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Emotion, place, and practice: Exploring the interplay in children's engagement in ecologists' sampling practices

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Abstract

In science education, there has been a sustained focus on supporting the emergence of science practices in K–12 and field-based settings. Recent work has elevated the integral role of emotion in sparking and sustaining such disciplinary practices, deepening the field's understanding of what is entailed in "doing" science. Yet even as we gain this richer understanding of practice, less attention has been given to the places where practice emerges. These places play a critical role in the co-emergence of emotion and practice, and while separate strands of research have elevated emotion and practice or, alternately, place and practice, rarely has their dynamic relationship been considered together. In this article, I explore this interplay of emotion, place, and practice emergent in children's sampling practices within a multiweek curriculum centered around their schoolyard soil ecosystem. Through a comparative case study analysis of two student pairs using video data, student interviews, and classroom artifacts, my analysis reveals how children's emergent emotion was entangled in their relationships with the schoolyard and life within, shaping not only how they

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engaged in sampling practices but also what dimensions of the ecological system they attended to. I argue that emotion and place should be central to the design, teaching, and analysis of learning contexts, in turn centering the social and emplaced dimensions of science disciplinary practices for children and scientists alike. Implications for science teaching and learning are discussed, with particular consideration of field-based sciences.

KEYWORDS

case studies, ecological education, elementary school science, emotion, place, sampling, science education, science practices

1 | INTRODUCTION

In science education, there has been a sustained focus on young people's engagement in the practices of science, to support conceptual, epistemic, and social understandings of the discipline (Duschl, 2008). Particular interest has centered on how to foster the emergence of science practices in K–12 contexts, in ways that are useful and meaningful to children as they make sense of the world (Berland et al., 2016; Manz, 2015). Yet how to support this emergence of disciplinary practice, particularly in ways that elevate the heterogeneity and variability inherent in science sensemaking (Rosebery et al., 2010), remains an ongoing challenge in the field.

Reflecting broader shifts in educational research at large, there has been an increasing focus on emotion as integral to how science practices are sparked and sustained. Work in this area has revealed the emergent nature of emotion within learners', educators', and scientists' disciplinary pursuits (Avraamidou, 2020; Davidson et al., 2020; Gilbert & Byers, 2017; Jaber & Hammer, 2016a, 2016b; Zembylas, 2016). Such scholarship reflects a broader "affect turn" underway across a range of educational research disciplines where scholars seek to offer situated, multifaceted understandings of young people's learning and development as they engage in varied disciplinary practices (Curnow & Vea, 2020; Dahn & DeLiema, 2020; Ehret & Hollett, 2016; Keifert et al., 2017; Leander & Boldt, 2018; Lewis & Tierney, 2011; Sakr et al., 2016; Vea, 2020).

Concurrently, there has been growing attention to the integral role of place in science learning, revealing how young people's relationships, histories, and hopes with and within particular places are inseparable from the emergence of disciplinary practices (Bang et al., 2014; Davis & Schaeffer, 2019; Kissling & Calabrese Barton, 2015; Lim & Barton, 2006, 2010; Marin & Bang, 2018; Marin, 2020; Nxumalo & ross, 2019; Pugh et al., 2019). This collective work has made visible how disciplinary learning is emplaced, dynamically in dialog with the natural, built, and historic dimensions of young peoples' "lived landscapes" (Seyer-Ochi, 2006). Such work reflects broader trends in educational research to move beyond "encapsulated learning" (Engeström & Sannino, 2010) to better understand the emergent and interactional dimensions of science disciplinary practices in situ (Goodwin, 1994; Hall et al., 2002; Marin, 2020).

Yet to date, the interplay of emotion, place, and disciplinary practice is rarely considered in discussions around the emergence of science practice, despite generative synergies among these lines of research and scientists' accounts of disciplinary practice. In this study, I aim to further situate studies of emotion and place as central to discussions of how science practices emerge and stabilize. In particular, I aim to develop theoretical and practical insights into how emotion, place, and practice are reciprocally intertwined, in turn informing the study and design of science learning opportunities.

Ecology is a generative science discipline for exploring this interplay of emotion, place, and disciplinary practice. From ecologists' memoirs and biographies, ecology is a discipline enmeshed in emotion—with organisms of study (Keller, 1984), with the land itself (Kimmerer, 2013), and with colleagues and peers (Bowen & Roth, 2007)—where such felt relationships and histories in particular locales are integral to fostering insights into ecological processes. Ecology is a dynamic discipline for making visible the development and refinement of disciplinary practices, with adaptation in the field necessitated by the complexity and messiness of transforming complex systems through tools and texts (Forsythe, 2018; Manz, 2015, 2016). Ecology is also a field of study engaged in navigating varying epistemological traditions of science teaching and learning, resisting depictions of science practice as purely cognitive and decontextualized towards more holistic and just relations with the world (Bang & Marin, 2015; Bang & Medin, 2010; Bang et al., 2013; Carlone, 2016; Haraway, 1991, 2016; Hecht & Nelson, 2021; Jaggar, 1989). Importantly, expansive conceptualizations of the discipline and disciplinary practices that center emotion and place are generating innovative insights into how complex ecological systems communicate and sustain themselves, in turn, disrupting narrowed depictions of how doing science should look, sound, and feel (Jabr, 2020; Kimmerer, 2013; Simard, 2021).

In this study, I examine the interplay of emotion, practice, and place within a larger design-based research project (Cobb et al., 2003) that engaged late-elementary students in ecologists' practices of sampling and data visualization using participatory GIS maps to support understanding a local socioecological system, the schoolyard soil ecology underfoot (Lanouette & Van Wart, 2019; Lanouette et al., 2016; Lanouette, 2019). It is important to note that this analysis was retrospective, prompted by attuning as a researcher to emotion emergent in the multiweek activities, particularly as children selected sampling sites in the schoolyard and gathered data about the organisms found within a familiar place. It was also sparked by learning more about the complexity of children's relationships with and within the schoolyard, emergent as the curriculum unit unfolded. Focusing on the most recent iteration of this multiweek collaboration, I studied two pairs of children (ages 10–11) as they engaged in ecologists' sampling practices over several months, asking the following research questions:

- How were emotion, place, and practice entangled for children, as they engaged in ecologists' practices of sampling?
- How did this entanglement shape children's sensemaking about socioecological systems?

In the sections that follow, I first provide a theoretical framework for how emotion, place, and practice are conceptualized in this study, defining key constructs. I then draw from existing work in science education research, elevating generative areas where the interplay of emotion, practice, and place have (and have not) been considered. I argue that by considering their interplay together, more holistic accounts of how science disciplinary practices emerge and stabilize become possible. From this, I present a comparative case study analysis of two pairs of children, examining the co-emergence of emotion, place, and practice as they engaged in sampling, a practice central to ecology. I conclude by discussing the importance of considering place and emotion together within larger discussions of children's emergent science practice, considering implications for teaching and learning science. I propose that considering emotion and place as co-constituted in discussions of emergent disciplinary practice is generative for not only the science education field but also broader fields of scholarship centering emotion, learning, and disciplinary practice.

2 | THEORETICAL FRAMEWORK: CONCEPTUALIZING THE CO-EMERGENCE OF EMOTION, PLACE, AND DISCIPLINARY PRACTICE

Drawing on sociocultural, situated theories of learning and development, emotion is understood as dynamic, emergent, and intertwined in the bodies, tools, and text inherent to disciplinary practices as participants seek meaning and understanding across shifting spatial and temporal dimensions (Ahmed, 2014; M. H. Goodwin & Goodwin, 2000; C. Goodwin, 2007; Leander & Boldt, 2018; Scheer, 2012). As Lewis notes (Boldt et al., 2015), emotion is both a mediated and regulated action, shaped by larger norms, ideologies, and power dynamics within and beyond the discipline (Agarwal & Sengupta-Irving, 2019; Curnow et al., 2020). As such, emoting—the process of experiencing and expressing emotion (Davidson et al., 2020)—is an enculturated activity, simultaneously influenced by local interactions and broader contexts.

