district website).

Parkview International School also serves PreK-5 and borders a 4.5-acre city park that

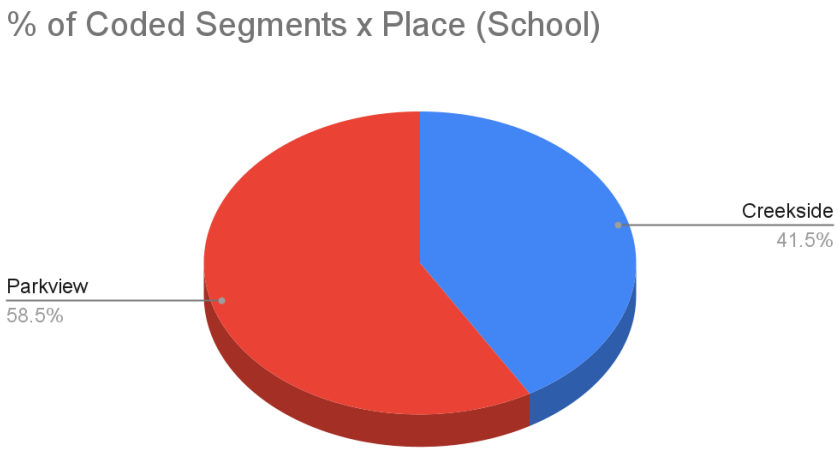
[1] 10 Native includes American Indian, Alaskan Native, Native Hawai'ian, and Pacific Islander.

features deciduous forest, wetlands, and public greenspaces and playgrounds. A major north-south pedestrian and biking trail is within walking distance of the school and well-worn footpaths routinely used by students and families lead to and from Parkview into nearby neighborhoods. Parkview has a history of family partnership managing the wetlands and forest areas near the school, and the school has raised garden beds in the courtyard that were built and managed as part of a past research-school partnership focused on garden and health education. Parkview is a Title 1 school with majority nondominant students (45.2% Asian, 16.1% Black/African American, 10.5% two+ races, 13.6% Hispanic/Latino, 13.9% White, 0.6% Native) (district website). Parkview is also the home of dual language immersion programs in tracked Spanish or Mandarin, with graded-banded educators in K-1st or 2nd-3rd that teach one grade in the morning and the other in the afternoon.

Reported in figure 4.3, 41.5% of coded segments (n=486) are from data collected at and around Creekside Elementary and 58.5% of coded segments (n=684) are from Parkview and the surrounding lands where educators brought their classes for wondering walks.

Figure 4.3

Percent of Segments by Place

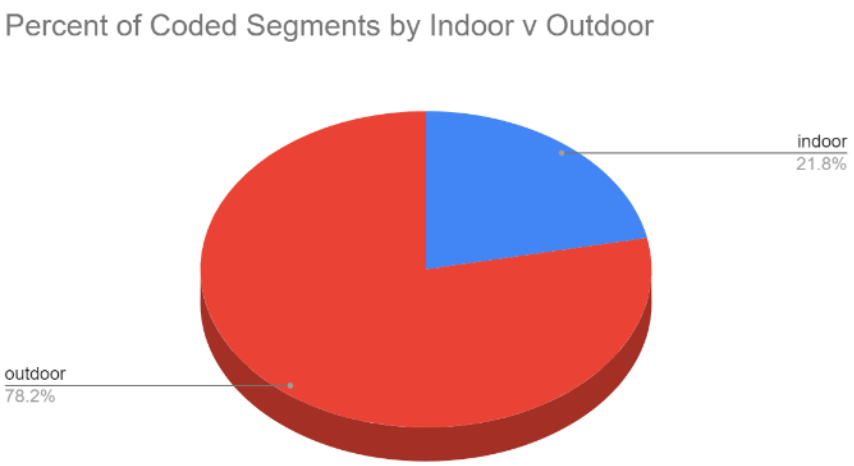


Indoor/Outdoor

Attendant to our focus on how outdoor contexts mediate sensemaking practices, a primary variable of interest in this analysis is comparing data collected outside during wondering walks to indoor data collected during the launch and synthesis of wondering walk activities. The majority of segments are from outdoor implementation data (78.2%, n=915, see figure 4.4). This is due in part to classroom communities generally spending more time outdoors than indoors during wondering walk implementation, as well as the presence of more cameras worn by participants while on walks. While outdoors, care was taken to have cameras placed on participants from different working groups to prevent overlap of data.

Figure 4.4

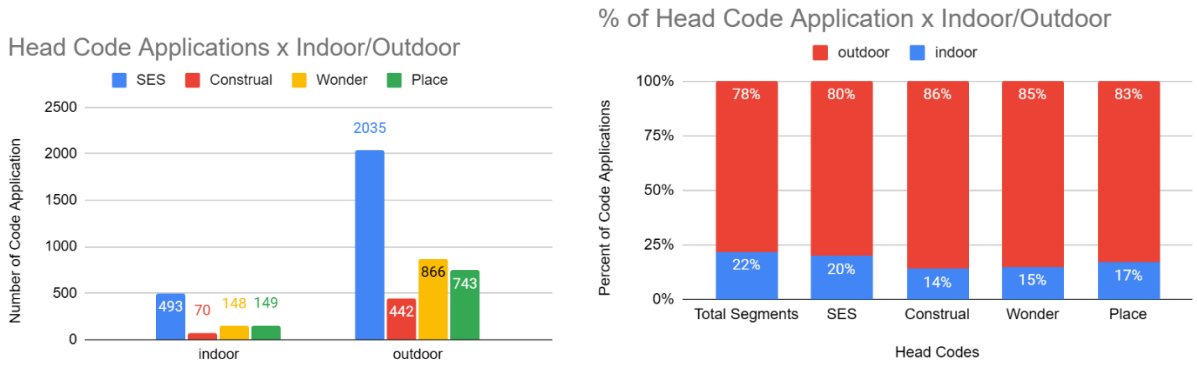
Percent of Segments by Environment



Figures 4.5 reports on the total sum and percentage of child codes applied within each head code, as well as the total percentage of head code applications by indoor and outdoor environments. Comparing the percentage of total segments coded with the percentage of head code application demonstrates how all head codes were applied more frequently outdoors.

Figure 4.5

Total Count and Percentage of Head Code Applications by Environment



LE 2/LE 5

The second variable of elevated interest in this analysis is comparison of code applications between LE 2 (initial, *open* wondering walks) and LE 5 (subsequent, *focused* wondering walks). Figure 4.6 reports on the percentage of segments within LE 2 (33.5%, n=388) and LE 5 (66.8%, n=782).

In addition to comparing activity structures in each LE, analysis of code applications based on LE is also used as a proxy for time. Occurring earlier in the FBSS, in LE 2 educators and learners are more unpracticed with LiP materials and supports for outdoor learning. In contrast, by LE 5 learning communities would be expected to have more developed practices to support socio-ecological sensemaking. Thus, we take comparisons between LE as an imperfect metric for how sensemaking shifts over repeated implementations as learners and educators become more accustomed to outdoor learning via wondering walks. Alongside more detailed analysis, this helps us make sense of emergent developmental arcs in activity and what changes as participants repeatedly engage in the FBSS over time.

Figure 4.6

Percentage of Segments by Learning Engagement

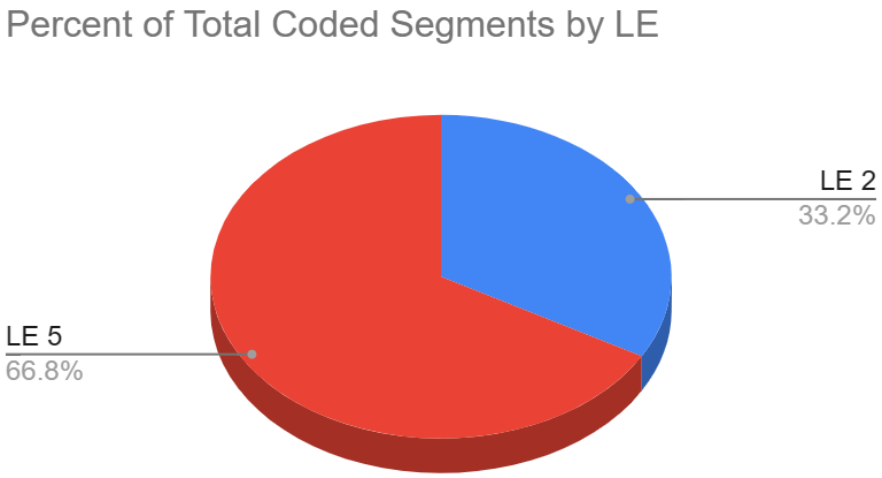
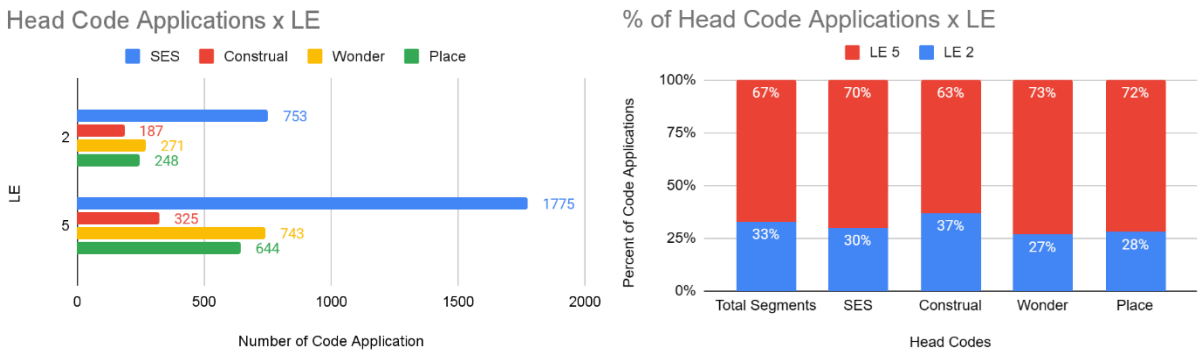


Figure 4.7 reports on the total sum and percentage of child code applications within each head code. Comparing the percentage of total segments coded with the percentage of head code application demonstrates most head codes were applied more frequently in LE 5.

Figure 4.7

Total Count and Percentage of Head Code Applications by Learning Engagement



Analysis and Findings

Overview and Organization of Reported Findings

Findings are organized into three sections. Section 1 presents significant findings for the relationships between child codes through measures of code co-occurrence within segments.

Section 2 first describes methods used to normalize data and measure the representational density of codes, before then reporting such measures in head codes across focal descriptors of environment (indoor/outdoor) and Learning Engagement (2 and 5). Focusing in further on analysis of representational density, Section 3 reports on the distribution of child codes for 'socio-ecological dimensions', 'typology of wonderings', and 'wonderings in places' across activity as measured by representational density. Mirroring the organization of section 2, section 3 presents findings for these groups of child codes is also across environment and Learning Engagement. In line with conceptual focus in this analysis, we specifically elevate findings regarding child codes for socio-ecological sensemaking and speculation in places.

Section 1: Significant Relationships between Child Codes

Building from the descriptive analysis above, this section first reports on findings in terms of code co-occurrence. Using Pearson correlation coefficient, we offer interpretations for all moderately correlated (r=.5-.7, n=4), and highly correlated (r=>.7, n=1) variables present within segments.

Table 4.7

Most Significant Child Code Correlations

Child Code	Child Code	r value
Place Emergent	Wondering At	0.716
Relationships	Wondering About	0.599
Wondering Whether	Human Decision-making	0.584
Place Emergent	Species, Kinds, & Behaviors	0.535
Wondering At	Species, Kinds, & Behaviors	0.529

Table 4.7 shows the 5 strongest correlations for child code co-occurrence within the data set. Tests for code co-occurrence and significance of relations were all performed using Microsoft Excel. To mitigate methodological limitations of calculating correlational measures

within entire 5-minute segments, we focus this analysis only on strong correlational values (r=.5-1) by excluding weak (r=0-.3) and moderate (r=.3-.5) relationships. In this section we offer an interpretation of the strongest relationships emergent from our statistical analysis with regard to our overarching design aims. A full table of all correlated coefficient values is included in appendix 4c.

Place Emergent x Wondering At. The most significant relationship between codes in this analysis is between 'wondering at' and 'place emergent' (r=.716). Based on the operational definition for these codes, alongside our engagement with data through use of grounded methods, we understand this relationship as evidence of centrality of place-emergent phenomena in provoking affect-rich experiences of awe, wonder, and amazement. This finding supports our design conjectures regarding use of phenomenological methodology through focus on how the semiotic resources emergent from places themselves are central to facilitating opportunities to marvel at the immensity or ineffable nature or complex socio-ecological phenomena. That is, these data suggest that affectively-rich sensemaking is consequentially related to routine opportunities to learn outdoors and engage with emergent phenomena within their authentic context. We suggest that this is because the phenomena which learners wonder at are emergent from the place itself and immediately noticeable within the attentional field. The significance of this finding is further triangulated through additional forms of analysis below through comparisons between LE 2 and 5, and is especially apparent in findings between indoor and outdoor learning environments.

Relationships x Wondering About. We interpret the strong correlation between 'relationships' and 'wondering about' (r=.599) as evidence for how our designs support scientific inquiry about relationships within socio-ecological systems. In contrast to normative approaches

to science education that focus primarily on isolated and decontextualized phenomena, we understand the strength of this relationship as evidence of how the ecosystem of materials within Learning in Places foregrounds relational epistemologies through emergent place-based activity. That is, these findings evidence how routine wondering walks can open up opportunities for sophisticated speculation that attends to the inherent relationality of socio-ecological systems as they emerge through learner noticings and wonderings.

Wondering Whether x Human Decision-making. In contrast to other strongly related codes, we interpret the correlation between 'wondering whether' and 'human decision-making' (r=.584) as evidence of the fidelity of code application in this analysis. That is, because both codes have to do with past, present, and possible actions, we would expect a strong correlation to emerge from analysis. This overlap, however, is not indicative of an exact match in coding criteria and application. Whereas 'human decision-making' was coded whenever there was discourse around human decision-making, codes for 'wondering whether' were more focused; applied within speculative discourses (e.g., within asking questions or wondering about decision-making). Procedurally, this means that in cases where 'wondering whether' was coded, it was very likely that 'human decision-making' was coded as well; but the reverse relationships would not necessarily be true; if there were no speculative sensemaking present only 'human decision-making' was coded. This nuance is important to hold in understanding the overlap and distinction between these otherwise similar codes, where 'wondering whether' is operationalized as a form of 'human decision-making' that indicates its presence within speculative sensemaking (i.e., wondering about human decision-making as opposed to actual of definite claims about human decisions).

Place Emergent x Species, Kinds, and Behaviors. Further elevating the correlational

centrality of sensemaking emergent from direct interaction with places and phenomena themselves is the strong relationships between ‘place-emergent’ and ‘species, kinds, and behaviors’ (r=.535). This is a particularly meaningful finding given our designed focus on supporting a robust focus on inquiry into the structural and behavioral functions of natural phenomena as they are situated in authentic contexts. Thus, we take this finding as evidence for the claim that places themselves significantly support socio-ecological noticings and wondering about species, kinds, and behavior. We suggest that this is because focal phenomena are immediately co-located within the attentional field.

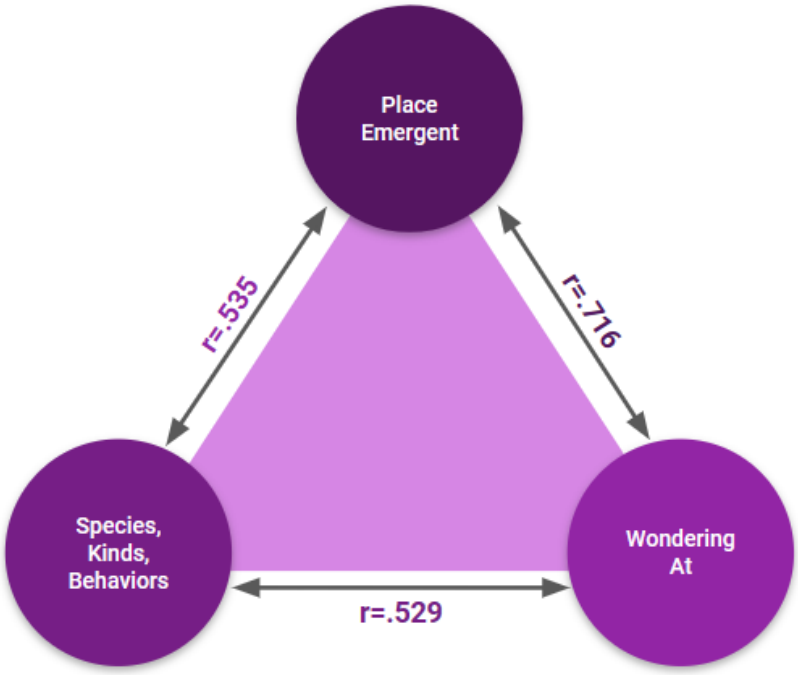
Wondering At x Species, Kinds, and Behaviors. Closely related to the strong correlations already involving codes ‘place emergent’, ‘wondering at’, and ‘species, kinds, and behaviors’ is the significance of the correlation coefficient between ‘wondering at’, and ‘species, kinds, and behaviors’ (r=.529). This indicates a strong connection between experiences of wonder and awe attendant to emergent sensemaking about the form, function, and behaviors of species, kinds, and places. Rather than locating affective landscapes as separate from scientific sensemaking, we suggest that this finding demonstrates empirical support for our claim that experiences of wonder and awe can and do occur within sophisticated scientific inquiry. Taken alongside prior correlational findings, this finding suggests a strong positive triangulation between code applications for ‘Wondering At’, ‘Species, Kinds, and Behaviors’, and ‘Place Emergent’.

Conclusions and Implications. Figure 4.8 represents an emergent, multidimensional relationship between three strong correlational coefficients previously reported on. Together, these relationships point to the special significance of speculative sensemaking emergent from noticing within places which are mediated by an affect of wonder and awe. Mutually reinforcing

as such, these interwoven findings support our design conjectures around the importance of routine outdoor activity for facilitating both affectively rich learning experiences *and* sophisticated scientific inquiry into the form and function of natural kinds as mutually reinforcing domains of practice. Of deep consequence, this strongly suggests that our design is transforming both the conditions and experiences of learning, while still engaging youth in rigorous scientific practice.

Figure 4.8

Correlational Triangulation between Core Dimensions



The significance of this finding reinforces how direct engagement with local places and more-than-humans' kinds is conducive to sensemaking grounded in experiences of awe and wonder. Aligning with how expert scientists talk about their affective motivations to pursue learning in their field of practice (e.g., Root-Bernstein 1996, 2002; Midgley, 2000; Jaber & Hammer, 2016), these relationships also suggest that our designs for socio-ecological sensemaking are shifting both the conditions *and* the content of learning through routine forms of

outdoor activity that nurture both the cognitive *and* emotional dimensions of learning.