In contrast to conceptions of emotion as adjacent to or about disciplinary practice (e.g., Pintrich et al., 1993; Tobin et al., 2013), emotion is understood as emerging *within* the science disciplinary practices themselves, inseparable from the social, conceptual, and epistemic threads of practice (Jaber & Hammer 2016b, 2016a; Jaber, 2021). Experiencing and expressing emotion, such as excitement, frustration, competition, and puzzlement, are ensnared in the process of developing and refining research questions, challenging claims, and analyzing new patterns in data.

To conceptualize the emergent and social work of emotion in collective activity, Vea (2020) describes *emotional configurations*, "an analytical tool for seeing the situated and reciprocal interrelationships between feeling, sense-making, and practice that give emotion social meaning for learning" (Vea, 2020, p. 338, see also Curnow et al., 2021). In contrast to a focus on individual, internal, and discrete states of studying emotion, such an orientation "encourages an analysis of how emotion becomes meaningful to us, how it supports and constrains particular forms of activity, and how activity and interaction shape what emotion can become and do" (Vea, personal communication, September 17, 2021). Such a conceptualization makes visible how emotion and practice are emerging and changing reciprocally, in relation to shifting social and material elements.

Yet across this collective work, there has been less attention to where emotion and practice are unfolding, and interlocutors' shifting relationships with and within these places. To this collective work, I aim to expand *emotional configurations* to elevate reciprocal relationships with place. Drawing on Tuan (1977), I understand place as space transformed through meaning and value, emergent through movement, relationships, and histories in a dialectical process (Nespor, 2008). I argue that emotion is inherently emplaced, co-constituted with and within the built, historic, and natural landscapes of daily life through social relations (Seyer-Ochi, 2006). Such understandings of emotion and place can already be found in social and cultural geography studies, where scholars describe emotion and place as co-constituted. For example, Davidson and Milligan (2004) write, "emotions are understandable —'sensible'—only in the context of particular places. Likewise, place must be *felt* to make sense" (p. 524, original emphasis). Such co-emergent conceptualizations make visible how emotion configures place and practice and simultaneously, how place and practice reconfigure emotion.

As I will detail below, such a conceptualization of emotion, place, and emergent disciplinary practice is nascent in existing science education research. Across science education and specifically ecology studies, I will point to how several separate strands of research collectively suggest such entanglements but are rarely brought together.

3 | EMOTION, PLACE, AND PRACTICE IN SCIENCE EDUCATION

Within science education research, there has been burgeoning research studying emotion in science teaching and learning across a range of settings (e.g., schools, teacher workshops, science/university collaborations) (Zembylas, 2005, 2016). Scholarship in this area has examined how emotion shapes disciplinary activity, focusing on students' learning (Hufnagel, 2018; Keifert et al., 2017; Radoff et al., 2019; Zembylas, 2004) and science teachers' learning (Davidson et al., 2020; Gilbert & Byers, 2017; Jaber, 2021; Zembylas, 2016). Combined, such work has elevated the dynamic and embodied nature of emotion in science learning and teaching, drawing on multimodal video analysis, interactional analysis, and multiyear ethnographies to understand how emotion is interactionally achieved.

To this study, Jaber and Hammer (2016a, 2016b) have argued that emotion is inseparable from how science practices are instigated and stabilized, entangled in the epistemic and conceptual knowledge building work of classroom and scientists' communities. In one study with late-elementary students, Jaber and Hammer (2016b) examine a fourth-grade discussion about cloud formations and a fifth-grade discussion about phase changes of matter, showing how emotion emergent in discussions sparks and sustains disciplinary practices and conceptual understanding. In another study spanning multiple years, Jaber and Hammer (2016a) study how emotion and disciplinary practice are ensnared within developing interests and motivation, revealing how emotion sparks and sustains the child's deepening engagement in science spanning several years. Across these studies, Jaber and Hammer argue that emotion is entangled in the emergence of disciplinary practice, part and parcel of what it means to both learn and teach science. In both studies, they draw parallels to professional scientists' accounts, pointing to evidence of similar processes in scientists' laboratory and field-based research (see Jaber & Hammer, 2016a for an extensive review). Yet the places where science sensemaking is unfolding have, to date, not been centered in analysis, leaving understudied how emotion emerging within the disciplinary practice is shaped by and shapes learner's relationships with place.

Concurrently, existing scholarship in science education has elucidated emplaced understandings of emotion and place, co-constituted in science sensemaking. Focusing specifically on children's relationships with place, Lim and Barton (2010) studied how 11- to 13-year-old children's strong and varied emotional relationships with their neighborhoods were central to children's understanding of environmental systems within the broader sociopolitical dynamics of city life. This study builds on earlier research, where Lim and Barton (2006) studied how urban middle school students' sense of place emerged in relation to specific science instruction, documenting how place relationships, often emotion-laden, were integral to both what was learned and how learning unfolded. In early childhood studies, Nxumalo and Villanueva (2019) have documented how young children's understanding of nearby streams are inseparable from the emotional, multisensory experience of walking along these waterways, elevating “affective pedagogies” that nurture hopeful and expansive relationships with ecological systems. Yet to date, this line of research hasn't centered on the emergence of disciplinary practices, leaving understudied how emotion and place may co-emerge in children's nascent practices.

3.1 | Learning about ecological systems: Intersections of emotion, place, and practice

Broadly, ecology entails studying the abundance, scarcity, and distribution of organisms and the relationships within and between these organisms and their environment (Cotterman, 2016; Korfiatis & Tunnicliffe, 2012). Conceptualizing ecological systems entails considering multiple interacting parts of a system, and their relationships with one another, across varying spatial and temporal scales (Pugh et al., 2019). Given the complexity of ecological systems, ecologists' work entails coordinating systemic levels of activity, many of which can emerge and unfold through agent-aggregate relationships involving complex causal chains of interactions (Danish, 2014; Hmelo-Silver et al., 2007; Hokayem & Gotwals, 2016). Within this scholarship, there has been deliberate attention to how disciplinary practices emerge and sustain with careful attention to the design, enactment, and study of varied learning environments.

Drawing on Science and Technology Studies' centering western depictions of ecologists' practice (e.g., Hall et al., 2002; Latour, 1999), one line of research has focused on supporting students engaging in modeling practices such as sampling, data visualization, and argumentation (Lehrer & Schauble, 2012; Manz, 2013; Metz, 2008, 2011). This research has centered around generating and visualizing variation and covariation within ecological systems to better understand system-level interactions between living and nonliving aspects of the larger system, with such work considered foundational to understanding system change and adaptation in micro and macroevolutionary processes (Metz et al., 2019).

Due to the size and complexity of ecological systems, a key focus has been on engaging students in sampling practices to select and study aspects of the environment to better understand larger system dynamics (Coe, 2008). Fundamental to sampling practices is making decisions about *what* in the system to focus on, *where* to collect samples that ensure an accurate understanding of the whole system through strategic spatial distribution, and *when* to sample, in terms of timing, frequency, and repetition, to address seasonal changes as well as potential variability or errors inherent to the sampling methodologies (Forsythe, 2018). Given the dynamic complexity of the systems under study, there is often substantial adaptation to these sampling plans, in the moment and over time, as students and ecologists encounter resistance from the material world (Bowen & Roth, 2007; Manz, 2015).

Approaches to supporting and sparking sampling practices in K–12 contexts often focus students' activities on a local ecological system that provides a complexity and resistance integral to sparking a need for the related practices to develop. In Forsythe's (2018) work, students engaged in repeating cycles of visiting a nearby stream, model making, and exploring the resultant data, over time shifting more attention to the spatial location of sample sites, the varied parts of the system, and the standardization of data collection methodologies central to sampling practices. Lehrer and Schauble (2017) describe a multigrade approach to supporting the development of sampling practices, shifting in complexity and support across first, third, and sixth grade classrooms as students' studied surrounding prairie, pond, and forest systems. Manz (2015) and Lehrer et al. (2008) focus on supporting emergent sampling practices by focusing on selecting attributes and constructing measures, shifting between inside physical models and local complex systems such as an overgrown area or retention pond on school grounds. Across these studies, sampling practices emerging in relation to the spatial and material contexts are elevated, with less attention to how emotion and place are ensnared. Similar to other research focused on supporting robust engagement in disciplinary practices (e.g., Engle & Conant, 2010; Engle et al., 2014), emotion occurring within children's emergent practices instead tends to be treated as an index of conceptually generative discussion or engagement but is not central to how the practices are instigated and sustained. Additionally, while the physical systems being sampled may be familiar to students due to physical proximity, researchers do not emphasize children's existing or emergent place relationships, instead focusing on the spatial and material dimensions of such locales as sparks for disciplinary practice.

In contrast, drawing on Indigenous science epistemologies, Bang, Marin and colleagues have focused specifically on intersections of place and practice to support robust understandings of ecological systems while also reconstituting nature/culture relationships (Bang & Marin, 2015; Bang et al., 2013; Bang, 2015; Marin, 2020; Pugh et al., 2019). Learning about ecological systems is supported by cultural practices of walking, reading, and storying the land (Marin & Bang, 2018). Such practices aim to nurture broader attunements towards multispecies relationships and multisensory aspects of being a part of ecological systems, recentering the body, place relations, and movement in children's developing understandings of ecological systems (Bang & Marin, 2015; Bang, 2015; Marin, 2020; Pugh et al., 2019). In one study, Marin and Bang (2018) describe a Native American family's walk in a regional forest preserve, showing how walking, collaborative storytelling, and observation emerge together to support new understandings of ecological systems. Pugh et al. (2019) studied children participating in an outdoor STEAM camp that centered on Indigenous resurgence, describing how a micropractice of spatial indexing enabled children to weave together multiple parts of an ecosystem across spatial, temporal, or relational scales to understand the present and past ecological system. Bang et al. (2013) describe a community-based design collaboration with middle school indigenous youth, using immersive river sampling practices in city waterways to desettle normative, dominant approaches to teaching and learning about ecological systems. Across these lines of research, varied disciplinary practices emerge in dialog with the emergent and ongoing relations youth and their families construct and reconstruct in place. Yet emotion, while referenced in multiple instances, is rarely central to the analysis of how disciplinary practices and conceptual understandings unfold. As such, there is an opportunity to further understand how emotion, place, and disciplinary practice are co-constituted in field-based science studies, an intertwining I examine in the comparative analysis of two student pairs in their schoolyard and the findings that follow.

4 | METHODS

To understand this interplay, I drew on comparative case study methodologies (Yin, 2014), as this methodology is generative for enabling new conceptualizations of complex inter-relationships while also elevating the variability and complexity of the phenomena of study (Creswell, 2013). Through the analysis of semistructured interviews, video data involving whole, small-group, and paired interactions, classroom artifacts, and field notes, this study aims to provide insight into how emotion configures place and practice and simultaneously, how place and practice reconfigure emotion.

4.1 | Research context

Data presented are drawn from a larger multiyear design-based research project (Lanouette & Van Wart, 2019; Lanouette et al., 2016; Lanouette, 2019) that aimed to support children understanding socioecological systems through engaging in science and data science practices through mapping and modeling using *Local Ground* (Van Wart & Parikh, 2013; Van Wart et al., 2010), a participatory GIS mapping platform. The curriculum was centered around the schoolyard as a means to interweave children's daily rhythms and routines into their learning about socioecological systems[1] and relationships. Throughout the project, the author and colleagues collaborated with a K–5 public elementary school in the Western United States (40% free or reduced lunch, 16% designated English Language Learners, 12% Black, 6% Asian, 27% Hispanic or Latino, 45% White, 13% two or more races). This multiyear collaboration was sparked by shared interests among the school principal, several teachers, and the research team in supporting science and data science practices in elementary classrooms, in ways that leveraged innovative technologies and children's local expertise as central to interdisciplinary pursuits.

In this analysis, I focus on Year 3 of the project, where I worked with one fifth-grade science class, the school's K–5 science teacher (Ms. Keeling[2]) and a fifth-grade homeroom teacher (Ms. Burns). Across 8 weeks during the late winter and early spring months (18 class sessions, lasting 60–90 min each), I designed and taught the multiweek curriculum during the children's science class time, in collaboration with the two teachers (Lanouette, 2019). Across two cycles of sampling, data visualization, and discussions, children created and critiqued varied data (e.g., sketches, photos, text notes, and numerical counts) in multiple forms (e.g., bar charts, two-way tables, *Local Ground* maps) to spark insights into what organisms needed to thrive in the schoolyard soil underneath their feet.

During these earlier lessons (Lessons 1–4), children considered the initial question: "Who lives underfoot and what do they need to thrive?" From students' initial ideas, the teacher recorded key parts of the system that children identified, including varying animals, water, sunlight, soil characteristics, and human activities in the schoolyard (e.g., built structures, daily/weekly/yearly routines and activities). As pairs, children then visited different schoolyard locations of their choosing and selected an initial site for sampling to study relationships among these parts in greater detail. At their chosen sites, children collected a range of data about earthworms, other invertebrates, and plants' root structures, as well as soil characteristics such as moisture, compaction, and composition (see Table 1). They also recorded human activities at their site, elevating aspects of children and adults' activity that they deemed important (e.g., foot traffic, sound levels, and other children's play activities) as well as spontaneous observations. After several class sessions devoted to exploring relationships in the classes' aggregated data using *Local Ground's* GIS maps and canonical paper forms (L7–12), student pairs had the opportunity to select a second sampling site in Lesson 13 to further support studying relationships emerging in the class data, as well as to explore puzzling patterns, outliers, or anomalies in the data. Subsequent class lessons explored the cumulative data using *Local Ground* maps. Across the curriculum, children often worked together as a pair, having autonomy in selecting sites of interest to study, gathering data together in the spots, and exploring trends and relationships in the data using collaboratively created GIS maps.

4.2 | Participants

Participants included a fifth-grade class of 27 students during their biweekly science class time. All students participated in general activities, with 24 children consented to be part of the research study. Students reflected the

TABLE 1 Summary of curriculum, highlighting shifting ecologist's practices and related activities

	Shifting Ecologists' Practices	Instructional activities to support related practices
Cycle I	*Sampling: Identifying parts of the system* *Define research inquiry, including refining questions *Begin to differentiate parts of ecological system and consider potential relationships	*Lessons 1–4* *Teacher poses the initial question: "What is underfoot? Who can thrive here? What do they need?" *Children begin to identify and differentiate parts of the schoolyard socioecological system, voicing different rationales for suggested parts and potential relationships *Children generate an initial list of sites to begin studying parts and potential relationships, visiting potential sites *Children select initial sites for sampling, spending time outside together as pairs
	Sampling: Transforming parts into variables *Observation and measurement at selected sites to examine variation and covariation in larger ecological system	*Lessons 5–6* *Teacher leads a discussion of potential data collection tools and techniques, posing question of "How can we find out more?" *Children decide on final sites for sampling *Children collect data at sites, including initial site observations outside, soil moisture, soil texture, soil compaction, invertebrate counts (including, specifically, earthworms), above-ground activity, and any additional data they think would be helpful for understanding the system, its parts, and interrelationships.
	Data visualization: Aggregating, visualizing, and explaining *Identify and reason about patterns of co-variation in the ecological system and conjecture possible explanations	*Lessons 7–12* *Children aggregate all their data using multiple representational formats to begin exploring patterns of variation and covariation in the ecological system (e.g., bar charts, two ways tables, paper, and digital GIS *Local Ground* maps) *Research meetings (Lehrer et al., 2008) involving children constructing, sharing, and contesting relationships emergent in data *Emergent discussions about reliability of methods and resulting data related to temporal and spatial aspects of sampling location, data gathered, and techniques used
Cycle II	*Sampling: Identifying Parts of System* *Refine questions and clarify sampling methodologies in response to earlier findings *Further differentiate ecological system parts and potential interrelationships	*Lesson 13* *Discussion of potential data collection tools and techniques, posing question of "How can we find out more?" *Children plan and select second site, with pairs deciding between returning to the original site or selecting a new site
	Sampling: Transforming parts into variables *Observation and measurement at selected sites with select variables to examine variation and co-variation in the larger ecological system	*Lessons 14–15* *Children collect data at the second sampling site, including soil moisture, soil texture, soil compaction, invertebrate counts (including,