Section 2: Shifts in Representational Density Across Child Codes of Interest

In this section we report on the methods used to normalize and compare child code applications for the following head codes: socio-ecological sensemaking, typology of wonderings, and wondering in places. Following from our dual focus on comparing indoor and outdoor space for learning alongside shifts between LE 2 and LE 5, these variables are used to organize and interpret measures of representational density throughout this and the following section. Through these processes, we highlight methodological processes and empirical insights provided through analysis of data collected during wondering walks in our pilot year of storyline implementation.

Data Normalization. Prior to reporting on findings in terms of representational density for focal head and child codes across descriptors of interest (i.e. environment and learning engagement), we first describe the methods used to calculate and compare these values in sections 2 and 3.

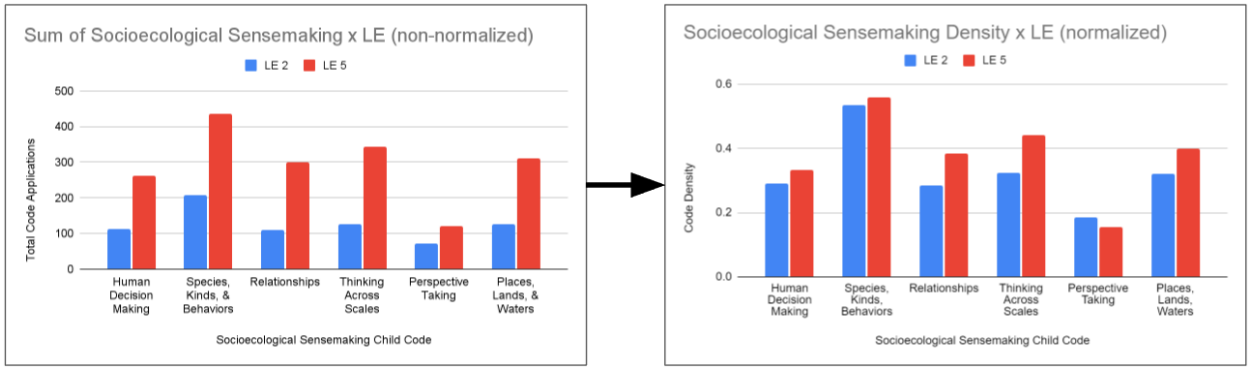
In line with the methodology described above, data were normalized by 5-minute segment to allow for comparisons of data varying in duration (# of 5-minute segments) (Dodge, 2003). Rather than comparing raw counts of child codes, data were normalized through dividing the number of total code applications in each categorical variable by the sum of 5-minute segments present in that descriptor. This results in a metric indicating average number of codes per 5-minute segment, or the likelihood that a particular code shows up in any given segment of data (see also Freedman et al., 2007). The resulting measure indicates the *representational density* (abbreviated to RD in tables below) of a given code across 5-minute segments. The common denominator of ‘rate per 5-minute segment’ allows for internal comparison of how

likely given codes were to be represented across the entire data corpus with regard to any descriptor of interest.

Figure 4.9 highlights an example of how representations of data shift to become comparable based on normalization by the common denominator of ‘rate per 5-minute segment’.

Figure 4.9

Normalized vs Non-Normalized Data Representations



The left shows a simple count of the sum of code applications for each of the 6 dimensions of socio-ecological sensemaking we coded compared between LE 2 and LE 5. However, these non-normalized measures are not internally comparable. For example, code applications for LE 5 will likely be higher due to there being nearly twice as many coded 5-minute segments in LE 5 (782 or 66.8%) vs LE 2 (388 or 33.2%). Without such normalization, it would appear as though variables within a greater number of 5-minutes segments appear more frequently, when the increase instead likely indicates a greater quantity of segments.

Represented on the right is the result of applying the method of normalization outlined above, resulting in comparable measures of representational density. Unrounded (raw) variables were used for all calculations, however only rounded variables are included in the analysis below.

For child code comparisons (reported on in section 3), measures of representational

density can theoretically fall between 0 (was never coded) and 1 (was coded in every segment). In practice however, the representational density fell between .05 and .5 (or coded in 5% to 50% of segments**.** As a normalized value, representational density should be read as the likelihood that a particular code is represented in a given 5-minute segments based on applied descriptors.[2]

Shifts in Representational Density of Head Codes Across Focal Descriptors. This portion of section 2 reports on comparisons of head code representation density between indoor and outdoor context and between LE 2 and LE 5 for all head codes. As mentioned above, these charts display normalized values for 'socio-ecological sensemaking' enabling direct comparison with other head codes (all at a maximum value of 4). The likelihood that any code is represented across the data set is also converted from representation density to percentage through division by common denominator of 4 to give a measure of the likelihood of any given code to be present within a given segment. For example, the representation density of 'socio-ecological sensemaking' indoors is 1.29, meaning that this head code is present in 32.35% of all indoor segments. Compared to a representation density of 1.48 outside (or SES head code present in 37% of segments), indicating a 15% increase in the presence from indoor to outdoor contexts. All relevant data are included below through successive paired figures and tables that compare measures of representational density (also converted to percentage of total segments) across all head and child codes and calculate the difference as a percentage of change between the two conditions. We offer a grounded interpretation of differences exceeding 50%.

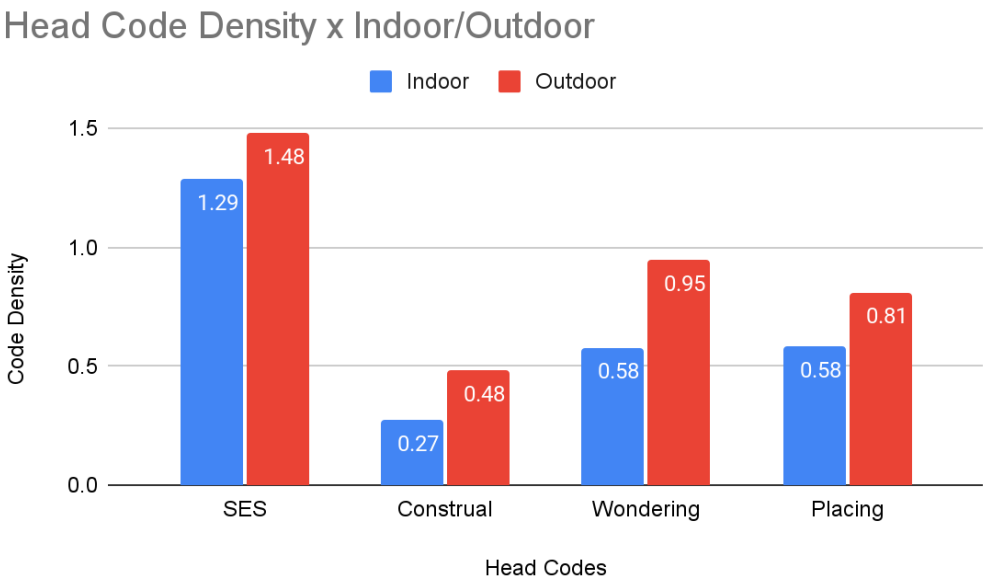
[2] For example, a density of .05 indicates that a code was coded in 1 of 20 segments, while a density value of .25 indicated that a code was present in one of 4 coded segments. Because head codes are represented relative to a particular number of child codes, the maximum density of a given head code will by equal to the number of child codes nested under it. This results in the 'socio-ecological sensemaking' (SES) head code having a maximum value of 6, while each other head code will have a maximum of 4. This can be normalized through by multiplying by $.\overline{6}$ to be comparable to other head codes, bring the maximum value of all head codes to 4 for internal comparability (see below).

Head Code Density x Indoor/Outdoor. The presence of all head codes is greater outside. Though one might expect this of the 'place' codes due to the immediacy of the outdoor environment, 'construals' and 'wonderings' are also considerably more present outdoors at 63% and 76% greater segment presence respectively.

Table 4.8

Density of Head Codes by Environment

Head Code	RD Indoors	RD Outdoors	% Difference
SES	1.29 (32.25%)	1.48 (37%)	**+15%**
Construals	.27 (6.75%)	.48 (12%)	**+76%**
Wondering	.58 (14.5%)	.95 (23.75%)	**+63%**
Placing	.58 (14.5%)	.85 (21.25%)	**+39%**



While not the focus of this analysis, that 'construals' are greater outside aligns with other recent work from our project. An analysis of family tools in the Learning in Places project conducted by Montaño Nolan (2020) found that construals were present in both greater quantity and diversity in outdoor contexts, indicating how the outdoor facilitations shift away from human-centric sensemaking and towards greater attention to diversity of construals.

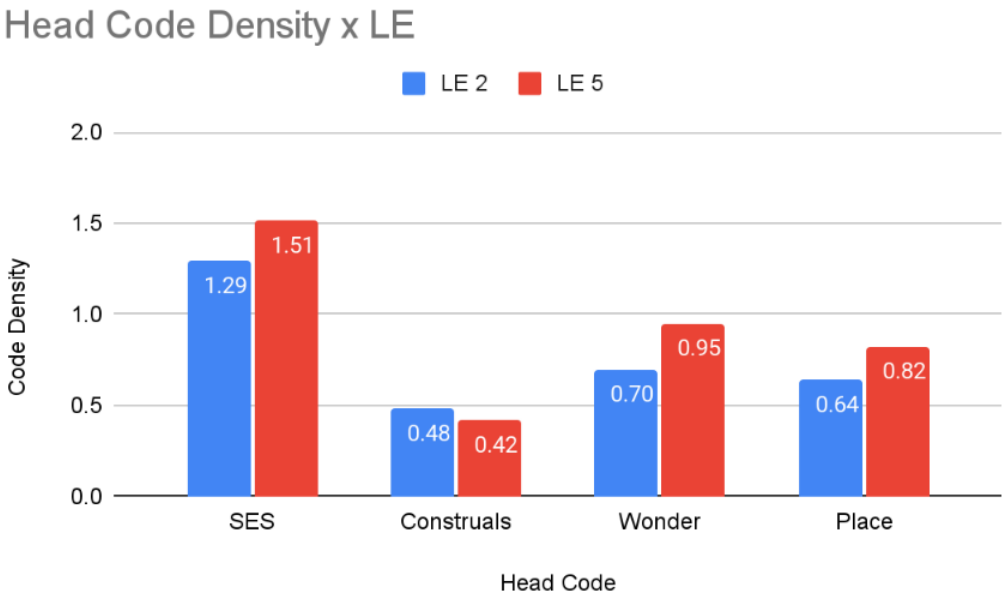
The comparable increase in ‘wondering’ head codes outside is also interpreted as evidence of the affordances of the outdoors in designing for speculative socio-ecological sensemaking. The increase in wondering outdoors is explicated in more detail through analysis of wondering child codes below.

Head Code Density x LE 2/LE 5. Only minor changes are present when comparing head code density from LE 2 to LE 5. There are modest increases in the 3 head codes of interest in this analysis. From a design standpoint, the general increasing trend from LE 2 to LE 5 is insightful as emerging evidence that our ecosystem is facilitating an increase in the frequency of engagement with the landscape of ethical wondering with people, places, and more-than-humans over time. Though it is slight, the decrease in ‘construals’ might be somewhat anticipated as the focus of wonderings gradually narrows in movement through LE 2 to LE 5. Held alongside prior findings of increases of head code density while outdoors, these findings reinforce the importance of spending continued (or even increasing!) time in outdoor contexts as participants move through Learning Engagements in the FBSS.

Table 4.9

Density of Head Codes by Learning Engagement

Head Code	RD LE 2	RD LE 5	% Difference
SES	1.29 (32.25%)	1.51 (37.75%)	**+17%**
Construals	.48 (12%)	.42 (10.5%)	**-13%**
Wondering	.70 (17.5%)	.95 (23.75%)	**+36%**
Placing	.64 (16%)	.82 (20.5%)	**+28%**



Section 2 Summary. Analysis of head code density characterizes measured shifts of key conceptual domains represented in participant discourse within data collected across our pilot year of wondering walk implementation. Within this broad space, we elevate greater evidence of complex sensemaking outside, as well as generally increasing measures of such sensemaking as learning communities progress through the FBSS.

While findings in head code representational density are insightful, the multiplicity of child codes within each head code requires deeper analysis before determining the significance of these shifts. That is, density of head codes is helpful context for understanding subsequent findings, but ultimately quite limited in explanatory capacity due to sheer conceptual breadth contained within each head code dimension. Towards a more focused view of these data, the next sections enrich these findings through analysis of child codes.

Section 3: Shifts in Representational Density of Child Codes Across Focal Descriptors

Reporting findings of child codes in this section follow the same logic as above. However, unlike head codes reported on in section 2, child codes have a maximum value of 1

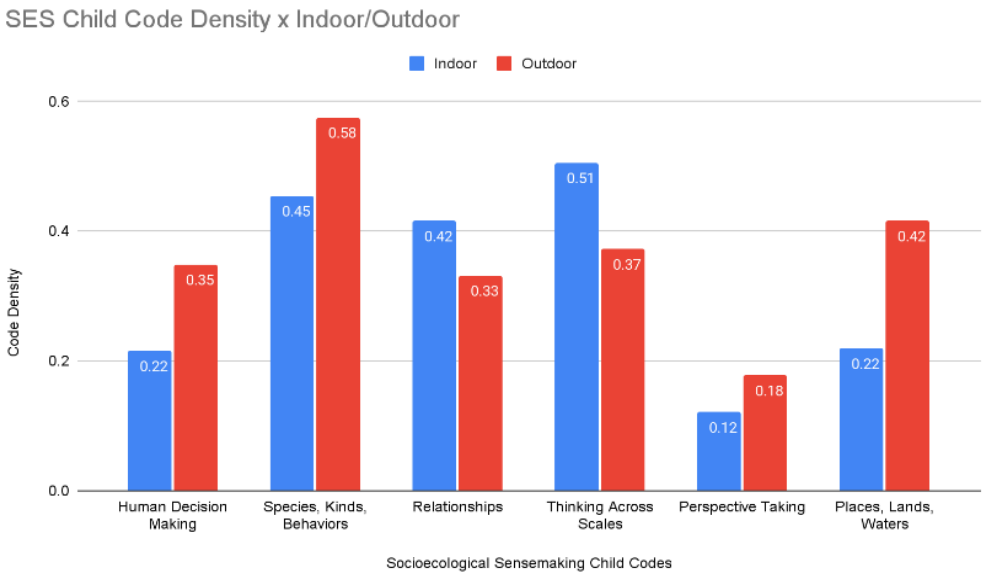
(i.e., present in 100% of segments), meaning measures of representational density are directly convertible into percentages. For example, 'human decision-making' had an representational density of .22 indoor and .35 outdoors, meaning that the code is present in 22% and 35% of segments respectively. Like above, difference is calculated as a measure of change in representational density percentage between conditions of comparison.

Socio-Ecological Sensemaking Child Code Density x Indoor/Outdoor. We see increases in representational density for 'human decision-making' (62%) and 'places, lands, waters' (89%), as well as less significant positive and negative shifts in the four other child codes.

Table 4.10

Density of Socio-ecological Child Codes by Environment

Child Code	RD Indoor	RD Outdoor	% Difference
Human Decision-making	.22	.35	**+62%**
Species, Kinds, Behaviors	.45	.58	**+27%**
Relationships	.42	.33	**-20%**
Thinking Across Scales	.51	.37	**-26%**
Perspective Taking	.12	.18	**+46%**
Places, Lands, Waters	.22	.42	**+89%**



We hypothesize that the increase in ‘human decision-making’ may be attributed to the need to make decisions concerning unfolding movement and possible courses of action more routinely while outdoors. That is, while moving though outdoor places, participants more frequently navigate physical, conceptual, and emotional landscapes that require them to speculate on and make decisions that direct activity as a matter of walking and wondering within places themselves. In so doing, wondering walks prompted a multiplicity of decision-making practices, from considering the impact of humans on natural ecosystems to revisiting behavioral norms while in outdoor learning contexts.

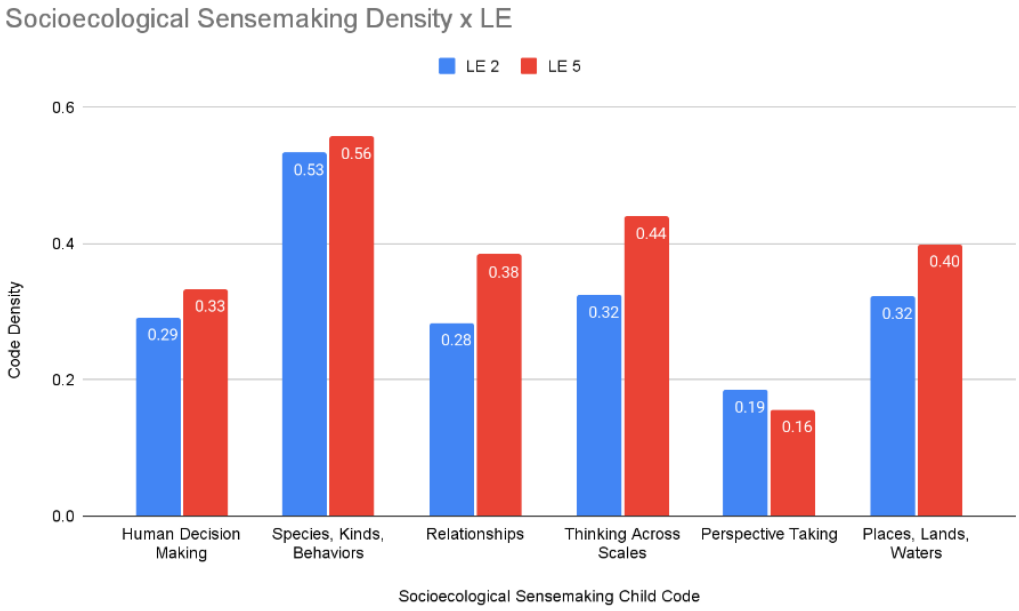
Conceptually overlapping with the ‘place’ head code, the large increase in codes ‘places, lands, waters’ when moving outside is somewhat self-evident. The immediacy of socio-ecological phenomena when outdoors presents more direct and frequent opportunities to engage in socio-ecological sensemaking as tied to particular local contexts. Due to the increased immediacy of outdoor conditions it has to do with forms of sensemaking that necessarily will occur more outdoors when one is in direct contact with places, lands, and waters. As such, this finding is also interpreted as evidence that our coding scheme was developed, refined, and applied in rigorous and consistent ways.

Socio-Ecological Sensemaking Child Code Density x LE 2/LE 5. From LE 2 to LE 5 we see varying modest increases in most forms of socio-ecological sensemaking coded across the data set. Particularly with ‘relationships’ and ‘thinking across scales’ (each at 35% increases between LEs) we take these increases as encouraging emergent indicators of how sensemaking shifts as participants move through the FBSS.

Table 4.11

Density of Socio-ecological Child Codes by Learning Engagement

Child Code	RD LE 2	RD LE 5	% Difference
Human Decision-making	.29	.33	**+15%**
Species, Kinds, Behaviors	.53	.56	**+5%**
Relationships	.28	.38	**+35%**
Thinking Across Scales	.32	.44	**+35%**
Perspective Taking	.19	.16	**-16%**
Places, Lands, Waters	.32	.40	**+24%**



Compared to differences between indoor and outdoor contexts, density of SES child codes tends slightly more towards positive increases. While not as significant as other findings reported in this analysis, the general tend towards increasing representation of SES child codes (with the exception of 'perspective taking') is taken as an indicator of an emergent developmental progression in socio-ecological sensemaking as participants become more familiar with and immersed in activities through engagement in the FBSS.