TABLE 1 (Continued)

Shifting Ecologists' Practices	Instructional activities to support related practices
	specifically, earthworms), above-ground human activity, and other observations of interest
Data visualization: Aggregating, visualizing, and explaining *Identify and reason about patterns of covariation in the ecological system and conjecturing possible explanations	*Lessons 16–18* *Children aggregate data at whole-class level, generating bar charts and interactive GIS maps to examine variation and covariation to reason about underlying mechanisms *Research meetings (Lehrer et al., 2008) involving constructing, sharing, and contesting patterns in data as well as revising research questions and methods

overall racial, ethnic, linguistic, and socioeconomic diversity of the K–5 elementary school. I worked closely with two teachers, Ms. Keeling and Ms. Burns. Ms. Keeling, the elementary school science teacher, had over 10 years of science teaching experience and had participated in the prior iteration of the research project, and Ms. Burns, the fifth-grade homeroom teacher, had 15 years of elementary classroom teaching experience. In addition to the whole-class activity, I focused on six focal students (three pairs) in more depth. The two teachers recommended these six students based on my request for students who attended school regularly and would be comfortable being interviewed several times.

4.3 | Selection of comparative cases

From focal pairs studied, I selected two student pairs for this comparative case study analysis: Amir & Marie and Elena & Alex. I selected these two pairs because they contrasted notably in terms of their engagements in sampling practices, such as *what* parts of the ecological system they were considering, *where* they selected to study, and *when* they thought sampling should occur. These two pairs also contrasted markedly in their expressed relationships and orientations to the schoolyard itself. For example, Amir and Marie appeared excited to explore and spend time in a favorite hiding place in the schoolyard that the two knew well from recess. In contrast, Elena and Alex alternated between expressing frustration and excitement, as they sought out organisms in unknown areas of the schoolyard and later worked to amass the highest earthworm counts in the class, regardless of location. As such, the two pairs offer insights into not only the interplay of emotion, place, and practice but also how variability in this interplay shaped differing engagements in the sampling practices and considerations of the ecosystem.

4.4 | Researcher role and reliability

Over several years of the larger design-based research project, I developed a familiar rapport with students and teachers at the school, working closely with Ms. Keeling, Ms. Burns, and two late-elementary classes for multiple months at a time. During the most recent iteration, reported in this study, I met regularly with the two teachers and one fifth-grade class, joining their science classroom time as a co-teacher and researcher two to three times a week, with weekly meetings with the teachers after school. While this extended relationship within the school community was an asset in design-based research (Sandoval & Bell, 2004) and case study methodologies (Yin, 2014), it potentially raises the possibility of bias in interpretation that I attended to throughout the analysis described below (Lincoln & Guba, 1986). First, multiple data sources were triangulated with one another, strengthening the consistency of findings (Tracy, 2010). Second, with a research assistant, codes were developed collaboratively. Combined with frequent sharing of initial codes and findings with an unaffiliated research group, this workflow enabled considering divergent or contrasting interpretations. Lastly, claims are based solely on expressed emotion as evident in speech, body positioning, text, and sketches, with thick descriptions (Sakr et al., 2016; Tracy, 2010) of emotion and place co-emergent.

4.4.1 | Data sources

Over the course of the 18-lesson curriculum, several data sources were collected with the help of two research assistants. During each class session, one research assistant video recorded all class sessions in the whole-group and small-group contexts. The second research assistant supported the distribution and collection of materials and artifacts in each class session, often supporting activities during the class sessions and recording reflective field notes at the end of each session. The author wore a Go Pro camera during most classes and also added to the reflective field notes. Combined, these collective efforts generated multiple data points supporting triangulation.

Video and audio recordings

During each class session, there were multiple video recordings, capturing interactions in whole-class, small-group, and paired collaborative activity. For the whole-class activity, two cameras were used in each class session, including a wide-angle camera capturing the whole-class activity and a focused camera angle documenting discussion in the rug area. For small-group table activities, focal student pairs were recorded as they worked with one another. During lessons that took the class outside the classroom, general activity was recorded using a wide-angle camera, focusing at times on the focal dyads' activities. Lastly, the attached video camera enabled the capture of informal interactions between the author and students.

Student and teaching artifacts

Student and teaching artifacts were collected at each class session. These included students' written work, such as site selection rationale sheets, data collection note sheets, and general note sheets. It also included author and student-generated data forms, such as bar charts, a two-way table of invertebrate data, and paper and digital data maps showing sites and related data.

Semistructured interviews

At four points in the curriculum, I conducted semistructured interviews individually with the six focal students. During these interviews, ranging from 20 to 40 min, I asked children questions about their experiences and decisions engaging in the ecology practices supported in the curriculum (e.g., sampling, data visualization, and argumentation). This included questions about students' rationale for selecting their sampling sites as well as their experiences collecting data in the schoolyard and collectively constructing varied data representations (e.g., bar chart, two-way table, and interactive digital maps). In the last interview, I asked additional questions about students' reflections on engaging in the curriculum across multiple weeks (see Appendix A for the full semistructured interview protocol sequence).

The semistructured interviews were timed to span the entire 18 lesson curriculum, to give insight into children's experiences and sensemaking at multiple time points (see Table 3 for the timing of the four interviews). The first interview occurred during the first cycle of class sessions supporting sampling, data visualization, and discussion practices. It occurred right after Lesson 4 (L4), when student pairs had just had the opportunity to choose sites, they wanted to learn more about and visit them. The next two interviews occurred in the second cycle of activities, with the second interview occurring after students had selected their second sampling site (L9) and the third interview occurring as students were sharing data relationships using their GIS maps (L17). The fourth interview occurred after the entire curricular unit ended, approximately 1 week after the last class session.

Reflective field notes

At the end of each class session, the second research assistant and I recorded reflective observations. These notes included a summary of the lesson activities, including how the time was structured and what activities occurred. It also included observations on children's conceptual understandings about ecosystems and data, class dynamics related to children's collaborative work and their engagement in the lesson activities, technical notes on the *Local Ground* GIS map technology, and questions that arose for us as researchers and teachers. These reflection notes were useful as an additional source of documentation about the implementation of the lessons as well as the social and conceptual issues that were observed. These reflective field notes were also helpful to us during analysis, first to identify relevant lessons related specifically to sampling practice and later to recall interactions and dynamics specific to particular class sessions and focal pairs.

4.5 | Data analysis

To study the interplay of emotion, sampling practices, and place, this retrospective analysis occurred in three phases described below.

4.5.1 | Phase 1: Identifying data sources related to children's sampling practices

In the first phase, the second research assistant and I organized the extensive data corpus, reducing the available data corpus by selecting only data involving children's engagement in sampling practices, and within these data sources, only data involving the two focal student pairs. For example, the second research assistant and I reviewed and identified data such as whole-class activity where potential sampling sites were discussed, small-group planning video where focal pairs talked about and selected sampling sites with one another, dyad activity outside in the schoolyard at the sampling sites, and individual semistructured interviews where children explained their site selection rationales and experiences. We also focused on relevant teacher and student artifacts, such as the whole-class map the class constructed showing proposed sampling sites and children's site planning and data collection sheets for sampling in cycle 1 and cycle 2 of the curriculum. These efforts resulted in a smaller data corpus, including select segments in (a) whole-class video, (b) small-group and dyad video, (c) individual semistructured interviews, (d) student and teaching artifacts, and (e) reflective field notes (see Table 2). Combined, these data sources provided multiple windows into children's activity related to the sampling practices supported within the curriculum, enabling us to triangulate findings related to emotion and place in the next phases of analysis across varying settingss, interactions, and material forms (Yin, 2014).

4.5.2 | Phase 2: Identifying emotion within and about sampling practice

Given the interest in understanding the interplay of emotion, practice, and place, the research assistant and I began reviewing and coding these selected sources using video and artifact analysis methodologies described below (see Table 3), focusing on emotion expressed through verbal, embodied, and text modalities. Analytic memos (Saldaña, 2016) were central for recording observations and descriptions as we examined the selected data sources.

TABLE 2 Data sources relevant to children's engagement in ecologists' sampling practices

Practices and lessons	Instructional activity	Data sources
Sampling (L1–4)	Discussing potential parts of the system Discussing and deciding on the first sampling site	Whole-class video (including outside) (L1–4) Dyad video (L1–4) Teaching artifacts: Parts of system brainstorming list, initial site selection map Student artifacts: Site-planning/selection sheets #1 Semistructured interview #1 (post L4) Reflection field notes (L1–4)
Sampling (L5–6)	Collecting data in pairs throughout the schoolyard	Whole-class video (including outside) (L5–6) Dyad video (L5–6) Student artifacts: Data collection field notes #1 Semistructured interview #2 (post L9) Reflection field notes (L5–6)
Sampling (L12–13)	Discussing potential parts of the system Discussing and deciding on the second sampling site	Whole-class video (L12–13) Dyad video (L13) Student artifacts: Site-planning/selection sheets #2 Reflection field notes (L12–13)
Sampling (L14–15)	Collecting data in pairs throughout the schoolyard	Whole-class video (including outside, L14) Dyad video Teaching artifacts: Second site selection map Student artifacts: Data collection field notes #2 Semistructured interview #3 (post L17) Reflection field notes (L14–15)
Postinstruction		Semistructured interview #4

TABLE 3 Identifying emotion within and about sampling practices: codes, descriptions, and examples

Verbal reference of emotion	*Description:* talking about emotion or emotional situations, talking about one's emotions about past emotions *Examples:* "I just love this spot" and "I felt frustrated and angry"
Multimodal expression of emotion	*Description*: emotion emergent in activity, expressed through body positions and movement *Examples*: shared gaze, smiles, crossed arms, and raising hands rapidly
Paralinguistic markers of emotion	*Description*: paralinguistic markers expressing emotion, such as accent, pitch, volume, speech rate, modulation, and fluency *Examples*: laughter, rising intonation, forceful exhalations, and rapid overlapping speech
Text expressions of emotion	*Description:* emotion expressed, in written and illustrated texts *Examples:* emotion-laden written words (e.g., peaceful, excited) and sketches showing emotional displays (e.g., smiling animals)

Video analysis

Video analysis enabled exploring how children expressed emotion in classroom interactions drawing on multiple modalities (Derry et al., 2010; M. H. Goodwin & Kyratzis, 2007). Using a video coding software (MAXQDA), we first focused on identifying any verbal statements made referencing or expressing emotion in the whole class, small-group, and interview video data. For verbal utterances, we coded any direct reference of emotion (e.g., Marie: "I just *love* this [sampling] spot!", Elena: "It would be kinda *boring* to all look in the same spot"). Video analysis also supported a multimodal approach to studying emotion emergent in activity, including body postures and movement, facial expressions, and temporal co-ordination of gesture and talk (M. H. Goodwin & Kyratzis, 2007; Sakr et al., 2016). Similar to Jaber and Hammer (2016a, p. 168), we also documented paralinguistics markers of emotion such as intonation, raised and lowered speech, overlapping and opposition speech, and exasperation or questioning tone as evidence of emotion using Jeffersonian transcription conventions (Jefferson, 1984), with examples shown in Table 3. Combined, these multimodal approaches supported identifying emotion expressed in activity, acknowledging that this approach provides only a partial understanding of emotion experienced and expressed in collective activity at any moment.

Focusing on the individual semistructured interview video, I coded their emergent verbal and embodied expressions of emotion as they talked about their engagement in sampling practices. I also coded children spontaneously *reflecting* on emotion across these four interviews (see Dahn & DeLiema, 2020, p. 369 for a similar approach), including instances where children spontaneously talked about their own or their classmate's emotions as they participated in sampling activities.

Classroom artifact analysis

In addition to these video data sources, I also reviewed student and teaching artifacts created during these whole-class- and dyad-level activities, focusing on emotion expressed in the text or sketches. This includes children's use of emotional words (e.g., calming, excited) and emotional states depicted in illustrations (e.g., smiling earthworms). For example, in Amir's site-planning worksheet, I noted how Amir described his proposed sampling site as "a beautiful, peaceful place" and his sketches included smiling aquatic organisms in his pond site sketch (see Table 3 for complete code descriptions and examples, involving verbal, embodied, and artifact analysis).

Throughout this phase of analysis, I shared my analyses regularly with the second research assistant and larger research group unrelated to the project (but interested broadly in STEM teaching and learning). With the research assistant, we meet often to discuss identified data sources and expressions of emotion and place relations within these select data sources. As we further developed portfolios of multiple data sources and interpretations for each pair, the research assistant and I regularly shared our findings with the larger research group. In and after these meetings, we further refined and broadened our interpretations, questioning and revising assumptions about how emotion, place, and children's sampling practices were emerging. These varied perspectives in the analysis and interpretation of rich data sources, coming from inside and outside the project, supported the rigor, credibility, and trustworthiness of the findings (Lincoln & Guba, 1986; Tracy, 2010).

4.5.3 | Phase 3: Considering select aspects of ecologist's sampling practice (what, where, and when)

To examine how emotion and place were co-emergent in children's sampling endeavors, I focused on children's sensemaking related to *what*, *where*, and *when* of ecologists' sampling practice. For *what*, I documented what parts of the system children were considering and coordinating relationships between (e.g., just plants; plants and animals; plants, animals, and broader environmental dimensions, such as human activity, soil characteristics, built environment, past land uses). For *where*, I noted if the pairs were considering the importance of spatial location and spatial distribution in sampling sites. For *when*, I focused on how children were thinking about the timing and frequency of repeat sampling as demonstrated in interviews, whole-class activity, and their site planning sheets. Combined, these three stages of analysis coordinating multiple data sources (interviews, video, field notes, and classroom artifacts) and varied indicators of emotion (embodied, verbal, text-based) supported triangulating interpretations (Yin, 2014), providing insights into the interplay of emotion and place in children's engagement in sampling practices in their schoolyard.

5 | FINDINGS

In this section, I examine how place and emotion co-emerge within children's developing sampling practice, focusing on their sensemaking about what, where, and when to sample. For each pair, I begin with a synthesis of the pairs' general activity and then examine the interplay of the emotion and place in their engagement across two cycles of sampling, drawing on semistructured interviews, videos of small- and whole-group activity, classroom artifacts, and field notes. Throughout, I detail how emotion and place are intertwined within children's emergent sampling practices, supporting, and constraining particular forms of activity and sensemaking about ecological systems.

5.1 | Amir and Marie

Amir and Marie's expressed love of their sampling site, coupled with their visible excitement at finding lots of animals, supported the pair considering multiple intersecting parts of the schoolyard soil ecosystem, animals' needs being met within a smaller niche environment in the schoolyard, and the utility of repeat sampling to see how time and seasons might change the data, all key understandings in ecology. For this pair, selecting sampling sites gave them the opportunity to be in a schoolyard spot they knew and liked, in turn, shaping how they thought about who lived there, slowing them down to closely observe, and sparking curiosity to repeat sampling to see how the animals and broader system might change in relation to shifting conditions.