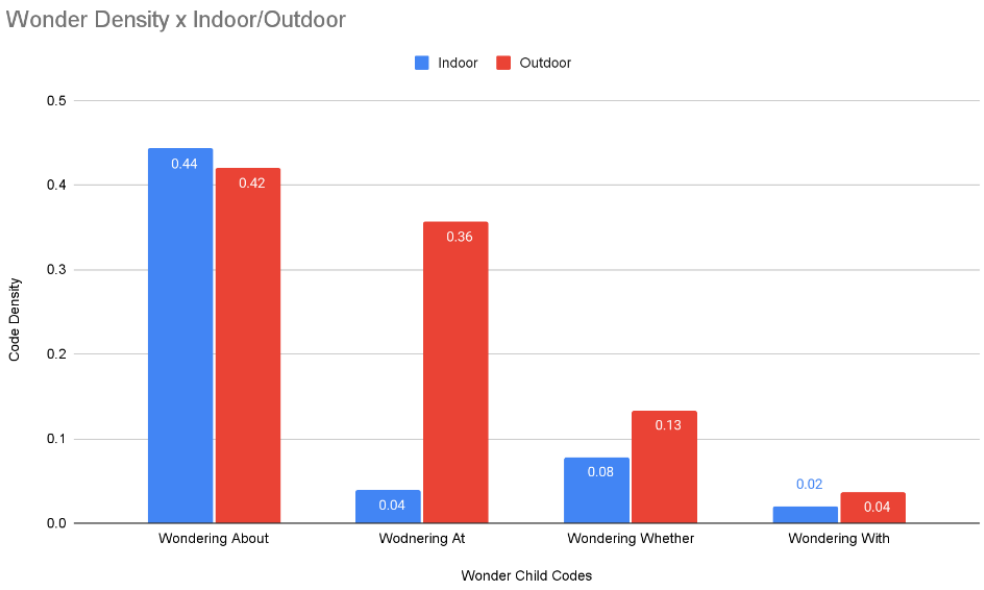
Wonder Child Code Density x Indoor/Outdoor. Child codes for 'wondering' across segments reflect some of the most significant shifts in representation of sensemaking across this analysis. To wit, increases of 70% and 90% for wondering 'whether' and 'with' help us

understand the affordance of outdoor context for speculative activities, particularly in supporting more routine discourse and speculation on human decision-making. Most significantly, the over eight-fold increase in wondering ‘at’ when moving outdoors resonates deeply with our contention that outdoor learning contexts hold profound potential for stimulating the affect-rich experiences of awe and wondering that our design aims to nurture.

Table 4.12

Density of Wondering Child Codes by Environment

Child Code	RD Indoor	RD Outdoor	% Difference
W About	.44	.42	**-5%**
W At	.039	.36	**+810%**
W Whether	.078	.133	**+70%**
W With	.02	.037	**+90%**



It is hard to overstate the significance of the 810% increase in representation of wondering ‘at’ across segments for our design conjecture that routine outdoor learning is central to cultivating an affect of awe, wonder, and amazement within socio-ecological sensemaking. These findings speak to how close proximity within the natural world can generate affectively-engaged experiences of surprise, awe, and joy. Indicated in our operationalization for wondering

‘at’ within design materials as well the coding scheme detailed above, it is evident how the outdoors provokes discursive interactions wherein participants grapple with the immensity, complexity, or otherwise profound nature of their sensory perceptions while outdoors.

While wondering ‘at’ is central to our attention here, we also see meaningful increases in both wondering ‘whether’ and ‘with’. Similar to SES child code ‘human decision-making’, we hypothesize that wondering ‘whether’ is increased due to how walking and wondering outdoors requires a greater frequency of decisions to be made compared to indoor activities. We understand this increase in representation of child codes as evidence that supports our design conjectures around how being outdoors brings participants into direct contact with evidence of socio-ecological decisions, thereby prompting more routine sense making about how and why certain decisions come to be made. Discourse about wondering ‘whether’ also likely extends towards as well as what decisions should be made in the present and how they enact particular relational configurations (e.g., how should we act while outside to respect the more-than-human beings we will encounter?).

Coming in at a 90% increase between indoor and outdoor contexts, wondering ‘with’ is one of the most infrequently coded dimensions in this analysis. The comparative infrequency of codes for wondering ‘with’ across the data set indicates opportunities to better support speculative activities that position places and more-than-humans as agentic partners in socio-ecological speculation. That being said, we understand the near doubling of representational density here as a proximal indicator for how learning in outdoor context might present great opportunities to refigure understandings of more-than-human agency and forms of speculation that position humans as a part of the natural world.

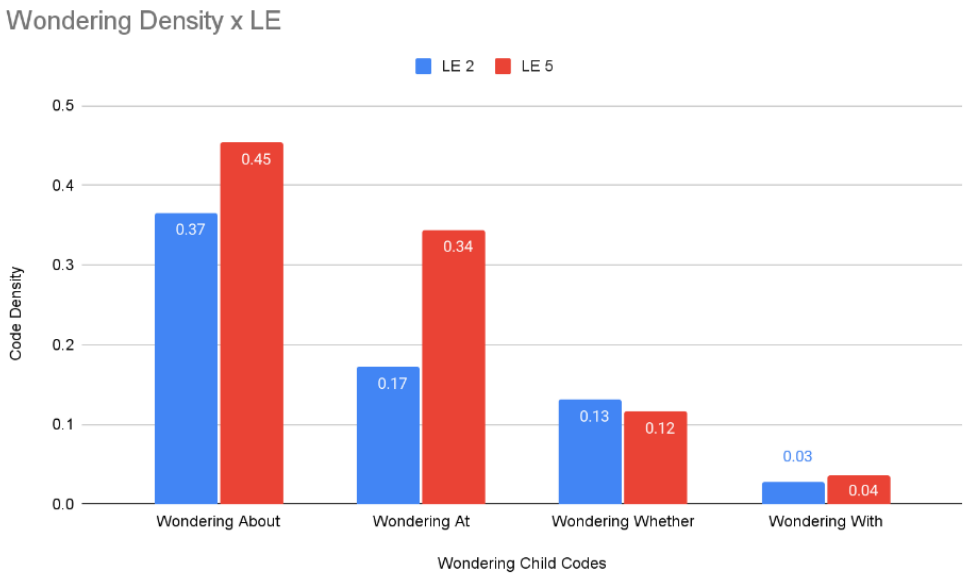
Wonder Child Code Density x LE 2/ LE 5. With the exception of a 99% increase in

wondering ‘at’, child codes for ‘wondering’ show minor changes from LE 2 to LE 5.

Table 4.13

Density of Wondering Child Codes by Learning Engagement

Child Code	RD LE 2	RD LE 5	% Difference
W About	.37	.45	**+24%**
W At	.17	.34	**+99%**
W Whether	.13	.12	**-11%**
W With	.028	.036	**+26%**



The significant increase in wondering ‘at’ is consistent with data reviewed above. Indeed, analysis of child code supports understanding shifts in head codes. For example, the increase in wondering ‘at’ reported on here is largely responsible for increases in ‘wondering’ head code density overall, indicating the increasing presence and development of inquiry grounded in awe. As such, we interpret this change between LE 2 and LE 5 as evidence of how as classroom communities become more accustomed to wondering walks, socio-ecological sensemaking is more regularly attended by a sense of awe, amazement, and even reverence for the complexity and utter profundity of the natural world.

Of particular note for ongoing redesign, we would expect to see significant increases in

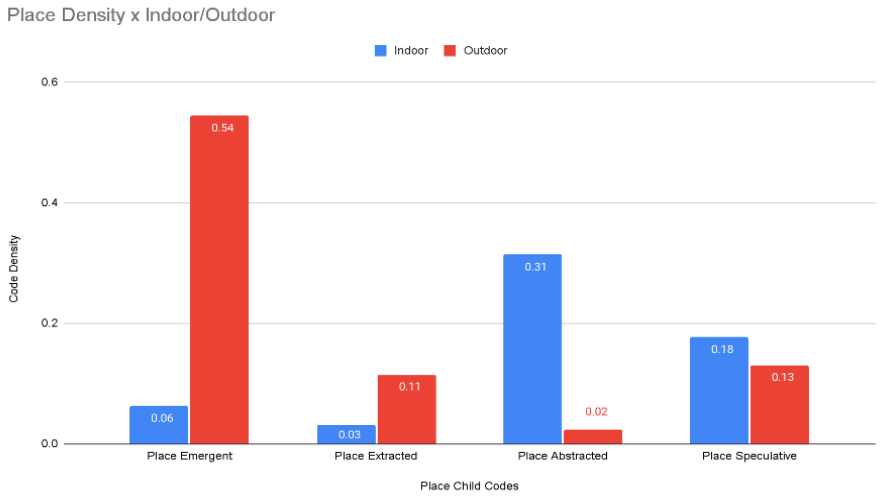
wondering whether due to shifts in activity emphasis between LE 2 and LE 5 as inquiry is gradually focused through the development of a class "should we" question. A partial explanation could be found in the knowledge that the relationship between focus walks and should-we question development in LE 4 and LE 5 was one of the last things to stabilize in storyline design. In any case, this finding points to the need to design more robust supports for speculating about possible decisions as noticings and wonderings are focused in the front half of the FBSS.

Place Child Code Density x Indoor/Outdoor. Comparing representational density of 'place' child codes across indoor and outdoor segments reveals three increasingly significant changes: a 266% increase in 'extracted', 767% increase in 'emergent' and a 92% decrease (1205% increase) in 'abstracted' codes.

Table 4.14

Density of Place Child Codes by Environment

Child Code	RD Indoor	RD Outdoor	% Difference
P Emergent	.063	.543	**+767%**
P Extracted	.031	.115	**+266%**
P Abstracted	.314	.024	**-92%**
P Speculative	.176	.13	**-26%**



Large increases in representational density are measured across both ‘emergent’ and ‘extracted’ codes lend empirical support to our contention that socio-ecological wondering is elevated through direct experience within places. That is, noticings, wondering, and meaning making in places is supported greatly through immediate outdoor experiences where places actively facilitate sensemaking trajectories and cultivate attention towards locally relevant socio-ecological phenomena. Emerging with place, these findings point to how these experiences also expand opportunities for interactions with more-than-human beings where learners increasingly observe phenomena in transformed contexts through direct physical interaction. Through learning outdoors, these multimodal embodied interactions (involving touching, picking up, or collecting e.g., Chapter 3 with seedpods), such ‘place extracted’ interactions extend wondering in dynamic ways that invite multiplicities of meaning-making.

In contrast, and somewhat unsurprisingly, abstraction becomes the primary mode of socio-ecological sensemaking indoors. Compared to other shifts in representational density, a decrease of 92% may seem less significant. However, because the relationship is reversed, a 92% decrease indoor to outdoors corresponds to an increase of over 1200% in representational density between outdoors and indoors, the largest shift reported on through this entire analysis. We take these findings as highlighting the complementary nature of indoor and outdoor activities, and their role in cultivating learners’ abilities to toggle between scales of concreteness and abstraction. With such toggling being an important feature of complex reasoning, his insight can be more deeply incorporated into design materials to better support educators in naming and modeling these kinds of shifts in their own pedagogical practices.

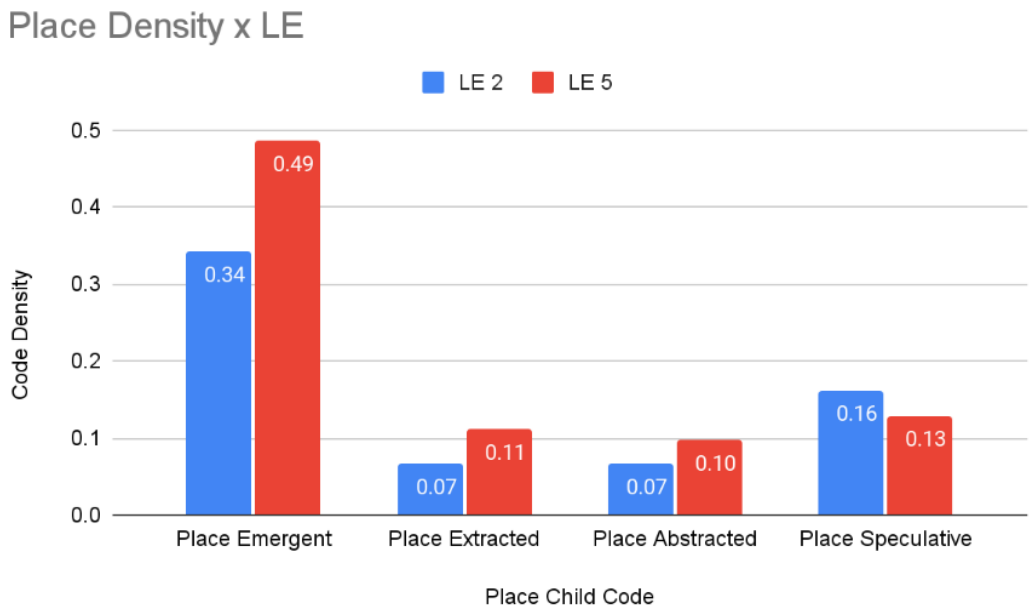
Place Child Code Density x LE2/LE5. Reporting on comparisons of ‘place’ child code density is the final set of findings included in this analysis. With generally more modest

significance than previous findings, ‘emergent’, ‘extracted’, and ‘abstracted’ codes show increases of 41%, 66%, and 45% respectively. ‘Speculative’ codes appear less regularly in LE 5 segments as compared to LE 2 (-20%).

Table 4.15

Density of Place Child Codes by Learning Engagement

Child Code	RD LE 2	RD LE 5	% Difference
P Emergent	.342	.485	**+41%**
P Extracted	.067	.111	**+66%**
P Abstracted	.067	.097	**+45%**
P Speculative	.162	.129	**-20%**



Similar to prior findings, the general increase in representational density across most codes here suggests the emergence of a developmental trajectory in terms of place engagement as participants move from ‘open’ (LE 2) to ‘focused’ (LE 5) wondering walks. While the activity scaffold in LE 5 may contribute towards these increases, we also interpret these shifts as stemming from educators and learners becoming more familiar with the LiP ecosystem that supports them in building more robust and personal relationships with places through routine

outdoor activity over time. In so doing, we take the shifts here as both resulting from changes in activity structure, but also understand shifts from LE 2 to LE 5 as proximal indicators of changes over time.

Discussion and Design Principles

Several findings outlined above warrant further discussion for how they inform our approach to wondering walks as we continue to engage in iterative processes of co-design. In beginning to close this analysis, we synthesize primary findings and put forward emergent principles of design to support teaching and learning in parallel contexts.

Design Principle 1: ***Socio-ecological learning activities should be designed to include routine outdoor experiences to cultivate expansive affective landscapes that enrich possibilities for life and well-being.***

The relationship between affect-rich experiences of awe and outdoor place-based activities is one of the most meaningful findings from this analysis. Findings from this analysis demonstrate how outdoor learning facilitates 'wondering at' through expanding opportunities for affectively rich experiences of awe and joy that are so vital to ethical socio-ecological sensemaking. Said simply, being outdoors transforms the emotional experience of learning. This finding reinforces the importance of our design for foregrounding awe and wonder through ontologies of place-based mobility as core to sophisticated socio-ecological sensemaking. That is, being outside shapes activities in ways that engage emotional landscapes in ways not often supported in approaches that prioritize content knowledge through routinely placing learners in direct contact with places and more-than-human beings. Supported by disciplined educator mediation, such outdoor activities cultivate ways of knowing grounded in affective engagement and personal relevance, a powerful alternative to educational activities and curriculum that

prioritize a narrow focus on epistemic achievement. Though primarily evidenced through dramatic increases in 'wondering at' in outdoor contexts, this principle is further substantiated through the near doubling of segments coded for wondering 'at' from LE 2 to LE 5.

Regarding this principle, it is important to emphasize how the shift towards the forms of outdoor teaching and learning characterized throughout this dissertation entail paradigmatic shifts from normative forms of education and their near-complete reliance on indoor places for learning. As such, these fundamental transformations take time, and significant shifts should not be expected over short periods of time. Thus, we interpret the general trend towards positive shifts in representational density of child codes measured above as emerging evidence of a developmental trajectory towards ethical wondering with people, places, and more-than-humans supported through engagement in the Learning in Places material ecosystem. This is particularly encouraging given that this data comes from the first full implementation (pilot year) of the FBSS. As such, these give an initial window into the landscape of socio-ecological sensemaking that Learning in Places aims to cultivate. Used to inform processes of re-design and subsequent implementation across classrooms in the next phase of our work, these findings inform future iteration and re-design of materials towards amplifying positive shifts and remediate findings of concern.

Design Principle 2: ***Designs for socio-ecological sensemaking should elevate the strengths of outdoor and indoor places to create local embodied experiences alongside developing capacities for abstraction and generalization.***

Focusing on the presence and role of places within sensemaking, this analysis reveals how 'place emergent' and 'place extracted' are greatly increased outdoors, while 'place abstracted' is far more frequent indoors. While this finding informs our understanding of the

central role of outdoor activity in facilitating socio-ecological speculations, it also reveals significant limitations in indoor learning. That is, these findings highlights how indoor learning results in socio-ecological sensemaking almost entirely devoid of direct experience with emplaced phenomena. As a result, socio-ecological sensemaking indoors requires a high degree of abstraction from place that can preclude the personally relevant and affect-rich experiences (i.e., 'wondering at') characteristic of such sensemaking outdoors.

While we see this as a limitation common to indoor learning contexts, through our focus on outdoor learning we understand this finding as also speaking to the complementarity of indoor and outdoor work. That is, in holding the affordances and constraints of both indoor and outdoor places for learning, this data prompts us to more deeply consider and more internationally design to support intentional toggling between the particularities of outdoor places while also developing capacities for abstraction cultivated while indoors. Just as complex socio-ecological sensemaking requires toggling between multiple scales (e.g., temporal, spatial, size, population), these data help us think more deeply and design for toggling between placed particularities emergent in outdoor places to more generalized abstraction necessitated by indoor environments.

Limitations and Future Work

There are several consequential limitations in the data set and analytic methods described above. These limitations point to future lines of work that can further enrich our understanding of wondering walks.

The nature of the secondary data set presents limitations to diversity and representation of particular classrooms and grades. Specifically, we note an underrepresentation of 1st and 3rd grade compared to 2nd grade and Kindergarten, as well as an imbalance of segments gathered across educators. While these limitations are not surmountable given the inherent qualities of this

data set (they literally represent who implemented more or less), future research can account for these in different ways through calculating representational density across and within other descriptors such as grade, educator, and place (school). For example, future research could analyze the density of codes based on grade and educator (e.g., figure 4.10 and for an example of this using wondering child codes). Another fruitful line of inquiry could analyze the representational density of codes across successive implementations for individual class communities (e.g., figure 4.11 showing shifts in density of wondering head codes across implementations for individual educators).