5.1.1 | Excitement to find animals and be in a special spot were central to considering multiple parts of the system

In selecting their initial site (L1–4), the pair quickly decided on a site near a small pond, a tucked-away spot (dyad pair video, L1, L2; site-planning sheets L1, L3; Interview #1). In the first interview (Interview #1), Amir and Marie both shared their site choice and rationale, excitedly describing their site as they simultaneously considered and coordinated multiple parts of the soil ecology system in their decision of what and where to sample.

> Author: Where did you study and why did you choose that spot? ((*gesturing towards the map of the schoolyard*)).
>
> Amir: Cause' there's a big tree with a lo:::t of animals ((*pointing to map showing their schoolyard site*)). I really like to study the animals! So:::o I wanted to be in the pond [area]…
>
> Author: Tell me more↑!
>
> Amir: I thought the soil was rea:::lly healthy so more animals would like to go there to find food to eat. And also, there's a lot of water! And also, there are a lo:::ts of plants there and sometimes berries (.) >And we will see woodpeckers↑, lo::ts of caterpillars, and worms—lots of worms! and even pregnant worms too ((*smiling*))!!<[3]

In his site selection notes (L3, site-planning sheet), Amir again brought forward emotional dimensions of this particular schoolyard site, describing it as a “beautiful, peaceful place” and including smiles on aquatic animals in the pond (see Figure 1, showing Amir's site-planning sheet).

As evidenced by Amir's speeding up talk, rising intonation, and use of emotion words, Amir expressed excitement at finding lots of animals and spending time in this specific spot. Importantly, Amir's “rea:::lly” liking to

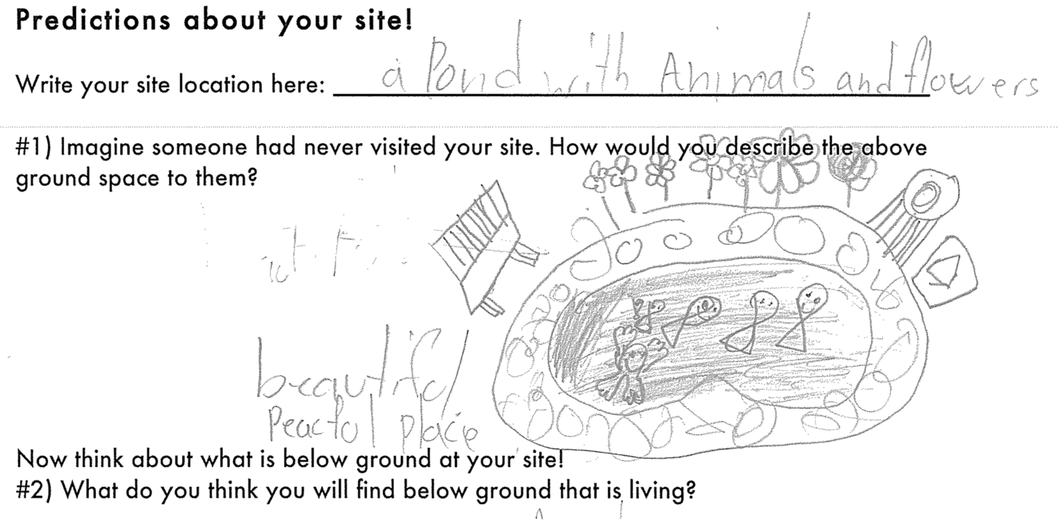

FIGURE 1 Amir's Site Description Worksheet. Amir's site description sheet from Lesson 3, showing smiling animals in the pond area along with emotion-laden text describing the site

study animals was ensnared in recalling and coordinating multiple parts of the schoolyard, including available water as well as the presence of numerous plant and animal species (e.g., worms, pregnant worms, caterpillars, and woodpeckers). Amir also elevated the emotional dimensions of this particular schoolyard site, describing it as a “beautiful, peaceful place” and sketching contented-looking animals. While one could argue that Amir's sketches are simply anthropomorphizing the animals, I argue that the combination of text words and his earlier stated affinity to this particular spot suggests emotional relationships with this schoolyard place.

Marie's rationale for the pairs' sampling site was also infused with emotion-laden relationships with their schoolyard spot. When asked in Interview #1 to describe why she selected their particular site, Marie described wanting to be in a place she knows well and where worms are likely to be found:

> Author: Why did you and Amir choose your site?
>
> Marie: There are a lot of plants there and um::::m I hang out there a lot (.) well I did when I was in third grade ((*smiling*)). We were thinking about places where no one would step on it [the sampling site] and where the soil was wet because we rea::lly wanted to find lots of worms!

As evidenced by Marie's smile as she recalls hanging out in the area in earlier grades, Marie's emotional attunements are ensnared in her considering not only soil wetness and plant growth but also foot traffic through the area, all in her pursuit of “rea::lly” wanting to find lots of worms and be in a place she knows well. In selecting a sampling site, the pair drew on their extended knowledge of their schoolyard, rich in affective and embodied relationships with this specific place spanning several years (Lim & Barton, 2010; Nespor, 1997). In doing so, they considered the spatial location of the sampling site, in relation to foot traffic and other human activity, while also considering what a variety of organisms might need to thrive and reproduce in that particular niche, including woodpeckers, earthworms, caterpillars, multiple plant species, and soil characteristics. As Amir and Marie engaged in the planning phase of sampling, both emotion and place are inseparable from their selection of sampling sites and the coordination of multiple parts of the socioecological system.

Outside in the schoolyard during the fourth class session, emotion and place are interwoven again in how they were observing and gathering data. During this class, children headed outside into the schoolyard, exploring potential sites of interest in the schoolyard pond and garden areas. Amir and Marie are spotted spending almost the entire time focused on their particular spot in the pond area, a hidden tucked-away spot along the wall of the school buildings and the perimeter fence. In contrast to other groups moving around to a variety of potential spots, Amir and Marie spent almost the entire 15 min at their hidden-away schoolyard location (outside video, pond area, L4).

As the camera focuses on the pair at varying points, squeals of laughter and exclamations can be overheard. In one moment (at 5:00), Amir and Marie can be seen kneeling at their site, where the two appear to delight in discovering earthworms and other invertebrates.

Amir: Oh my G-d!

Amir/Marie: giggling ((*as the two continue digging in the soil*, Figure 2a))

Amir: Look at this little one!

Marie: Ahhhh! ((*smiling*))

Amir: Another worm too! ((*Amir turns towards Marie, gently draping a worm onto Marie's knee as both Marie and Amir smile*, Figure 2b))