Figure 4.10

Future Work: Wondering Code Density by Educator and Grade

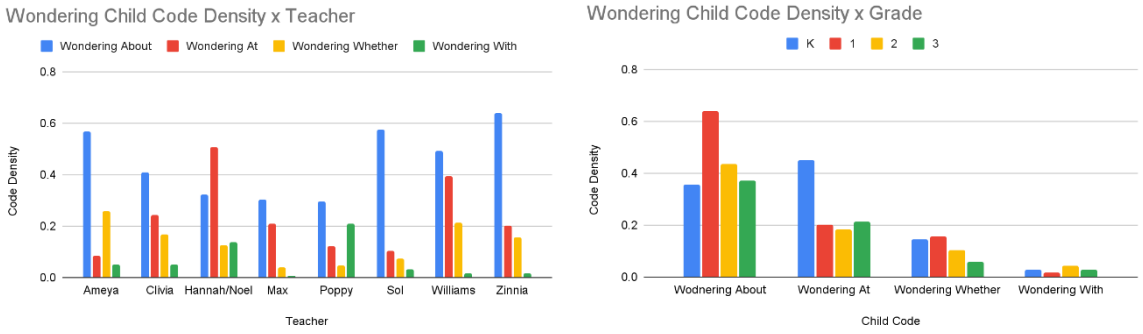
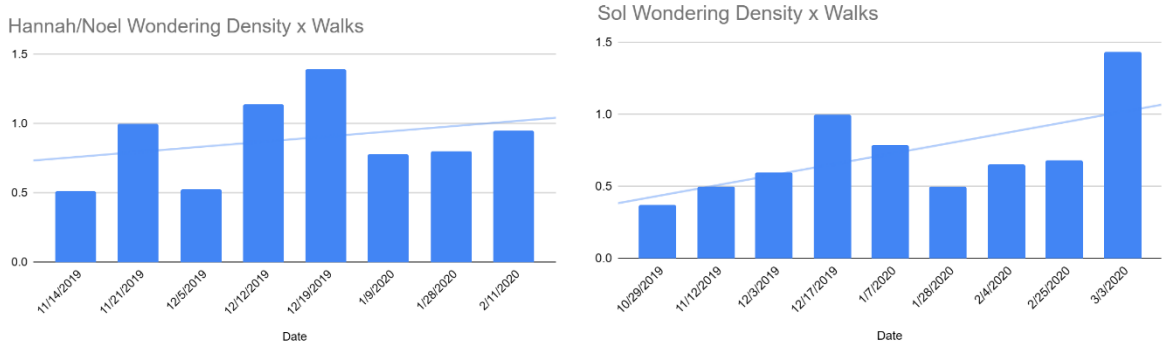


Figure 4.11

Future Work: Shifts in Wondering Density Across Educator Implementations



Perhaps the most salient limitation in this analysis stems from the application of codes to indicate the presence or absence of codes at 5-minute intervals. This method was chosen, in part, for its efficiency in logging and coding data simultaneously of this large data set in much less time than coding with 5-minute segments[3]. While this balance of pragmatic constraints and analytic depth results in the ability to draw quantitative insights about the regularity of distribution of code applications *across* the data set, it does not allow for measurement of density (i.e. code weight) *within* 5-minute segments. For example, the analysis above is not fine enough to distinguish between 5-minute segments in which there was one qualifying instance of "wondering whether" versus another instance where "wondering whether" was engaged multiple times within a single 5-minute segment. Thus, this analysis cannot provide more fine-grained insights into code density beyond the presence of sensemaking dimensions that meet the threshold for code application described in the codebook. Following from this, measures of correlation coefficients must also be understood as related across 5-minute segments, rather than at the level of the utterance. It is for this reason that we only report on findings for r values above .5.

Finally, it is worth mentioning that our conception of 'wondering with' developed significantly over the course of coding. Thus, the more sophisticated conception of 'wondering with' presented in earlier chapters is not adequately captured within codes used in this analysis. To this point, and with adjacent relevance to other codes applied here, future work might further differentiate codes for 'wondering with' into their ethical, mediational, pedagogical, and socio-ecological forms. Implemented across analysis, splitting any of the child codes used in this

[3] Internally collected statistics for time spent processing and logging data estimate that our team spent approximately 200 hours logging and analyzing data in 5-minute intervals, whereas initial approaches to logging within segments took 3-5 times longer.

analysis into multiple sub-codes would allow for a finer grain of coding that would result in more conceptually nuanced findings.

Conclusion

In closing, we reflect on the broad quantitative analysis of the wondering walk secondary data set. Through characterizing the presence (and absence) of key dimensions of ethical wondering with people, places, and more-than-humans across the entire corpus of wondering walks collect in Year 3 of Learning in Places implementation, this work compliments the theoretical framing introduced in Chapter 1, the design-based analysis in Chapter 2, and the qualitative case study in Chapter 3. As such, this paper presents empirical support for our ongoing design work through demonstrating how key outdoor activities (wondering walks) have a marked effect on the forms and frequency of socioecological sensemaking within supported place-based activities.

Located within the continually unfolding and iterative processes of co-design, this analysis provides and elevates deep insights to guide our ongoing co-design work. Additionally, this work supports development of methodological frameworks needed for additional analytic work, both within the ~98 hours of data reported on here as well as in our approach to additional data collection in future iterations of storyline implementation with communities of learners, educators, and families. Both practically and methodologically, this analysis has contributed greatly to how we understand and design to support more ethical forms of wondering with people, places, and more-than-humans to support the well-being of youth, families, and communities. In evidencing the routine occurrence of central frameworks, forms of sensemaking, and design aims of the Learning in Places project, we understand the data and claims presented through this analysis as deep contributing to the characterization of particularly potent

possibilities for imagining and enacting new forms of socioecological engagement given the global challenges and opportunities of the 21st century.

Chapter 5. General Discussion: Implications and Future Work

Introduction: Dissertation in Retrospect

Through design-based, mediational, and quantitative analyses, this dissertation has characterized what can happen when we design learning activities from *ethical wondering with people, places, and more-than-humans*. Located within the Learning in Places project, and centered around routine outdoor activity via *wondering walks*, this orientation aims to realize possibilities within science education for designing learning from the noticings and wonderings of learners in ways that position humans a "a part of" complex socio-ecological systems, and away from "apart from" models linked to narrow epistemic focus, human-centric reasoning, and unsustainable decision-making (Medin et al., 2012; Medin & Bang, 2014; Bang & Marin, 2015). In analysis of the designed materials and pedagogical interactions within Learning in Places, this dissertation contributes to how we understand the centrality of wondering in education, while also attending to the "how" of learning at the micro-interactional levels within which ethical pedagogical mediation unfolds. In so doing, this work demonstrated how a pedagogical focus on wonder contributes towards co-designing expansive forms of learning with people, places, and more-than-humans that support educational wellbeing, dignity, and justice.

Return to Chapter 1

Grounding the work within historical developments in science education and the role of questioning practices, Chapter 1 provided a broad framework for wonder applicable across the three papers that make up the body of this dissertation in Chapters 2-4. In particular, this first chapter emphasized the pedagogical potential of wonder through the capacity to weave together multiple dimensions of experience (i.e. cognitive, emotional, ontological, embodied, existential) to support more holistic forms of inquiry grounded in both curiosity and awe. Drawing on

phenomenological perspectives to position noticings in places as ontologically prior to experiences of wonder I elevated the affective potentialities of wonder in light of how they are often muted through narrow focus on epistemic achievement alone. Learning in Places is then introduced as a participatory design-based project that positions wondering as central to the beginnings of socio-ecological education. Taking up this conceptual framework within the design space of Learning in Places, I then formulated a series of interconnected research questions that are explored in subsequent chapters. By way of summary, I return to and reflect on the findings of this dissertation in relation to these questions.

Return to Chapter 2 (Paper 1)

Guiding the analysis of materials designed to support ethical wondering with people, places, and more-than-humans, I asked:

- *What conceptual ecologies and commitments support our approach towards ethical wondering with people, places, and more-than-humans; and how are these stances embodied, concretized, and/or operationalized within our design materials?*

Chapter 2 took up this question by characterizing a tripartite structure for ethical wondering with people, places, and more-than-humans through articulating three interconnected dimensions of the work: ethical wondering, wondering with, and our particular context of socio-ecological education through Learning in Places. Grounded in the design-based research and social design experiments (Bang & Vossoughi, 2016; Barab & Squire, 2004; Bell, 2004; Design-Based Research Collective, 2003; Gutiérrez & Jurow, 2016; Gutiérrez & Vossoughi 2010), empirical philosophy (Dewey 1916; Feinberg, 2015; Wilson & Santoro, 2015), and the pedagogical potential of wonder (Egan et al., 2014; Hadzigeorgiou, 2013; Opdal, 2001; Schinkel 2017, 2018), Chapter 2 elevated the role of ethical wonderings and "should-we" questions as central to our

design for axiologically-engaged education. Drawing on concepts and practices such as pedagogical decision-making, disciplined improvisation, interpretive power, Chapter 2 also attended the "how" of designing to support ethical wondering ("wondering with") at the micro-interactional level within which relationships are formed, dignity is conferred, and learning unfolds (Bakhtin 1981, 1986; Erickson 2006; Espinoza, 2009; Espinoza & Vossoughi, 2014; Goodwin 2017; Shotter 2005, 2015).

In doing so, I support claims that designs for transformative forms of education must reach beyond dissemination of epistemic content knowledge to seriously consider the affective dimensions and mediational means through which emergent learning unfolds. Within our focus on complex socio-ecological sensemaking, findings from the analysis of designed materials in Chapter 2 empirically characterize five central dimensions and core commitments to our design for ethical wondering with people, places, and more-than-humans: nature-culture relations, more-than-human agency, histories of places & place design, seasonal timescales, and field-based learning.

From this grounding in the conceptual and design-based ecology of Learning in Places, Chapters 3 and 4 provide complementary qualitative and quantitative analyses of *wondering walks*; key activities in the beginnings of our Field-Based Seasonal Storyline (FBSS). Together, these analyses represent emerging answers to the questions posed in Chapter 1 which seek to characterize and quantify the interactional and conceptual landscape of activity within wondering walks as designed and enacted in our first year of storyline implementation.

Return to Chapter 3 (Paper 2)

Through deep analysis of interaction and sensemaking of a rich "case study" wondering walks emergent in analysis of our pilot data, Chapter 3 began to answer the question:

- *What are the interactional characteristics of ethical wondering with people, places and more than humans and how do they reconfigure relationships and shape sensemaking within contexts of socio-ecological learning?*

Using extended transcripts as concrete examples, I articulated 5 dimensions that emerged from grounded analysis of implementation data: disciplined socio-ecological improvisation; emergent place-facilitated inquiry; focus on the patterned structure, function, and behavior of places, species, and kinds; expansive and embodied perspective taking; and complementary nature-culture positioning. Across this analysis I highlight the specific discursive moves that enact and weave these dimensions together within the emergent flows of place-based inquiry. At a minimum, these include spatial and temporal toggling, modeling affectively rich noticing and wondering, elevating immediate noticings and learner sensemaking, frequent bids for clarification and extension, encouraging multiple forms of representation, use of open-ended questions and tentative or provisional language, positioning place as teacher, and elevating the fundamental ontogenetic similarities and relationality of human and more-than-human being.

Informed by these concrete discursive examples, Chapter 3 makes an empirical case for the potentialities of ethical wondering with people, places, and more-than-humans for reconfiguring relationships between and among youth, educators, and the rest of the natural world. In addition, this analysis characterizes the deep pedagogical affordance of starting learning with place-based noticing and wondering for engaging multiple dimensions of human experience (e.g., cognitive, affective, ontological, existential) towards more holistic models sophisticated scientific sensemaking. In so doing, Chapter 3 suggests a needed shift away from predefined and over-constrained curricular models of learning that are premised on the superiority of humans, adults, and the indoors. Within the broader context of this differentiation,

this Chapter thus provides an empirically grounded proof of concept for the importance of emergent activity, practiced mediation, and ethical wondering for engaging whole people and reconfiguring models of self and inquiry towards those that recognize the agency and dignity of youth and more-than-human beings.

Return to Chapter 4 (Paper 3)

Complimenting the qualitative depth of analysis in Chapter 3, Chapter 4 reported findings from the first phases of statistical analysis to determine and compare the representation of key codes across all wondering walk data from the first full year of storyline implementation. This analysis set out to answer the following questions posed at the outset of this dissertation:

- *What kinds of socio-ecological sensemaking practices, specifically in relation to our core design propositions, are represented across wondering walks? Are there significant correlations? If so, what are their implications?*
- *(How) does the representation of coded sensemaking practices shift between open wondering walks in LE 2 and focused walks in LE 5, as well as between storyline engagement indoors and outdoors? What are possible implications of these variations?*

In pursuing these questions, 98 hours of video data were logged and coded at 5-minute intervals for the presence of 18 codes designed to capture key dimensions of socio-ecological speculation (socio-ecological dimensions, nature-culture construals, forms of wondering, and relationship the place). Descriptive statistics for the data corpus were generated and statistical analyses for code co-occurrence within segments were performed using Pearson correlation coefficient. Analysis was then further focused to compare representational density of code application between Learning Engagements 2 and 5, as well as between indoor and outdoor learning contexts.

The findings of this analysis suggest a strong and significant triangular relationship

between noticing place-emergent phenomena, affectively rich experiences of awe and wonder, and engaging in scientific sensemaking about species, kinds, and behaviors. This finding aligns with our design intentions and corroborates the qualitative findings detailed in Chapter 3, providing solid empirical evidence about the mutually reinforcing nature of place-based complex socio-ecological reasoning and affectively rich experiences of wonder and awe.

Findings in code co-occurrence between Learning Engagement suggest an emerging developmental trajectory from LE 2 to LE 5, evidenced through the modest increases to most codes of interest. These findings also highlight the complementarity of indoor and outdoor learning context for facilitating distinct forms of sensemaking. Possibly most significant to our overarching lines of design, we see significant increases in affectively and ethically salient forms of wondering with outdoors. Further reinforcing the centrality of routine outdoor experience in our design work, the analysis and findings detailed in Chapter 4 provides a statistically concrete foundation from which to understand the affordances and constraints of wondering walks for socio-ecological learning.

Together, we understand the findings detailed in Chapters 3 and 4 as reflecting how our design accomplishes transforming the conditions and experiences of learning, while also maintaining rigorous engagement with field-based science practices. To wit, the analyses reported on in this dissertation concretize how the approach t ethical wondering with people, places, and more-than-humans in Learning in Places via wondering walks actually *increases* scientific rigor through unmuting and centering affective and embodied capacities through dignified mediation of place-based noticings and socio-ecological wonderings. Beyond rigor and content knowledge alone, this dissertation emphasizes how ethical wondering with people, places, and more-than-humans *feels*. It is relationally saturated in an understanding that we are

never wondering in vacant places, but within historically unfolding contexts of lively human and more-than-human interaction whose recognition and contribute towards cultivating more interdependent construals of self. By framing learning as fundamentally relational endeavor between interspecies and intergenerational participants, this approach elevates how we both live within deep histories of places and are surrounded by the agencies of more-than-human beings as central to complex socio-ecological deliberation and decision-making.

Principles of Design

In closing, we put forward three design principles that have emerged through this dissertation. We understand these principles as fundamental not only to our understanding of *ethical wondering with people, places, and more-than-humans,* but as also broadly applicable in guiding educational endeavors that reach towards more healthful, just, and livable futures.

Principle 1: ***To enact more ethical possibilities for life and learning, we must design for education that transforms historically accumulating systems, practices, and dynamics of power that perpetuate the supremacy of some over others.***

Designing learning activities that transform unjust power dynamics is a critical task for ameliorating inequalities and marginalization within society at large. Assisting youth in navigating and developing critical understandings of power structures, discrimination, and oppression is central to creating more ethical forms of knowing, being, and doing that can dismantle systems premised on the superiority of some over others. Learning activities that intervene in such power dynamics contribute to building more just and livable futures through encouraging learners to think critically about complex issues and cultivating empathy through examining different perspectives.

Because no one project can do it all, we elevate how this principle of design is

operationalized in ways specific to the particular pedagogical contexts engaged through Learning in Places. For example, through ethical wondering with people, places, and more-than-humans, this dissertation focuses on transformations within nature-culture relations, as well as refiguring normative dynamics between adult educators and youth learners that recognize educational dignity and enact ontological justice. Synthesized from this dissertation, we propose the following principles to guide the transformation of such power dynamics.

To cultivate more ethical human-nature relationships, designs for learning should:

- Routinely position humans as a part of the natural world in discourse and sensemaking.
- Recognize the agentic and educative contributions of more-than-human beings and the facilitative capacities places themselves.
- Conduct inquiry through cultivating relationships with local places and kinds through routine outdoor activity over longer-term timescales (e.g., seasons, years).
- Support relational construals of complex phenomena through opportunities to experience wonder, awe, curiosity, and joy within land-based and place-emergent sensemaking.
- Design learning experiences from the particularities of local places and kinds (i.e., place-designing, histories of places).

To support must just and dignified relationships between adult educators and youth learners, pedagogical designs and interactions should:

- Continually develop educators' interpretive power and the mediational capacities required to notice and support expansive learner sensemaking to recognize youth as agentic sense-makers and dignified participants within and across moments of unfolding interaction.

- Structure and facilitate learning activities using methods that authentically engage and build with the noticings and wonderings of learners through disciplined forms of pedagogical mediation.
- Reach beyond dissemination of instructional content to also consider the ethical implications of *how* pedagogical interactions unfold to desettle the dimensions of power which maintain the supremacy of adults, humans, and indoor learning environments.

Principle 2: ***Design for expansive affective and embodied landscapes in learning.***

This dissertation makes the case that expanding affective and embodied landscapes for learning is crucial for the enactment of more healthful forms of inquiry. Throughout this body of work, we have maintained that integrating the cognitive and emotional processes inherent in learning within the ontological doings of educational activities is central to realizing more just and equitable forms of teaching and learning. Empirically, we make the case that learning is enhanced through activities that expand opportunities for holistic engagement and social collaboration that more accurately reflects the affective states that motivate sustained expert practice in "real-world" contexts. Given our attention to socio-ecological sensemaking in school-based learning contexts, the particularities of this principle in Learning in Places are reflected by a subset of more specific principles concerning ethical mediation, educational dignity, and expanding sensemaking through the practice of wondering and moving within local places. The edges of our work prompt formulation and reflection on a subset of principles following from this second overarching principle

Design for expansive affective and embodied possibilities in learning should:

- Recognize the dignity of all collaborators (human and more-than-human) as meaningful participants and agentic co-designers of learning trajectories through flexible design

structures that support multiple modes of emergent sensemaking through disciplined mediation and shared agency.