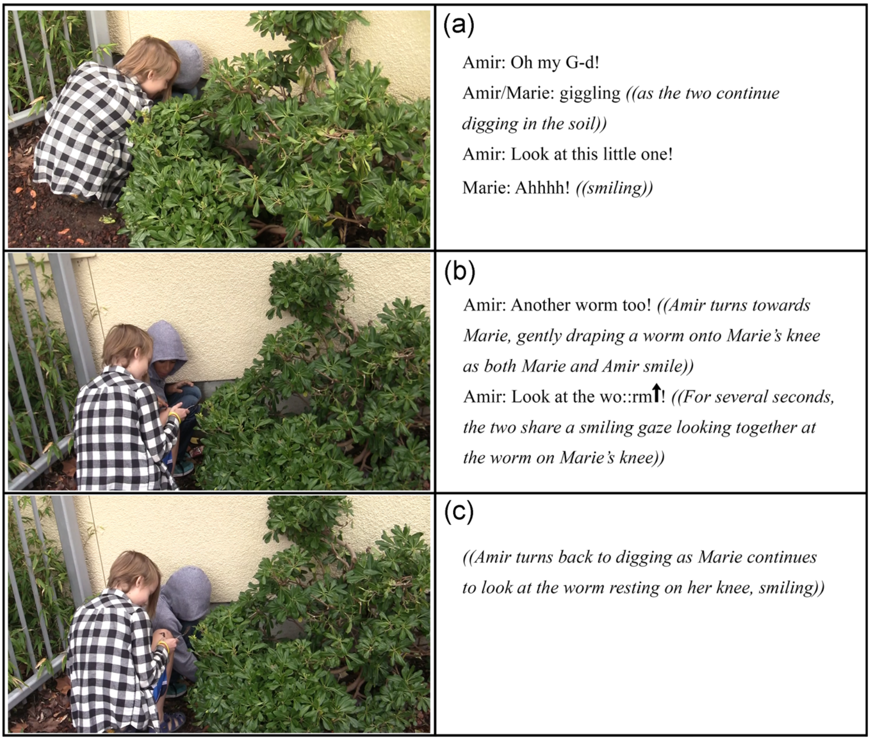

FIGURE 2 Amir and Marie's earthworm discoveries at their sampling sit. (a–c) Outside at Amir and Marie's pond site, the pair excitedly unearths several earthworms: (a) Amir and Marie excitedly dig in the soil, emitting squeals and laughter, (b) Amir drapes the worm on Marie's knee, and (c) Marie looks at the worm, smiling while Amir returns to digging

Look at the wo::rm↑! ((*For several seconds, the two share a smiling gaze looking together at the worm on Marie's knee before Amir turns back to digging*, Figure 2c))

As evidenced by the pairs' sustained time at their site, their animated, excited exchanges (e.g., giggles, screams), and their smiles, Amir and Marie's time at their site is rich with emotion, discovering, and unearthing earthworms in their tucked-away schoolyard place. There is also gentleness and warmth in how they hold and talk about the animals, coupled with sustained observation. In sum, the first round of sampling was replete with emotion ensnared in their relationships and histories with the schoolyard, in turn, shaping how they considered what and where to sample. Simultaneously, the sampling practice of selecting distinct sampling sites elevated their emotional relationships with that particular site, enabling the pair to spend additional time in a particular favored place.

5.1.2 | "Liking" their spot and finding lots of animals opens up insights into repeat sampling

When it came time to select sampling sites again, Amir and Marie returned to their original site a second time. In their planning notes, interviews, and whole-class discussions, Amir and Marie described continuing to want to find lots of animals, to be in a space they "really like," and additionally, to see how the site and the larger pond area might change due to time passing and recent rainstorms as well as potential errors in sampling (Interview #3, #4; L11 whole-class video; L12 site selection sheet). Notably, they were one of only two pairs to return to their sampling site a second time, compared to the classes' 11 other pairs that sampled in new schoolyard locations. In addition, they were the only pair to elevate interest in how the site might change over time and in relation to changing weather, a key consideration in ecologists' sampling practice related to when and where to sample.

During Lesson 11, Marie expressed liking her site again during a whole-class discussion where students shared their rationales for choosing their second sampling site locations. After waiting and waving their hands over several turns, Marie and Amir are finally called on. Marie moves up towards the larger digital map projection with a sticker in hand.

Marie: I want to study my own site ((*placing sticker on map showing the pair's site location*, Figure 3a))

(a) (b)

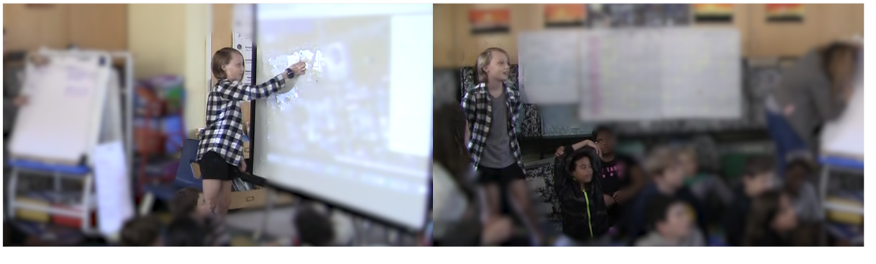

FIGURE 3 Marie explaining how she really likes her sampling site. (a, b) Maire shares her and Amir's second sampling site, (a) pointing out its location on the digital schoolyard map (*Local Ground*) and (b) smiling as she shares how much she really likes her site. Her partner, Amir, looks on with crossed arms over his head, smiling along with Marie

Author: Why would you want to study your same site again? You can learn cool stuff. Tell us what you hope to learn.

Marie: ((*walking back to rug spot*)) We:::ll, I really like my site↑ ((*small smile spreads on face*, Figure 3b)) because nobody ever really notices it.

Classmates: giggles among the class ((*with Amir smiling too*))

Jonah: [or goes back there]

Marie: or like nobody ever runs back there or stomps on it ((*walking back to her rug spot and sitting back down*)). And it has moist soil and you can find lots (.) like different invertebrates and worms in it ((*turning back to Amir, where the two briefly exchange inaudible talk and smiles*)).

Author: So that's neat↑! A secret hidden spot.

As evidenced by her statement "We:ll, I really like my site↑" and her accompanying smile, it appears Marie's emotional connection to this tucked-away place is interwoven with her attention to soil moisture, a variety of invertebrates, and regular foot traffic in the area. Emotion, as expressed through giggling by classmates and the author's rising exclamation of "that's neat!," also permeates this interaction, pointing to collective expressions of emotion around site selection and sampling.

Emotion ensnared in the pair's particular sampling spot also opened up key insights into the benefits of repeat sampling. In their Lesson 13 planning sheet, pairs decided on a second sampling site, writing down their reasons for selecting the particular site (L13 small-group video). Marie and Amir wrote they were selecting their original site a second time, providing the following rationale: "because their [sic] are lots of animals and we would like to see what more we could find. And if the season/day/month changes we will see the differences?" Here, their expressed emotional connections to this sampling spot appear generative for sparking curiosity into what other animals they might find and how their particular site might be affected by the start of the rainy season and time passing. This last rationale is notable, in that a key aspect of thinking about ecological systems and ecologists' sampling methodologies involves thinking about variation and potential changes among multiple system parts across time and space. Additionally, emotional relationships with ecological systems of study are well documented in ecologists' memoirs and studies (Kimmerer, 2013; Bowen & Roth, 2007), pointing to reciprocal relationships among emoting, observation, and conceptual understanding.

5.2 | Elena and Alex

Elena and Alex's expressed excitement at discovering new locales that were not "boring" and seeing how animals coped with human-built structures was interwoven in their emerging sampling practices, with the schoolyard as a context for generating novel insights and testing interactions. Yet once outside in the schoolyard, emotion and relationships with the schoolyard shifted, with Elena expressing competitive interests in wanting to find the most earthworms and the schoolyard becoming smaller niches where earthworms might thrive. The pair also expressed frustration with one another in having to compromise with each other on site selections, as Alex remained interested in their original site and related questions. This entanglement of emotion, place, and practice was integral to how the pair considered (and reconsidered) the benefits of spatially distributed sampling sites and how human-built structures might be influencing organisms' presence and abundance.

5.2.1 | Avoiding “boring spots” and seeing how animals cope opens up insights into spatially distributed sites and multipart systems relationships

In the early lessons, Elena and Alex decided on a less-visited part of the schoolyard for their sampling site, nestled between a concrete retaining wall and a chain-link fence (dyad video, L1, L2; site-planning sheets L1, L3). In the first interview (Interview #1) and their site selection note sheets, Elena and Alex explained their rationale for this site choice. Alex wrote he wanted to study the “sidelines because I want to see how the living and nonliving things cope with the concrete” (Alex note sheet, L3), a similar sentiment to what Elena wrote down. Yet in the first interview, Elena added that “I wanted to do the sidelines ‘cause I figured there'd be a lot more bugs the::rer ↓(.) and a lot more things to discov::er and explore↑.” She described it as a schoolyard spot she didn't know that well relative to other spots and she wanted to see what was there. For Elena, it appears the schoolyard is full of discovery and novelty, infused with emotion-laden relationships as she imagines exploring unknown locales and findings lots of animals. For Alex, the schoolyard appears to be a place for testing relationships.