- Intentionally plan for routine forms of movement across a multiplicity of places, times, and corporeal arrangements to support porous and embodied approaches to learning across the life course.
- Position educators as responsible for modeling and supporting holistic forms of inquiry through sharing their own genuine interest and continual learning about socio-ecological phenomena and relationships.
- Expand opportunities for learners to notice the beautiful and puzzling things in the world to support experiences of awe, curiosity, and joy within everyday activity.

Principle 3: ***Designs for axiologically-engaged future-making must support routine opportunities to wonder and ethically deliberate on possible courses of action.***

This dissertation has articulated how our work desettles normative ontological and epistemic approaches to education through beginning pedagogical trajectories within contexts of sustained axiological engagement relative to the particularities of local places. In elevating wonder, values, and ethics within trajectories of place-based learning, we have conceptually and empirically characterized how our work recognizes, cultivates, and nurtures opportunities to experience joy, awe, and hope about our relationship within the natural world and our collective socio-ecological futures. Through starting in axiology and foregrounding the role of interpretation, values, and perspective taking, we have elevated how dynamics of power and historicity continually shape and contextualize socio-ecological inquiry across multiple spatial, temporal, and relational scales. Said another way, this dissertation has described how grounding epistemic sensemaking and place-based ontologies within particular axiological orientations (i.e.,

ethical wondering with people, places, and more-than-humans) is necessary to supporting cohesive and authentic forms of knowing, being, and doing that take seriously how culture, learning, and identity are central to ethical approaches to teaching and learning. In so doing, this principle captures how our work constitutes a consequential reversal of approaches to education designed for the delivery of content knowledge through outcome-based standardization. Together, the papers that make up this dissertation have described how our work moves towards forms of world-making and re-making grounded in forms of expansive wonder and radical hope needed to imagine and enact more just and livable socio-ecological possibilities now and in the future (Lear, 2006).

Necessarily intertwined with the two principles explicated thus far, we offer us a subset of design principles elevated in this dimension of our approach:

- Designs for educational equity must continually recognize and engage how power and historicity shape places, contents, and trajectories of learning within and across the micro-moments that constitute all of life and learning.
- Designs for more just and livable futures must reach beyond dissemination of content knowledge to expand authentic opportunities for experiencing hope about the possibilities of our collective social futures.
- Designs for ethical deliberation and decision-making must take seriously the relationships between pedagogies of wondering and our collective capacities to imagine and enact more healthful worlds in times of complex challenges and possibilities.
- Designs for ethical epistemic expansion must ground ways of knowing within practices of doing and being that recognize and operationalize interdependent values, relational

construals, and reciprocal socio-ecological understandings to support holistic well-being and realize more just and livable futures for all life on this planet.

Limitations, Strengths, & Future Work

Along with the powerful insights explicated about, the papers that make up the core of this dissertation present notable limitations, some due to method and others to circumstance.

Regarding the latter, the global COVID-19 pandemic beginning in early 2020 interrupted our first full year of storyline implementation during the 2019-2020 academic year. Due to sudden school closures in March of 2020, data collection of storyline implementation across the 10 classrooms ceased abruptly. Thus, we do not have sufficient data to understand how orientation towards ethical wondering with people, places, and more-than-humans manifests in practices near the end of the storyline (LEs 8-10) where investigation and data collection becomes more central.

Another limitation is present due to how analysis for each paper moved forward from multiple centers. For example, because the frameworks presented in Chapters 1-3 were not fully articulated when the analysis presented in chapter 4 began, our understanding of *wondering with* has shifted somewhat. While we now understand "wondering with" as an orientation towards pedagogical mediation, when broad analysis in Chapter 4 began "wondering with" was operationalized as an orientation having more to do with positioning places and more-than-human beings as agentic partners in inquiry (see code descriptions in chapter 4). Future work thus includes a refinement of conceptual categories based on the frameworks presented in earlier chapters, particularly to elevate mediational characteristics as emergent within unfolding pedagogical interactions.

A central strength of the approach this dissertation has taken is in use of complementary

methods of analysis to triangulate a rich set of concepts and commitments between design-based (practical), mediational (interactional), and quantitative (statistical) instantiations of ethical wondering with people, places, and more-than-humans. This multifaceted analytic grounding makes visible the rich interconnections between conjectures and processes of design within interaction, contributing towards more rigorous and holistic understandings of core phenomena through holding empirical, philosophical, and design-based elements together.

Future Work

The formation and pursuit of the questions that have guided this dissertation have produced a range of important findings that will continue to guide the iterative design of conceptual structures and material supports within Learning in Places' ecosystem. As such, this dissertation is a momentary and necessarily partial concretization of emergent work that continues to flux and flow beyond its written representation here. As the first steps of an increasingly rigorous and contextualized inquiry into the design and enactments of education for more healthful futures, there are numerous paths for future work in both design and analysis. Implied in this (and a product of the "three paper" dissertation), will necessarily include the further refinement of the lines of analysis presented through this dissertation towards and broader dissemination via publication in select academic journals. Beyond this however there exist several other notable lines of design-based, methodological, and analytic work ahead.

Further design work includes ongoing iteration on materials, particularly in those Learning Engagements where educators tend to settle in the storyline as implemented and supported so far. For example, some educators we have partnered with get into practice of wondering walks and start seeing the potential for shifts implicated in routine outdoor activity for learning, but tend to need additional support in gradually developing and pursuing more focused

wonderings that bridge into subsequent cycles of investigation and data collection. Addressing this insight, recent iterations of our design work have aimed to develop novel forms of support for educators in gradually moving from more open to focused wonderings through scaffolding and modeling the creation of the should-we and investigation questions taken up in later FBSS Learning Engagements.

Methodologically, this dissertation informs qualitative, quantitative, and design-based processes of data collection and analysis. These include the continued development of coding frameworks and approaches to analysis that are both micro-longitudinal and micro-latitudinal across the existing data set (DeLiema et al., 2015). For example, lines of inquiry focusing on case studies of youth or educators that are present in multiple "rich" segments of data could help us more deeply understand the interactions that result in the presence of key phenomena and forms of sensemaking within the broader storyline of inquiry that emerge over the course a particular groups engagement with the FBSS. Because Chapter 4 presents only a particular slice of available data, there still exist numerous other readily accessible lines of subsequent analysis that could be performed to calculate and elevate meaningful comparisons and shifts across educators, places, and case study classrooms over time.

Finally, and in an important sense, all this future work (and much more) is already underway. At time of writing, Learning in Places is gaining momentum within a second round of NSF-funded implementation and refinement. Given the design-based complexities of our work–and compounded by the sheer length of time it takes to craft a (this) dissertation–the insights shared here have been shaping aims and values in Learning in Places since their inception in spaces of project discourse for months and even years. The development of this work in conjunction with the ever-iterating nature of our ecosystem more broadly; helps inform our

approach to redesign of existing materials as well as expansive design of new materials that might better support the aims detailed throughout this dissertation. For example, in the next rounds of design we are working to elevate the many transdisciplinary connections in our materials, bringing the civic and social studies elements of ethical wondering to the foreground (e.g., Lee et al. 2021), or what we are starting to imagine as *Wondering Talks* to support community-based conversations about socio-ecological histories, decision-making, and futurity.

Closing

> *In the end, science as we know it has two basic types of practitioners. One is the educated [person] who still has a controlled sense of wonder before the universal mystery, whether it hides in a snail's eye or within the light that impinges on that delicate organ. The second kind of observer is the extreme reductionist who is so busy stripping things apart that the tremendous mystery has been reduced to a trifle, to intangibles not worth troubling one's head about.*
> *(Loren Eiseley, 1978, p. 190)*

> *I believe that part of what propels science is the thirst for wonder. It's a very powerful emotion. All children feel it. In a first grade classroom everybody feels it; in a twelfth grade classroom almost nobody feels it, or at least acknowledges it. Something happens between first and twelfth grade, and it's not just puberty. Not only do the schools and the media not teach much skepticism, there is also little encouragement of this stirring sense of wonder.*
> *(Carl Sagan, 1987)*

In closing this work, I re-emphasize how taking wonder seriously is a matter of educational justice, mental health, and ontological well-being. This is especially true given how normative approaches to education are replete with structures and practices that routinely narrow affective and existential possibilities for life through robbing learners of opportunities to experience wonder and awe. My dissertation elevates the importance of starting learning in ways that open up wonder, joy, and authentic interest to make space for and prioritize the importance of kids noticing beautiful and puzzling things in the world. In doing so, I illustrate the affordances of a pedagogical focus on beginnings through emplaced wonder and awe for expanding affective, ontological, and epistemic landscapes of learning to authentically engage

whole people and support ethical sensemaking about complex socio-ecological situations.

As I draft the final words of this dissertation I reflect on the connections between my own emergent story and the forms of socio-ecological sensemaking supported in this dissertation. While writing this dissertation, my wife and I welcomed a child into the world, putting into even more stark contrast the importance of work to prepare ourselves and future generations for a world characterized by increasingly disruptive socio-ecological shifts. In this space, this line of work details how increasing content knowledge is not sufficient for nurturing forms of wondering and hope about the possibilities of all our social and ecological futures; an orientation towards hopeful pedagogical practices that people aren't often afforded in times when "scorched earth" stories of decay and mourning are so prevalent. Indeed, increased knowledge alone, without expansive affective possibilities, is increasing distress via feelings of despair, apathy, disengagement, and other defuturing effects (Fry, 2015; see also; ecological grief and anxiety: Coffey et al., 2021; Cunsolo, et al., 2020); Thompson, 2021. This speaks to the need for alternative ways of being and knowing that can encourage expansive possibility thinking and cultivate "radical hope" that anticipates a future goodness for which we do not yet have the concepts with which to fully understand (Lear, 2006).

In this spirit, the concepts and practices of ethical wondering with people, places, and more-than-humans provides an additional frame and path of action from which to productively engage questions and decision in times of socio-ecological precarity to inform how we might collectively design for a future with livable futures (Escobar, 2018). Contributing to the desettling of colonial logics and lifeworlds that ask "How do I know *about*" some *thing*, ethical wondering with people, places, and more-than-humans turns towards collective imagining from the entanglements of epistemic sensemaking alongside affective, ontological, axiological, and

existential dimensions in questions of “How we can live well *with*” *one another* as essential to the forms sensemaking and affective care vital to well-being and healthfulness of people, places, and more-than-humans within the human experience. Because at the end of the day “we are going to change the world together” in some way regardless, “so we should be thoughtful about how we do it” Green (2023).

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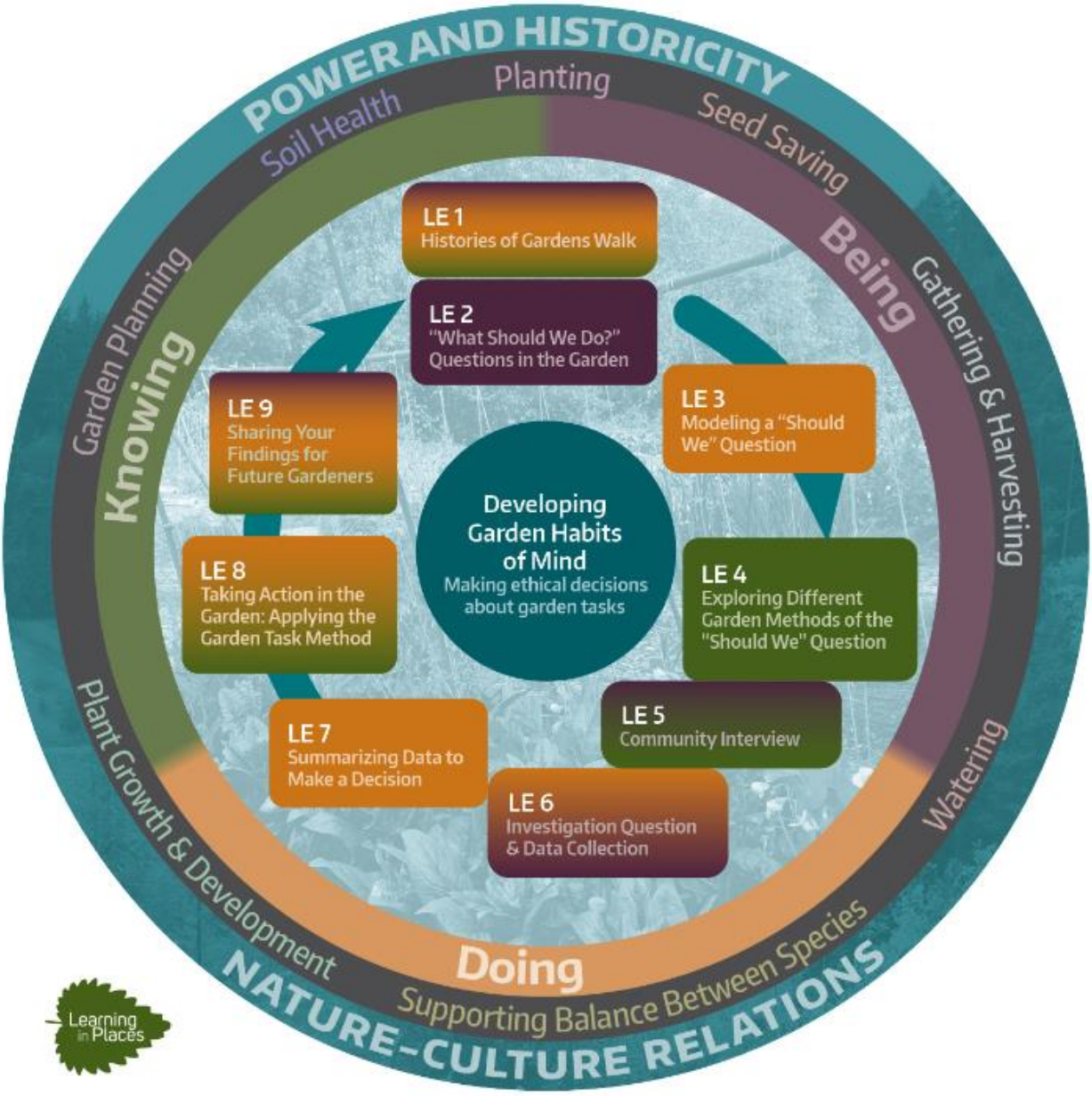
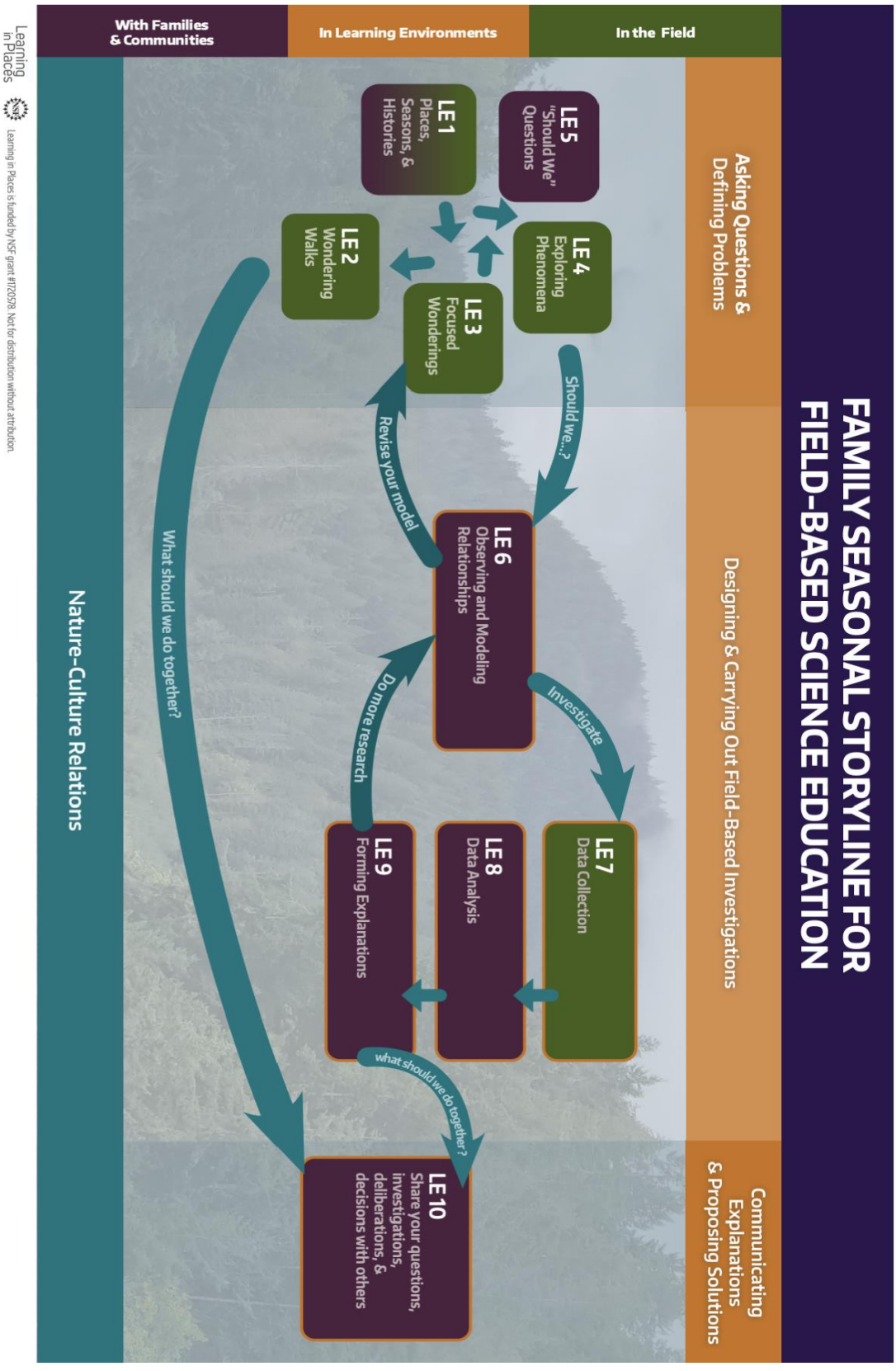
Appendices

Appendix 1a:

Garden Storyline Graphics



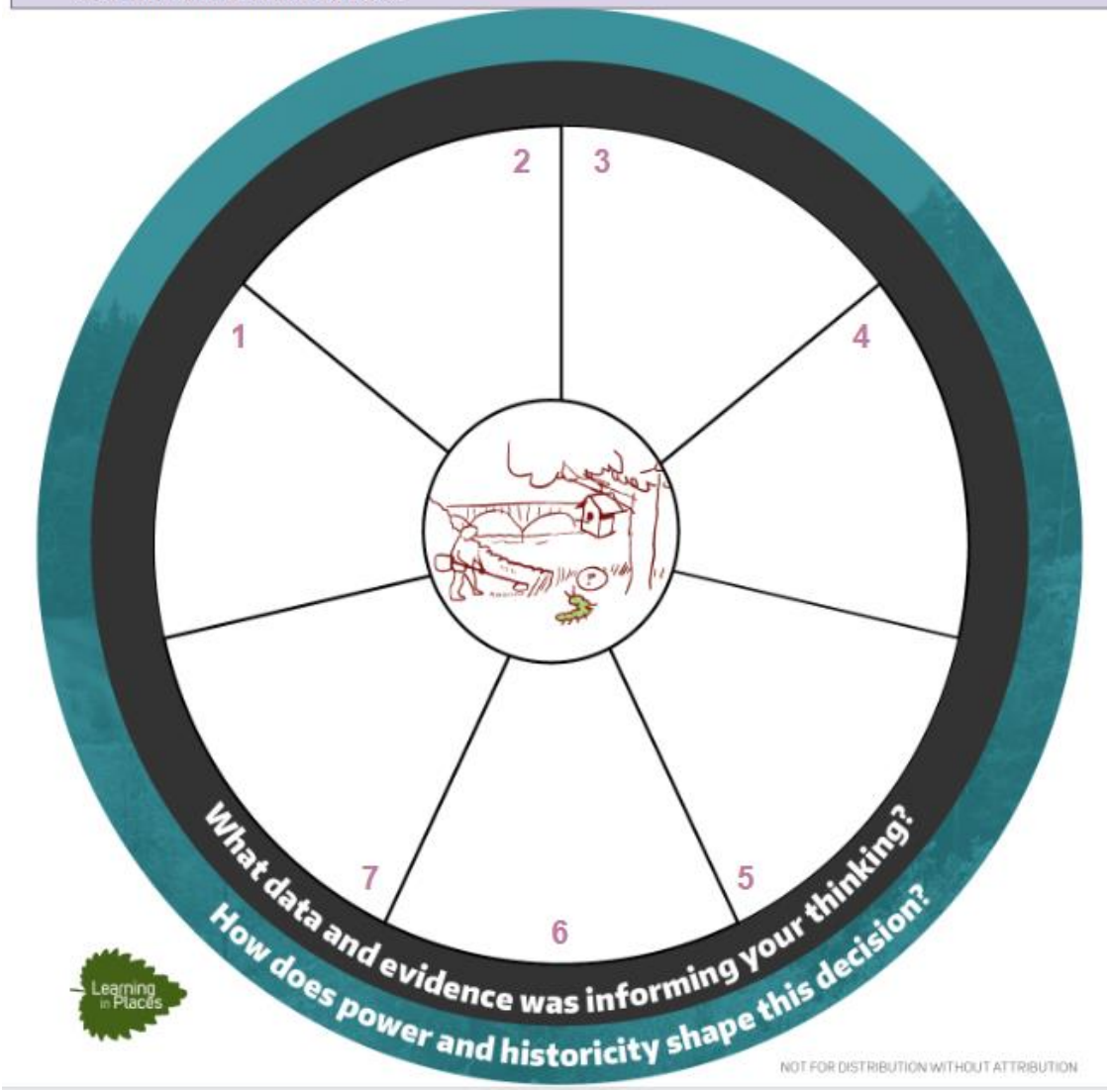
Family Storyline Graphic



Appendix 2a:

Backpocket Practices for Ethical Wondering (Reverse Side)

1. How did the **need** to make this decision **come to be**?
2. What **values** will guide your decision?
3. How does the **place** you are in or live impact this decision?
4. How does the **natural world** impact this decision? How is the natural world impact*ed* by this decision?
5. **What options** are we considering? Why would this be the **best decision** to make?
6. **Who will be impacted** by this decision and how (both human and more-than-human)
7. How will the decision impact you, your students, and their families **in the future**. How will it impact more-than-human communities?



Appendix 2b:

Relationships in Socio-Ecological Systems Framework Examples

Part 1: Framework for Socio-Ecological Relationships

This framework is intended to help identify the range of social and ecological relationships that scientists, policy makers, and communities think about as they engage in everyday activities and collective deliberation and decision-making. Nature-culture relations - that is the cultural values, activities, learning opportunities, decisions, and interactions - are reflected across both social relationships with the natural world and how scientists study ecological relationships within systems. Typically, science education focuses on ecological relationships where the types of human relations and interactions are invisible to learners. Educators should use this framework to consider 1) what kinds of human relationships are shaping local learning environments (indoors and outdoors), and 2) what kinds of ecological relationships are observable and shape local lands, waters, and interactions with humans. Learners should be able to identify their own social and ecological relationships in and across the many different places they live and learn.

Quality and Types of Social and Ecological Relationships

a) **Economic relations** include commodification of lands, waters, species, and kinds for profit as well as regional employment and tourism.

b) **Political relations** include nation-state interactions and policies that affect and govern access to-, ownership of-, and/or the rights of- lands, waters, and more-than-human others.

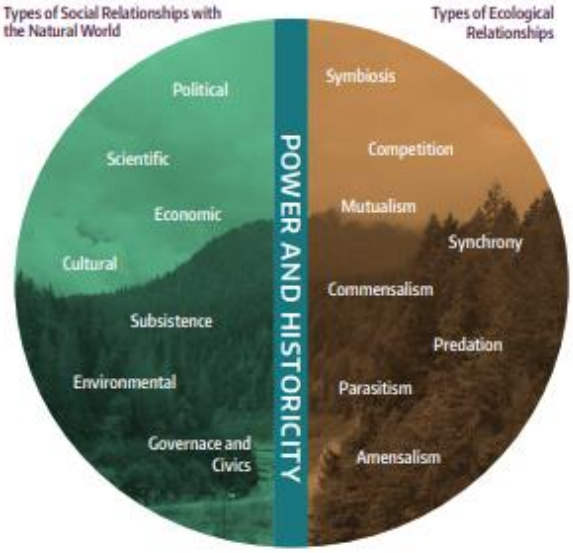
c) **Scientific relationships** include the study of socio-ecological systems and components within systems in both natural and controlled environments.

d) **Cultural relations** include the spiritual, religious, leisure, recreation, and other practices and activities on lands, waters, and with more-than human others. All social relationships with the natural world are cultural.

e) **Subsistence relations** include the human cultivation of the natural world for food or economic subsistence or ecosystem management.

f) **Environmental relations** include the use of- or conservation of- lands, waters, and more-than-humans others to protect the health of environments.

g) **Governance and Civics Relations** include the collective management of lands, waters, and more-than-human others through informed citizenships and civic feedback cycles, observation & data collection.



h) **Symbiosis** is the interdependent relationship of two dissimilar organisms who live together in a long-term, intimate association. Below are types of symbiotic relationships.

i) **Competition** is when two or more organisms rely on the same environmental niche or biological need.

j) **Mutualism** is a symbiotic relationship where both organisms benefit.

k) **Synchrony** is when species time parts of their lifecycle (reproduction, migration, etc.) based on seasonal changes in behavior in another organism.

l) **Commensalism** is a symbiotic relationship where one organism benefits and one does not benefit but is unharmed.

m) **Predation** includes any interaction between two species in which one species benefits by obtaining resources from and to the detriment of the other.

n) **Parasitism** is a symbiotic relationship where one organism benefits and one is harmed. Many ecologists include parasitic interactions in discussions of predation.

o) **Amensalism** is a routine interaction in which the presence of one species has a negative effect on another, but the first species is unaffected.

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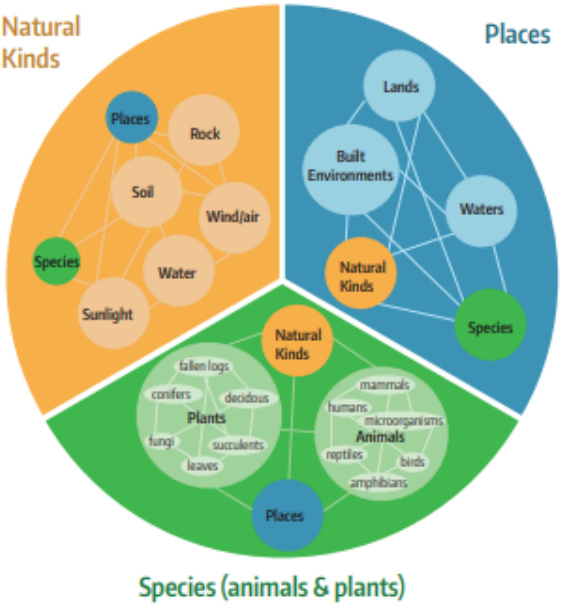
Relationships in Socio-Ecological Systems Framework Examples (continued)

PART 2:
Foundational Conceptual Relationships in Socio-Ecological Systems

"Base relationships" are the basic conceptual building blocks of socio-ecological systems that include pairs of relationships between species, kinds, and places over time.. This framework is intended to help learners identify, collect data about, and reason across the base relationships they directly and indirectly observe in their field investigations and in sense making about socio-ecological phenomena. Educators can use this framework to assess learners' sensemaking about interdependent relationships and design opportunities for learners to expand their knowledge.

This framework is not intended to reinforce strict taxonomies or categories of life on Earth. Such taxonomies often confuse learners as they try to fit species or kinds within narrow conceptions of living or nonliving beinghood or types of species or kinds that are typical of Western science. This can foreclose meaningful sense making about the behaviors, functions, and structures of particular species and kinds as well as relationships between them.



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Appendix 2c:

Relationships in Socio-ecological Systems Framework Examples

5 Dimensions of Reasoning About Complex Socio-Ecological Systems

There are many opportunities to connect learners' socio-ecological sensemaking with their lived experiences, interests, cultural practices, and the like. Here are some ways to start:

- **Power and Historicity**
  Power and historicity shape every aspect of socio-ecological systems.
- **Species, Kinds, & Behaviors**
  Species include humans, animals, plants, fungi, etc. Kinds include land, water, air, and soil, etc. Behaviors are the roles, actions, or decisions that species and kinds make within a system.
- **Relationships**
  All socio-ecological systems consist of interdependent relationships among species (including humans), and kinds. Webs of relationships can vary across scales - from agent (individual) to aggregate (population level).
- **Places, Land, and Water**
  The functions (purpose and roles) of socio-ecological systems are intimately tied to places, lands, and waters. Places, lands, and waters shape and are shaped by human and more-than-human behaviors and decisions.
- **Thinking across Scales**
  Socio-ecological systems are dynamic and span across multiple temporal and spatial scales. Sensemaking about socio-ecological systems requires learning about histories of places, observing phenomena in multiple locations, and taking the perspective of others.
- **Ethical Deliberation and Decision-Making**
  Humans have always made, and will continue to make, important daily and large scale decisions that impact socio-ecological systems. Deliberating the impacts of human decisions is a moral and ethical endeavor.

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Relationships in Socio-ecological Systems Framework Examples (continued)

Teacher background information

Below is a description of the five socio-ecological systems that students and families use in this lesson. The corresponding graphics are ways for you to help your students and families make sense of and explain each dimension.

Species, Kinds, and Behaviors: This includes different species of plants, animals and bugs. Kinds are the abiotic beings such as rocks, water, soil, etc. Behaviors are the many different ways species and kinds interact with the environment.

Relationships: Relationships are the ways in which beings interact with each other. For example, how does the behavior of water change with the weather? Which plants do you typically see caterpillar munching on?

Places, Lands, and Waters: This includes looking at the landscape and noticing where the water is, where the land dips and rises, where the people, animals and plants tend to gather.

Thinking across scales: This includes thinking through different time and space scales, as well as observing using different perspectives (taking the perspective of a plant, or an animal, or a rock, for example). Thinking across scales is particularly helpful when thinking about life cycles, energy cycles, water cycles, etc.

Human Decision- Making: Humans have had, and will continue to have, important relationships that shape places. Be sure to think about Indigenous Peoples' Time, Recent History, and the Future when listening to student wonderings. Also, listen to how students position humans in relation to the natural world. Do they position humans as part of the natural world or apart from (i.e., separate from) and/or dominant over the natural world? Help support students' sense-making using position of humans as part of the natural world.

One entry point into a discussion about these dimensions is asking students to **notice** and **wonder** about the various elements in each of the pictures for each dimension. For example, for the "relationships" picture, you can ask, "What relationships do you notice in this picture? Who is the bird in relationship with, why,and how? Who is the tree in relationship with,how, and why? Who is the caterpillar in relationship with, how, and why?" You can also find other pictures and/or use examples from the Wondering Walk you took in LE 2.2.

Appendix 2d:

Forms of Reasoning about Socio-Ecological Systems

Forms of Reasoning about Socio-Ecological Systems

The list below provides sample types of relational reasoning that support sensemaking about socio-ecological systems. The goal is for learners to engage in *multiple* forms of reasoning. Educators can foster this over time and across activities. The list is not exhaustive, but meant to highlight what learners are already doing, and what can be scaffolded.

Different Forms of Reasoning for Complexity	
Relational	**Chain-Like Relationships** start with 1-1 then extend into chains that follow a linear relationship (e.g., fly - frog - snake; or succession of trees in an ecosystem). This is particularly helpful to support making predictions.
	Weblike Relationships among 3 or more organisms/kinds whose relationship is not linear (e.g., eagles, bears, and humans eat salmon, and trees absorb nitrogen from salmon die-off). This is helpful to support reasoning across different spatial and temporal scales.
Analogic	Reasoning that relies on an analogy to compare similarities across two or more entities. Finding the limits of similarities is often also a helpful aspect of analogical reasoning. Analogical reasoning is a robust and helpful form of sensemaking. This type of reasoning can support many different aspects of complex socio-ecological systems reasoning, like exploring **functions and roles of species or kinds** within a socio-ecological system. For example, bioengineers have specific relationships with land and/or waters and many different organisms perform this bioengineering role including humans, beavers, bees, ants, etc).
Perspectival	Taking the perspective of others in order to make sense of behaviors or functions of different parts of a system. This includes taking the perspective of more than humans! For example, reasoning about the **impacts of human decisions** on human and more-than-human relationships requires considering conflicting perspectives about positive, neutral, or negative impacts to different relationships.
Toggling	Thinking with at least two scales at a time (could be temporal, spatial, agent/aggregate, relational, etc) or holding complementary/contrasting perspectives. In complex systems reasoning, it is important to toggle across scales because these systems e*xist at multiple scales and a change at one scale can lead to unpredictable or nonlinear changes at another level.* Any given place, phenomenon, or event has multiple histories, and connections to phenomena in other places.
Reasoning with Uncertainties	In complex systems decision-making, there are a series of factors and relationships that are seemingly obvious, but making decisions about them is less clear. It is important for learners to think about possible, emergent connections or decisions.
Abductive	Complex systems often require us to use a wide range of observations as foundations for sensemaking and problem solving. We use abductive reasoning when we synthesize our noticings in order to engage in decision making that includes some level or sense of uncertainty.

Appendix 2e:

LE 2.4 Instructional Sequence and Tools

Teacher background information

This lesson will focus specifically on relationships and ask students to collect evidence of relationships. The Relationships in Socio-Ecological Systems Framework will be very helpful because it provides some background on the different types of relationships in socio-ecological systems. Interdependent relationships undergird all aspects of socio-ecological systems, are dynamic and shift across time, space, and levels of organization. Research shows that sensemaking across these multiple shifting scales requires intentional scaffolding, particularly for young learners. NGSS practices such as observing, modeling, and data collection can support learners' attention to webs of relationships in and across places. This framework features two aspects of interdependent relationships in socio-ecological systems sensemaking: 1) quality of social and ecological relationships that expert scientists, policymakers, and communities think about; and 2) the base relationships of species and kinds that undergird interactions in a system. This framework is intended to develop learners' relational habits of mind - that is the routine sensemaking about interdependent relationships - and support educators, students, and their families to develop a language for attending to powered and historicized relationships at the intersections of social and ecological worlds.

MATERIALS

- LE2.4 student tool (students do at school),
- LE2.3 Five socio-ecological dimensions graphic organizer
- LE2.3 Socioecological dimensions packet

TIME

60 min

Instructional Sequence

1. Have the LE2.3 Five socio-ecological dimensions graphic organizer showing and use it to remind students of the 5 dimensions of socio-ecological reasoning they defined in their last lesson.
2. Ask students to share their wonderings from their LE2.3 family tool (Taking a focused walk together: Thinking across scales). Even if not all of the students have returned this, give students a few minutes to share their wonderings and noticings from their family tools with each other and then share as a whole class. Add the noticings and wonderings to the graphic organizer from LE2.3. Many of these will fall under the "reasoning across scales" row, but some may fall under "relationships" or "species, kinds, and behaviors". Be intentional about putting these noticings in other rows and saying something like, "I appreciate how you were reasoning about scale AND relationships, so I'm putting that in the relationships row. Many of your wonderings can fit under more than one of these! They are connected!"
3. Explain to students that today, they are going to explore another of these rows, the **relationships** aspect of places as they go on an outdoor walk. Remind students of the definition of **relationships** that they came up with in the last lesson. Ask: what relationships do you think we'll see when we're outside today?
4. Show the **LE2.4 student tool** on the doc cam and explain to students that this is going to be like their family walk around **scales,** except this time, they are going to be noticing and wondering about relationships. Explain to students that they may see all kinds of relationships outdoors and that you are really interested in seeing how many different kinds of relationships they can notice and wonder about.

Giving students a chance to share their family knowledges and practices is an important part of signaling to students that the family tools will be an important part of classroom knowledge-building.

Continued next page...

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Going outside

5. As students go outside, give them a question to wonder about as they walk with each other. This is a way to invite sensemaking immediately. For example, you might have them discuss the types of relationships they predict they are going to find and why they think that.

Making predictions is an important scientific practice. It attunes students to the observations that they will make, and also helps them connect their prior knowledge to new observations.

6. Even though this walk is focused on relationships, you might want to prompt students to think about some of the other socio-ecological dimensions if you think it will deepen their sense-making and discussions. Below are some examples of prompts you can use to engage and extend your learners' thinking.

Keeping these 5 dimensions visible and present in your teaching through questions will support students in thinking across the dimensions. Notice that the question prompts all have to do with relationships.

Species, Kinds & Behaviors (SKB	Relationships (REL)	Places, Lands, and Waters (PLW)	Thinking across scales (Time Space and Perspective	Human Decision-Making (HDM)
What species are learners noticing? What are they noticing about them? Are there different relationships they're noticing? Where did the bird land? Why? Where is that plant or tree growing? What is below and around it?	What kinds of relationships are students noticing? Who is in relationship with whom? What are the connections to place, time, and humans?	Who is in relationship with the land and water here? Where are students doing most of their observations? Above, ground level, or below ground? How are humans in relationship with this land? What would this place be like in a different season?	What are students saying about time - a long time ago, recently, or in the future? Are students thinking about how places, animals, and/or plants have changed over time?	What are students noticing about human impacts and decisions? Are they narrating them as helping, harming, or neutral relations? How do the decisions we make today impact the future of this place?

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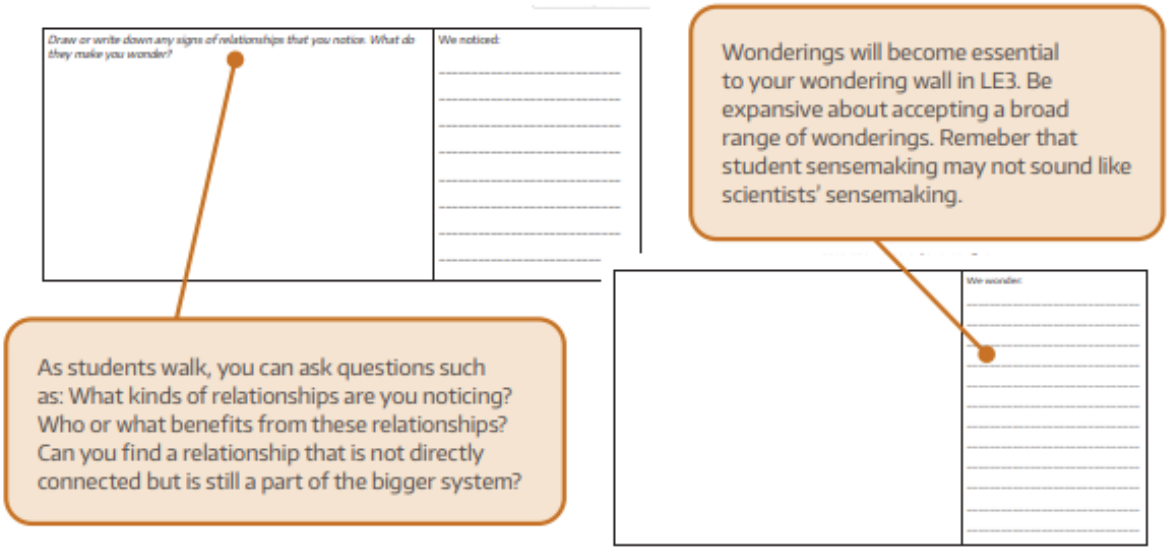
Back in the classroom: sharing observations and wonderings

7. As students return to the classroom, have them partner up to share what they observed, what relationships they noticed, and what they wondered about. Ask students to share their wonderings, observations about relationships with each other, circling the wonderings and noticings that were **similar** to what their partners wondered about, and underlining the wonderings and noticings that were **different** from their partner's.
    a. The partner groups should decide which wonderings and relationship observations they want to share with the rest of the class.
    b. Partners can either write them on sticky notes or just share in a whole-group discussion. These wonderings will be added to your wondering wall in LE3.

Assessment Opporunity: Listening to students discuss their wonderings is a good opportunity for you to understand what their understanding of "relationships" is.

Relationships family walk

8. Explain to students that they are going to get to go on another wondering walk with their families, this time focusing on this idea of **relationships**. They're going to walk around their neighborhoods and notice and wonder about relationships. For example, they might notice that certain birds are in relationship with certain trees or with each other. They might notice that certain kinds of plants attract pollinators and others do not.
9. Hand out the **LE2.4 Family walk–relationships** handout.
10. Give families time to return their notes, pictures, wonderings, etc. from their relationships walk (about 5 days).
11. Once the tools are returned, these noticings and wonderings about relationships will be added to the Wondering Wall in LE3, along with noticings and wonderings from LE2.2, 2.3, and from LE2.4.



LE2.4 Family tool: Focused wondering walk--Relationships

LE 2.4 Focused wondering walk: Relationships

Please return by_____

Relationships: *Relationships are the ways in which beings interact with each other. For example, how does the behavior of water change with the weather? Which plants do you typically see caterpillar munching on? What plants do people step on and which ones do they protect?*

Activity Purpose:

We are investigating **relationships** in the natural world around the school. Learning to notice relationships in the social and natural world is important for thinking about socio-ecological systems. Focusing on relationships among different members and parts of a system helps us understand the many ways in which everything is connected. You might notice relationships between humans and plants, directly or indirectly, when you notice things humans have built. For example, you might notice plants growing in the cracks of sidewalks or in yards. Or you might notice relationships between animals, like a dog chasing a squirrel. You can also look for relationships between the land and water.

Activity Overview:

- Use the activity sheet to guide your thinking while you walk.
- Look for signs of relationships and draw or write anything interesting that you see.
- If any new questions come up, write them down and come back to them later to see if you have additional thoughts about them.

What can you do to support learning:

- Talk about relationships in your own family, and don't forget to mention neighbors, teachers, pets, plants, etc. Ask children what they think is important about those relationships. While you walk, look for examples of relationships in the neighborhood. *Who is in a relationship with whom? Why? What does it remind you of?*
- Pay attention to what captures your family's interest. Look above, below and around to discover what might be in relation with each other. *What kinds of relationships are you noticing? Who or what benefits from these relationships?*

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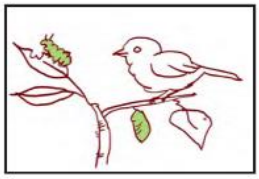
LE2.4 student tool Relationships wondering walk

LE 2.4 Relationships wondering walk



Relationships: Relationships are the ways in which beings interact with each other. For example, how does the behavior of water change with the weather? Which plants do you typically see caterpillar munching on? What plants do people step on and which ones do they protect?

Draw or write down any signs of relationships that you notice. What do they make you wonder?	We noticed: _____ _____ _____ _____ _____ _____ _____ _____

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Learning in Places Family Science Learning LE #2.B

Taking A Family Wondering Walk

Take a family walk outside. Talk about, draw, and write what you are noticing AND what questions you have about what you are noticing -- your wonderings!

The weather during our walk (you can circle more than one):

The temperature during our walk is: _____

The place we walked is: _____

Find a Plant

Draw or write what you notice that is interesting to you.	We noticed: _____ _____ _____ _____ _____
Do you notice any relationships that involve this plant? (For example, relationships with other plants, with an animal, with soil, with an insect, with water?)	We wonder: _____ _____ _____ _____ _____ _____

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Learning in Places Family Science Learning LE #2.B

Find an Animal

Draw or write what you notice that is interesting to you in the space below.	We noticed: _____ _____ _____ _____ _____ _____
Do you notice any relationships that involve this animal? (For example, relationships with other animals, with a plant, with water?)	We wonder: _____ _____ _____ _____ _____ _____

Are there other things you noticed on your walk that you observed and wondered about? Draw or write about those here:

Appendix 2f:

LE 2.1 Instructional Sequence and Tools

LE2.1 Preparing for Outdoor Learning

Purpose

Outdoor learning is experientially and pedagogically different than indoor classroom learning. Especially if you use the same spaces outdoors that students also use for recess, it will be important to allow time to prepare for a different way to interact with those spaces. This lesson will give you and students an opportunity to think about their own and others' needs outdoors, and also to think about how to respectfully interact with outdoor spaces. This begins with the understanding that outdoor spaces are not just for humans' enjoyment and use; they are also homes for more-than-humans such as birds, worms, the soil, and trees. Taking on the perspective of these outdoor neighbors is an important type of complex socio-ecological reasoning, and will be important for students to consider as part of the decisions they make everyday while outdoors.

Why this is important

Many times, students might engage with the outdoors purely from their own points of view--their own needs and wants for play, exercise, space, or even food in gardens. In this lesson, students will be asked to take the perspectives of others who they share outdoors spaces with in order to understand that their own actions outdoors have consequences for these more-than-human others. Because of this, humans are closely connected to, but not dominant over, outdoor spaces.

Engaging family and community knowledge and practices

This lesson asks students to specifically reflect on their own family's needs in terms of food, air, shelter, and water, as a way of connecting to those same needs of their outdoor neighbors. Be broad in the ideas that are included in this discussion: students and their families may have very different needs from each other and from you. This will be a good way of thinking about the diverse needs of outdoor neighbors as well. Just as families all over the world have different needs for survival and thriving, so too do plants, animals, the soil, etc.

LEARNING GOALS

By the end of this lesson, students will be able to:

1. Describe their and their families' own needs in terms of food, air, water and shelter
2. Describe, from the perspective of outdoor neighbors (plants, animals, etc.) what their needs are in terms of food, air, water, and shelter
3. Imagine more-than-human uses of places

CONNECTIONS TO NGSS

- **Crosscutting Concepts:** Cause and Effect
- **Science Practices:** Asking questions; Obtaining, evaluating, and communicating information
- **Disciplinary Core Ideas:** ESS3A: Natural resources (K-2)

  ESS3.C: Human Impacts on Earth Systems (K-2)

ASSESSMENT OPPORTUNITIES

- Whole-class discussions
- LE2.1 Student tool

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Teacher background information

The **Ethical Deliberation and Socio-Ecological Decision-Making framework** and the **Relationships framework** will be useful here as a way to get you started in thinking about how perspective-taking and reasoning from more-than-human points of view are important for ethical deliberation and decision-making. When we can imagine the needs of others besides ourselves (especially more-than-human others), we start to understand the connection between our own decisions and consequences for others that we share outdoor places with.

Centering equitable practices:

- **Encourage more-than-human perspective taking:** Avoid describing ecosystems only in terms of how ecosystems are useful for humans. In order to engage in ethical deliberation and decision-making about places, we need to support students in taking the perspective of more-than-humans in natural systems. How is this decision good for the trees? How is this place good for the worms? for the soil? Beginning to ask these questions will encourage students to take on broader perspectives when engaging in ethical deliberation and decision-making around ecosystems.
- **Encourage human connections to ecosystems**: Avoid positioning humans as disconnected or apart from nature. This activity encourages thinking about connections between humans and the rest of the natural world and starting from assumptions of complex interdependence instead of human-centric or dominance.

To prepare for this lesson

Fill out the tool yourself in terms of your own family's and outdoor neighbors' needs for food, air, water, and shelter. This will help you both model and anticipate some of the ideas that students will bring to the discussion. You will need to do some **place mapping** to understand some of the outdoor neighbors that you share your schoolyard space with, and do some research on what their needs are. For example, what do cedar trees need to survive in terms of food, air, water, and shelter? How do humans affect the food, air, water, and shelter of the bees that we share our outdoor places with? These kinds of questions will support your students in taking the perspectives of specific more-than-humans outdoors. The **Place & Place Designing: Mapping Opportunities to Learn framework** will be a helpful resource as you plan your outdoor instruction.

MATERIALS
» LE2.1 student tool

TIME
40 min

Instructional Sequence

1. Ask students: remember when we went on a walk around your schoolyard to see who we shared that place with? What did we find? Who do we share our places with?
2. Explain to students that today, they are going to be thinking about what those outdoor neighbors need to survive. Ask: why is it important to consider what they need to survive?
3. Ask students to think about one plant or animal that they share the outdoors with. Ask: what does that plant or animal need for food? for water? for air? for shelter? As students share their ideas, fill out a chart that mirrors the LE2.1 tool:

This kind of perspective-taking is important for students to consider ethical relationships between humans and more-than-humans in ecological systems.

What do animals or plants need to live a healthy life?

What are their needs for **food**?	What are their needs for **air**?
What are their needs for **water**?	What are their needs for **shelter**?
How do they use **soil** for a healthy life?	

4. Ask students: now think about your families. What do your families need in terms of food, air, water, or shelter? How is soil important to your life? Give students a chance to individually write or draw some ideas about each of these. Share out as a class: what were your ideas about what your families need in terms of food, air, water, or shelter?

Putting family knowledge alongside classroom knowledge is a way to share power in the classroom.

5. Compare and contrast your two charts, the one for "plants and animals" and the one for "our families". Ask students: what do you notice is **the same or similar** between the two charts? What do plants and animals need and what do our families need? What is **different** between the charts? What do you think that means in terms of how we're connected to plants & animals outside?

Seeing similarities between the needs of their families and the needs of more-than-humans is a way for students to see themselves as a part of socioecological systems.

6. Now move on to the final chart: preparing for outside. Explain to students that in the next lesson, they will be taking a walk outside to see what they notice as they walk. Ask students: why do you think we thought about what our families, plants, and animals need to survive as we prepare to go outside? Can you think of ways that we can respect plants and animals' needs while we are outside? What do you think we'll observe about their needs when we go outside? Let's think about that together as we think about how to respect their food, air, water, and shelter. What is an example of respecting plants' and animals' food?
   - Go through the chart, filling in students' ideas.

This discussion is asking students to think about the decisions they can make when they're outside in terms of more-than-human others who live outdoors.

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7. Explain to students: tomorrow we'll be going on a walk outside to see what we notice outside. Ask students: what do you usually do in the schoolyard outside? *Students will probably say "play, run, go to recess."* Ask students: if we're going to go outside to learn, how is that different from going outside to play? You can use a t-chart like the one below to compare and contrast going outside to play vs learn.

What do we do outside when...

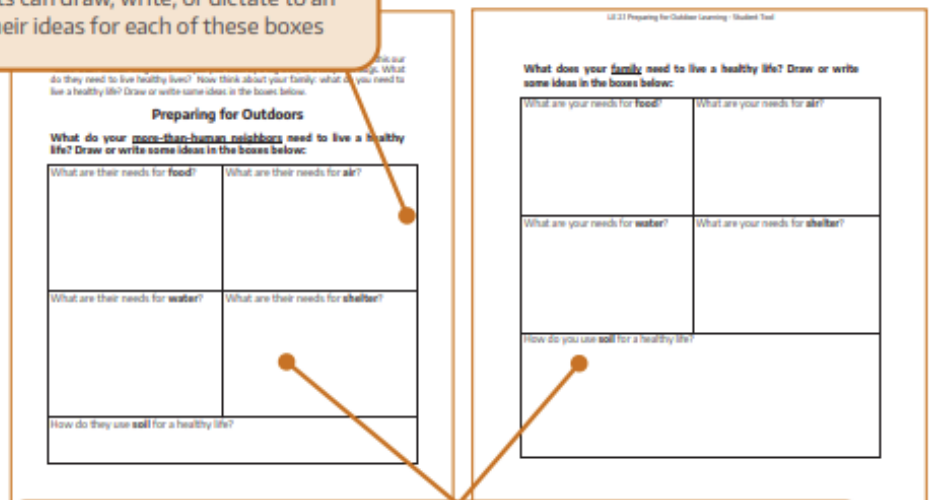
We are playing?	We are noticing and wondering?

Students will need practice learning how to learn outdoors, especially in settings where they usually play.

Hopefully students will say "have fun" in both places. You can ask guiding questions like, "what do you think about when you play? What do you think you'll think about when you're going outside to notice and wonder? What do you look at when you play? What do you look at when you're making observations? Is there a difference between how you look at those things?" Why or why not? You can also ask students which of the things they list (in either column) are **also** respecting plants' and animals' food, water, shelter, and air.

8. Tell students that you'll be keeping this list visible in the classroom so that each time they go outside, they are reminded of what they should be thinking about and looking at as they go outside to learn.

Students can draw, write, or dictate to an adult their ideas for each of these boxes



Once you have both charts filled in, compare between them to see similarities and how families and more-than-human neighbors are connected.

LE 2.1 Preparing for Outdoor Learning - Student Tool

Think about a plant or animal that lives around your school or home. We will call this our "more-than-human neighbors". Maybe you walk by a big tree, or a couple of bugs. What do they need to live healthy lives? Now think about your family: what do you need to live a healthy life? Draw or write some ideas in the boxes below.

Preparing for Outdoors

What do your more-than-human neighbors need to live a healthy life? Draw or write some ideas in the boxes below:

What are their needs for **food**?	What are their needs for **air**?
What are their needs for **water**?	What are their needs for **shelter**?
How do they use **soil** for a healthy life?	

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LE 2.1 Preparing for Outdoor Learning - Student Tool

What does your <u>family</u> need to live a healthy life? Draw or write some ideas in the boxes below:

What are your needs for **food**?	What are your needs for **air**?
What are your needs for **water**?	What are your needs for **shelter**?
How do you use **soil** for a healthy life?	

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LE 2.1 Preparing for Outdoor Learning - Student Tool

Preparing for Outdoors

When we are outside, what can we do to make sure we are respecting our more-than-human neighbors?

Draw or write some ideas in the boxes below:

Respecting their food	Respecting their air
Respecting their water	Respecting their shelter
Respecting their soil	

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Appendix 2g:

Examples of Materials Supporting Histories of Places Sensemaking

LE # 1.2

Time Scales	What did we observe in our place related to each of these time scales?	What questions or wonderings do we have about our place related to these time scales?	What decisions have people made that shaped this time? Which people? Why did they make those decisions?
Geologic Time: Land and ocean processes, mountain formation, glaciation, etc.			
Plant, Animal, and Soil Time: Plants, animals, and soils of the area, species extinctions or adaptations			
Indigenous Peoples' Time: Recognizing First Peoples and their histories and current relationships to this place			
Nation State Time: How the development of nations over time has shaped and impacted this place			
Global Time: How this place is connected to, impacts, or is impacted by other places across the earth and interacts with other time scales			
Living Ethical Responsibilities and Possibilities Time: What's possible for this place?			

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Centering equitable practices:

- **All places have historical contexts:** Science is often taught from ahistorical perspectives, as if scientific studies and theories were done in a social and political vacuum. We know that this isn't true. Surfacing histories of places is an important step to help students realize that all places have ongoing histories, past, present, and future.
- **"Histories" are ongoing:** It is very easy for students to assume that, because we talk about timescales as "histories", they are in the past. In this lesson and throughout the storyline, we are trying to understand timescales as ongoing--with histories but also futures. This is why the "living ethical possibilities and responsibilities time" is a timescale that cuts across all timescales, so that we can start to imagine futures for lands, waters, plants, animals, soil, indigenous people,nation-states, and/or the world on a global scale.
- **"De-settle" your own ideas about place and Indigenous peoples:** History is often taught in a way that (1) completely invisibilizes Indigenous peoples, (2) romanticizes relationships between Indigenous peoples and settlers, and/or (3) makes it seem as if Indigenous peoples no longer exist. Educate yourself about what Indigenous lands your school sits on, which Indigenous nations are your school's neighbors, and how Indienous practices influence the places, science, and stories of the places where you live and work. Doing this work is an important step in supporting your students to think within and across timescales about complex socio-ecological systems. Vignette A in the Histories of Places framework can give you an example of how to structure this discussion with your students.
- **Continuously support students and families in thinking about the histories of the places they are learning about and studying:** One error educators can make is grounding students and families in the histories of places that are interesting and important to them in LE 1, and then failing to use this framework throughout the rest of the Seasonal Storyline for Field-Based Science. Throughout the storyline, you should continuously be asking important Histories of Places questions and asking learners to keep using these various timescales as part of their sense-making. This will help to ensure that learners are thinking deeply about the complex socio-ecological systems they are studying, and it will help to ensure that their deliberations and decision-making about aspects of those systems are as complex and informed as possible.

Appendix 2h:

Select Supports for Designing With Places in LE 1

Teacher Background/Preparation Information

Throughout this bundle, you have engaged students and families in noticings and wonderings about place and the various timescales within the Histories of Places framework. It is important to take some time now to think about all of the noticings and wonderings that have been shared both in the classroom and from families in order to establish a firm foundation in reasoning across timescales for the rest of the storyline.

To prepare for this lesson

Gather all of the tools from LEs1.1-1.4 and reflect on what has been shared so far using the chart below. This chart does two things. First, it helps you keep track of what students and families share about the places that are important to them and why they are important. Second, you see the diversity of family practices in the places where they learn. For example, after you've synthesized information from students and families, you can share this with students to see if there is anything they would add (e.g., a new place they might add to the list, more information about why a place is important to their family, more information about what they do in a place). This will also give you ideas about **building partnerships with community-based organizations** that families name as important to them. These organizations contribute to students' relationships with places, give you perspective on histories of communities with which your students identify, or even offer learning activities to enhance your investigations. Finally, you can also **map (using Google Maps, for example) the places that are important to families** and communities. Over time, this map could include the places where you are conducting your classroom investigations so that students can see that the places you investigate are also places that are important to them.

Places that are important to students and families	Why the places are important to students and families	Practices that students and families use the places for or do in the places	What time scales are students and families attending to?	What questions are they posing about those time scales?	How do you see power and historicity reflected in the family and student tools?

LE # 1.4

Part 1: An Important Family Place

What is a place that is important to your family? _____

If you can, go for a walk in this place.

Draw or paste a picture of this place.	Why is this place important to your family? _____ _____
	What are you curious to learn more about in this place? _____ _____
	What does your family do in this place? _____ _____

Appendix 2i:

Select Supports for Phenological Sensemaking in LE 1

Why is this season important to your family?

What season is it in the place we live? _____

In the space below, write down 1 or 2 things that your family does in this season.

What do we do that is special in this season?	**Why do wedo these things in this season?**	**Why are these things important to ourfamily?**	**What decisions do we usually need to make in this season?**

1. Think about another place that is important to your family. What season is it right now in that place? In what ways is that place different than where you are now?

2. Look at family pictures of places that are important to your family. What season was it in the different pictures you took? How do you know?

3. Look for pictures of different places online, in magazines, or in books. What season is it in the different pictures you find? How do you know?

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Now you are going to make some observations in this place. What do you hear? What do you see? What do you smell? What does something feel like if you touch it (make sure it is okay to touch!)?

My observations using my senses In each box, write or draw what you **hear**, what you **touch**, what you **smell**, and what you **see**.		**This makes me wonder about....** Now draw or write **any questions or wonderings** about what you heard, touched, smelled, and saw in this place.
 hearing		
 touch		
 smell		
 sight		
Look back at the season you think it is in this place (page 1). What observations did you make that convince you that it is this season?		

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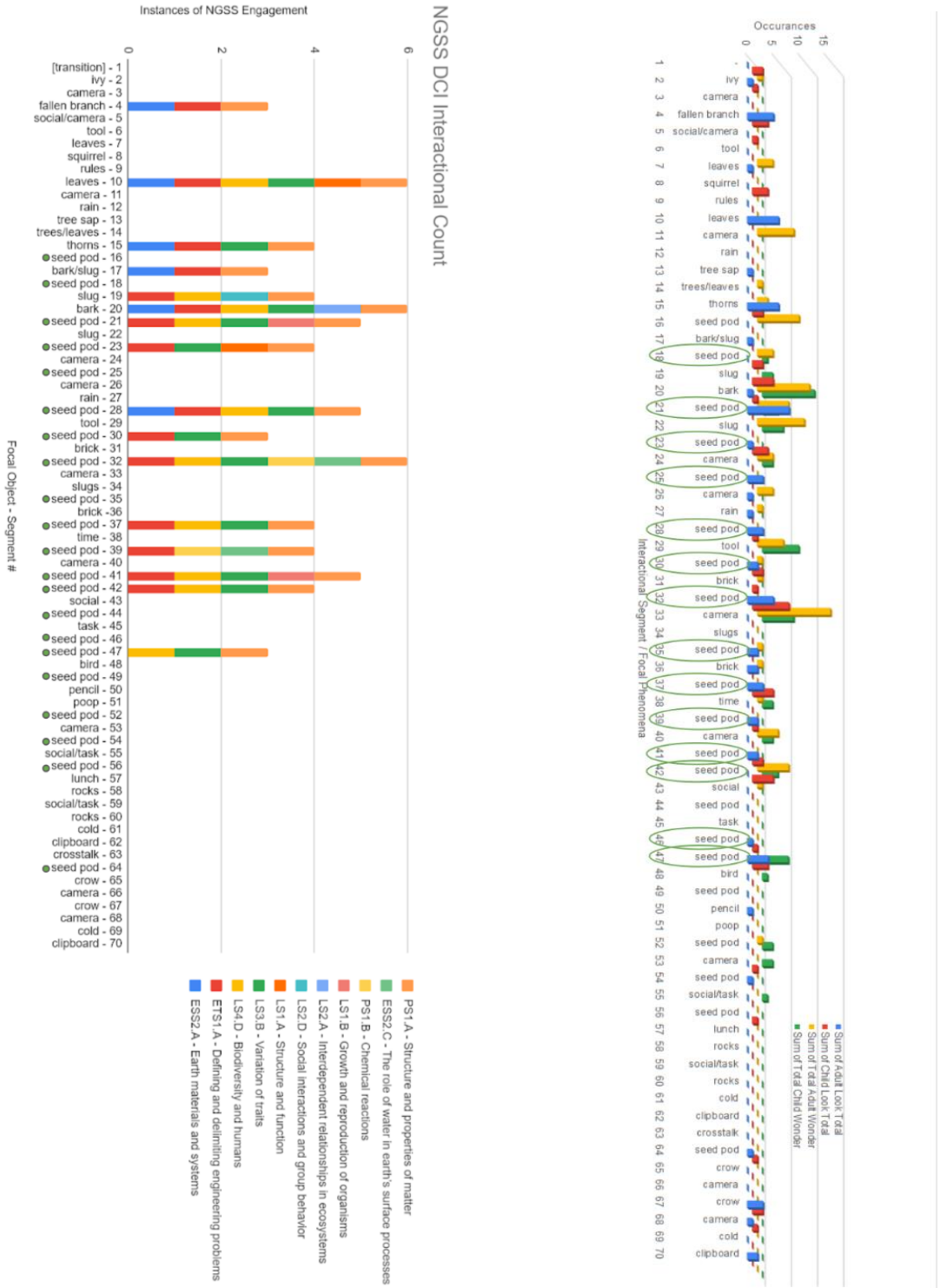
Appendix 3a:

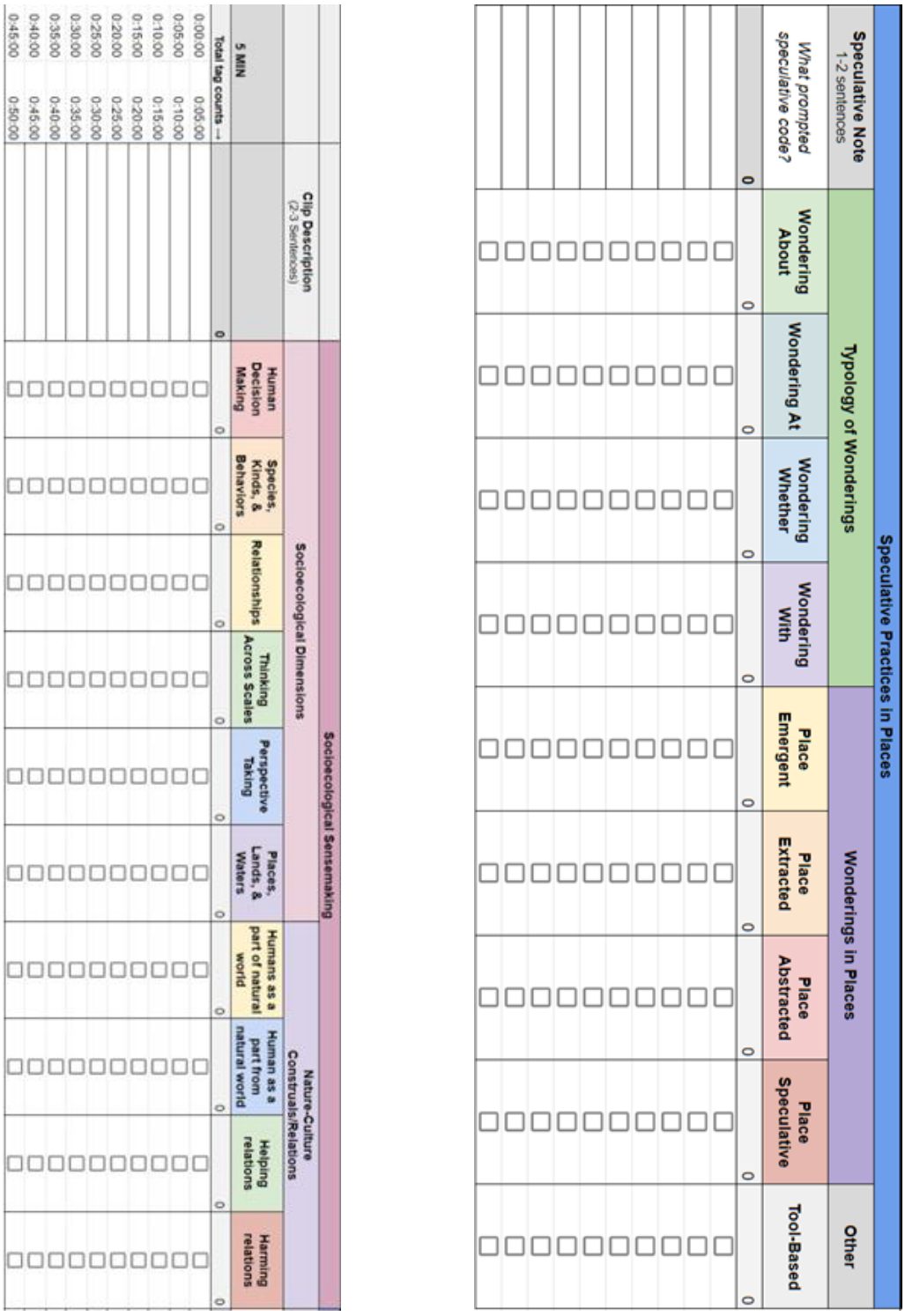
Exploratory Analysis of Wondering Walks Case Study: Coding and Segmentation[4]



[4] "Seedpod" focused segments are highlighted in green.

Appendix 4a

Interval Time, Clip Description, and Socio-ecological Sensemaking Codes & Speculative Note, Typology of Wonderings, and Wonderings in Places Codes



Appendix 4b

Typology of Socio-ecological Sensemaking Codebook

Socio-ecological Dimensions		
Human Decision-making	Discussing or observing human decisions in the past, present, or future. Considering the rationale behind certain decisions, the impact of particular decisions, and/or what should or shouldn't be done within a nature-culture relationship.	"What should we do?" "What would happen if we picked up all of the worms?" "The settlers decided to take the land for themselves"
Species, Kinds, & Behaviors	Noticing, discussing, or otherwise differentiating between particular species or kinds of phenomena (kind of spider, type of tree, etc.) and/or sensemaking via the behavior of particular phenomena (spiders build webs, trees make pollen)	"These thorns look different from these ones over here…" "Why do mole dig holes and leave dirt on the surface here?"
Relationships	Identifying relationships between and among phenomena, including humans, more-than-humans, lands, waters, or other natural kinds.	"Does the ivy help or hurt the tree it is growing on"
Thinking Across Scales	Toggling across temporal (past, present, future), spatial (perspectival, e.g., home & school, indoor & outdoors), and/or agent-aggregate (population) scales	"What looks different from the last time we were here?" "I see leaves above and below us" "What if we considered all the worms here?"
Perspective Taking	Sensemaking from the positionality of another: people, places, and/or more-than-humans. Can also be embodied. Can involve reasoning from assumptions of affective states or agentic capacities to more-than-human beings	"How would you feel if you were a bird in that situation?" "What stories to you think this tree could tell us from its time in this place?"
Places, Lands, & Waters	Noticing how observed phenomena are connected to particular places. (May be accompanied by "here" or "this", indicating specific focus on a particular kind of phenomena).	"This tree right here is just the one I was looking for!" "Do these kinds of bird only live here?"

Typology of Wonderings Codebook

Typology of Wonderings		
Wondering About	"Reflects the activity of scientists" and involves epistemically forward questions designed to "know more" about phenomena such as: How does it work? What would happen if? Why? When? What next? - Associated with curiosity, to finding out more within a particular framework. (A known unknown-attending to yet unknown facts) (Sometimes chained in succession)	"What kinds of worm is that?" "Why do worms come out when it rains?" "How do birds find worms to eat?"
Wondering At	"Reflects the human response to discoveries and understanding", and to "our capability to wonder at all" Pertains to exclamations and "affective sparks". Can manifest in ontologies of amazement, or the ineffability of experience via extended awe or puzzlement/aporia. Wondering that suggests a new framework for understanding is needed (unknown unknown, not just new facts).	"Wow! I see so many worms!" "Oh! That water is cold cold cold!" "Woooah, that's SO beautiful" "That's so cool! I don't even know how they do that"
Wondering Whether	Wondering about possible actions: What to do, what one could do, what one shouldn't do. Reflects speculative discourse and questions that engage axiological considerations involving values, moral and ethical judgements: (e.g., Should I do this? Must I do this? (Can reflect value judgements: Why is this important? What is the right thing to do? May imply concepts of good/evil, right/wrong, reward/punishment.	"What is the right thing to do?" "I don't think we should do that…" "Should we move the worms back into the grass"
Wondering With	Speculative activity that attends to human-nature positioning (dominance/deference), positioning humans as a part of nature. Sensemaking about complex interdependence. Assuming agency of natural kinds, sometimes via pronoun use (e.g., "them" vs "it". Nature is not objectified. Signals axiological stances.	"What do you think worms can teach us about their relationships in this place?" "The slug will be lonely if we take it away from its family here in the forest"

Wonderings in Places		
Place Emergent	Speculative activity via observations directly located in, or emergent from, place; sensemaking about, at, whether, with something in the sensory or perceptual field / surrounding environment. Can also include the lack or absence of something expected if triggered by immediate observations in place.	"Look over there! I wonder what that is…" "Why are there so many trees on this side of the river?" "Are the squirrel and the crow playing with each other over there?"
Place Extracted	Wondering about emplaced phenomena that was/are either extracted from places and thus in a transformed context (e.g., holding a berry or leaf that is removed from where it was found, e.g. picking up or collecting. Showing documentation or representations as removed from places (photographs, drawings).	"This seedpod is dark on one side, but light on the other." "What looks different from this picture I took when we we're last here"
Place Abstracted	Wondering about abstracted places and kinds not presently co-located. General ideas and/or concepts about phenomena relative to, but not immediately present in, a particular place. A generalized view/sensemaking from "nowhere" in particular – distanced	"What kinds of relationships do forests usually have" "I wonder where the snail we found is now"
Place Speculative	Speculation and/or anticipation about was or will be done or perceived in a particular place – not in present moment. Recalling past or speculating on future events and/or phenomena in particular places. Wondering about origins or destinations, where something came from or where it is going. What happened/will happen in past/future.	"What was here 100 years ago?" "Where did these seedpods come from?" "I wonder what this will look like next month."

Appendix 4c

Complete Code Co-Occurrence Table

	Human Decision Making	Sketches, Knots, & Behaviors	Relationships	Thinking Across Scales	Perspective Taking	Places, Lands, & Waters	Humans as a part of natural world	Human as a part from natural world	Helping relations	Harming relations	Wondering About	Wondering Al	Wondering Whether	Wondering With	Place Emergent	Place Entwined	Place Abstracted	Place Speculative	Tool-Based
Human Decision Making		0.422	0.32	0.316	0.447	0.147	0.199	0.425	0.25	0.355	0.317	0.424	**0.584**	0.111	0.151	**0.482**	0.257	0.021	0.091	0.013
Sketches, Knots, & Behaviors	0.422		0.427	**0.459**	**0.488**	0.169	0.1	0.402	0.152	0.212	0.384	**0.529**	0.369	0.056	0.062	**0.535**	0.252	0.106	0.158	0.14
Relationships	0.32	0.427		0.424	0.214	0.297	0.184	0.229	0.27	0.324	**0.599**	0.139	0.241	0.056	0.062	0.334	0.15	0.307	0.352	0.283
Thinking Across Scales	0.316	**0.459**	0.424		0.296	0.223	0.142	0.203	0.088	0.085	0.444	0.156	0.237	0.062	0.062	0.311	0.168	0.185	0.302	0.174
Perspective Taking	0.447	**0.488**	0.214	0.296		-0.03	0.257	0.317	0.181	0.216	0.068	0.373	0.306	0.105	0.291	0.291	0.095	-0.07	0.081	-0.03
Places, Lands, & Waters	0.147	0.169	0.297	0.223	-0.03		0.024	0.152	0.052	0.247	0.465	0.237	0.15	0.037	**0.485**	0.257	-0.07	-0.07	0.293	0.19
Humans as a part of natural world	0.199	0.1	0.184	0.142	0.257	0.024		0.024	0.338	0.104	0.167	-0.03	0.134	0.141	0	0	0.276	0.175	0.232	0.024
Human as a part from natural world	0.425	0.402	0.229	0.203	0.317	0.152	0.024		0.148	0.38	0.229	0.412	0.269	0.131	0.437	0.276	-0.14	0.103	0.066	0.066
Helping relations	0.25	0.152	0.27	0.088	0.181	0.052	0.338	0.148		0.4	0.294	-0.07	0.213	0.089	0.137	0.055	0.125	0.108	0.161	-0.06
Harming relations	0.355	0.212	0.324	0.085	0.216	0.247	0.104	0.38	0.4		0.318	0.134	0.266	0.135	0.302	0.215	0.037	0.161	0.052	0.052
Wondering About	0.317	0.384	**0.599**	0.444	0.068	**0.465**	0.167	0.229	0.294	0.318		0.099	0.289	0.064	**0.461**	0.27	0.349	**0.512**	0.311	0.311
Wondering Al	0.424	**0.529**	0.139	0.156	0.373	0.237	-0.03	0.412	-0.07	0.134	0.099		0.255	0.088	**0.716**	0.263	-0.15	-0.02	0.062	0.062
Wondering Whether	**0.584**	0.369	0.241	0.237	0.306	0.15	0.134	0.269	0.213	0.266	0.289	0.255		0.127	0.386	0.267	0.071	0.151	0.086	0.086
Wondering With	0.111	0.151	0.056	0.062	0.105	0.037	0.141	0.131	0.089	0.135	0.064	0.088	0.127		0.114	0.035	0.001	0.107	0.07	0.07
Place Emergent	**0.482**	**0.535**	0.334	0.311	0.291	**0.485**	0	0.437	0.137	0.302	**0.461**	**0.716**	0.386	0.114		0.269	-0.22	0.135	0.122	0.122
Place Entwined	0.257	0.252	0.15	0.168	0.095	0.257	0	0.276	0.095	0.215	0.27	0.263	0.267	0.035	0.269		-0.06	0.083	0.116	0.116
Place Abstracted	0.021	0.106	0.307	0.185	-0.07	-0.07	0.175	-0.14	0.125	0.037	0.349	-0.15	0.071	0.001	-0.22	-0.06		0.27	0.207	0.207
Place Speculative	0.091	0.158	0.352	0.302	0.081	0.293	0.232	0.103	0.108	0.161	**0.512**	-0.02	0.151	0.107	0.135	0.083	0.27		0.165	0.165
Tool-Based	0.013	0.14	0.283	0.174	-0.03	0.19	0.024	0.066	-0.06	0.052	0.311	0.062	0.086	0.07	0.122	0.116	0.207	0.165		