In early discussions, Elena expressed excitement at discovering and exploring new spots again. Elena voiced wanting to avoid “bor::ing” spots, an emotion-laden focus interwoven in her arguing for spatially distributed sampling sites, an important consideration in ecologists' sampling practice. During a whole-class discussion in Lesson 4, students discussed potential sites, looking at a map of the schoolyard and a chart showing the pair's proposed sites. The author at one point asks, “Why might we not want to sample all in the same spot?”, with several students sharing their ideas. Most students evoked practical concerns related to the safety of the school community, such as avoiding hurting each other with tools or other animals with too much digging in one place. Yet when Elena was called on, she argued that students should be sure to spread out for a notably different reason, arguments infused with emotion (L4_Whole Class, at 9:40).

Elena: Well, um…. people would be finding out (.) like the exact sa:::me information and so

Ms. Keeling: [yessssss! ((*pulling in fisted arms in celebration move*))]

Elena: everyone would be just figuring out the exact same stuff and it would be kinda bor::ing↓

Author: [laughing ((*smiling*))]

Elena: >cause someone would be like (.) “Oh! I found this here!” And someone else would be like, “So did I!” And everyone does this and then <no one> is really finding out ne:::w information.

At this moment, Elena elevates emotional aspects of sampling, centered on novelty and discovery of unknown spaces and organisms. In turn, the schoolyard becomes a place of known and unknown areas, full of possibilities for finding variation and surprise. For Elena, coming to see the variation in a data set as useful and considering spatial distribution of sampling sites are inherently emotional, ensnared in shifting relationships with the schoolyard itself. Emotion is also a collective endeavor, with emotion expressed by the author and Ms. Keeling as Elena speaks. This interaction reveals how Elena's attention to variability in sampling and spatial distributions are emotional and emplaced endeavors, for students and teachers alike (Figure 4).

5.2.2 | Shifting spaces, shifting emotions, emerging disagreements, and clustered sampling sites

However, the next day as the class heads out into the schoolyard, Elena's excitement for the discovery of the unknown switches to the excitement for finding high earthworm counts, regardless of the spatial distribution of sampling sites. That

FIGURE 4 Elena's "boring" rationale for selecting spatially distributed sampling sites. As Elena (wearing a light green hat) describes clustered sampling sites as boring, the classroom science teacher, Ms. Keeling (corner, right) pulls her arms back in a celebration gesture

day, as Elena and Alex began digging at their original sampling site along the schoolyard perimeter, shrieks of excitement could be overheard in the school garden about 50 yards away where classmates are unearthing lots of invertebrates (outside video_L5). As Elena and Alex continue digging, they find no signs of animals. After several minutes, the pair gathers their tools and relocates to the garden's compost pile, a location teeming with earthworms and within arms' reach of Elena's friends and their sites.

In reflecting on their sampling endeavors, Elena and Alex acknowledged how shifting emotion and orientations to the schoolyard shaped their site selection and data collection activity that day. In the last interview (Interview #4, at 24:50), Elena was asked if she would recommend letting children choose their sampling sites in a future iteration of the curriculum, as she and Alex did.

> Elena: No:::oooo. I think >you< should choose the spots <fo:::r> the kids, with half the spots having lots↑ of animals and half not. You see … my partner, me and him, we had some pro:::blems because I↑ wanted to go to places with animals ((*smiles*, *drawing hands together*)) and he wanted to go to the dr::::y places ((*smiling*, *extending hands out*)).
>
> Author: Where he thought there'd be less animals?
>
> Elena: Yea, so I think it would be <ea:::sier> for the partners and it would be more helpful to collect the data if <you> decide [the sampling site locations].

In Alex's interview later that day (Interview #4, 2:50), he responded differently to the question, saying: "I think the kids should choose because well, there will be more thinking. I mean I am not saying <you> were not thinking enough but. there are <so> many kids and there would be all this thinking with diverse ideas that would come up about whe:::re to go." When asked about his group's first site Alex remarked, "I think Elena was really excited about finding lots of earthworms ((*shrugging up shoulders*))! I mean, how could it be a garden <with::out> lots of worms!"

This mismatch of emerging emotion and place relationships between Elena and Alex caused "pro:::blems" as the two decided on what and where to sample. With shifting locations of activity (from classroom to schoolyard), Elena's focus became more myopic in sampling, attending to simply finding the most earthworms, being close to friends, and disregarding the benefits of spatially distributed sites. For Alex, his focus remained on understanding organisms—or the lack thereof—in relation to the built environment and soil characteristics, noting only Elena's emotional responses to selecting a sampling location.

5.2.3 | Shifting spaces, shifting emotions, shifting sampling sites again

As pairs selected their second sampling site several weeks later, Elena's expressed frustration with Alex and expressed competitiveness are interwoven in their site selection deliberations. In Lesson 13, as the pair discussed possible sites in the classroom, Alex insisted on returning to their original site—a spot near the schoolyard wall that might reveal relationships between soil characteristics, the concrete wall, and the absence of organisms (L13, Alex note sheet; L13 dyad video). Elena sat with her arms crossed for several minutes avoiding eye contact with Alex, leaning forward at one point to ask: “So we won't find any:::thing↓ ((*exhales loudly*))?” and writing only “Ask Alex” in the site selection worksheet (L13, Elena notes sheet). Yet the next day, as pairs headed out to their second sampling sites, Elena and Alex shift once again to a new site, a spot along the perimeters of the sports fields where Elena's friends are also sampling and likely to find lots of earthworms.

In Interview #4 (28:30), Elena shared feelings of competition that came up during site selection and data collection as she worked with her partner.

> Elena: Like me and Alex, I was just like MORE *((hand bangs down hard))* (.) more *((hand taps down again))* (.) mo::ore↓” *((hands tap down lightly))*. I thought of it like a competition (.) weirdly enough↑ < and so, I was like > ‘I need to go to places that are thriving!’ and now I am like, ‘Why would you do that?’

For Elena, competition was central to her engagement in what, where, and when to sample as sampling cycles continued. She emphatically describes wanting to have “MORE,” banging down her hand on to the table to express the in-the-moment emotional intensity of the feeling. Finding the most was central to where she wanted to sample and how she thought about the schoolyard. Notably, in reflecting on her emotional shifts, Elena tacitly recognizes that these competitive expressions about amassing the highest earthworms were not how she should have emotionally experienced the data collection activities or how she should have related to the schoolyard. Why does this shift occur, particularly given Elena's initial stance of valuing variation in data and spatial distribution of sampling sites, imbued with curiosity and novelty? Perhaps the sampling practices of quantifying organisms and aggregating numerical data in collective settings initially sparked competitive emotion, in turn shifting her relationship to the schoolyard as finding spots having the highest counts (e.g., school garden's compost pile, the shaded grassy spot by the athletic fields). Yet subsequent class lessons focused on finding relationships among multiple variables, involving discussions of low counts that proved helpful in understanding what numerous organisms, not just earthworms, needed to thrive in the schoolyard. Shifting work with the data, from focusing on initial counts at one site to pattern finding across multiple sites and variables, as well as shifting data forms (e.g., bar charts to interactive multivariate spatialized using *Local Ground maps*), might have also supported Elena's shifting understandings of what she thought she was expected to feel and the kinds of relationships with the schoolyard she was expected to have. Alternatively, perhaps, the physical and temporal distance from the schoolyard enabled these insights.

Later in the interview, Elena was asked to tell more about her end-of-unit written assessment, a series of short questions. In one question, two fictitious children's responses about not finding butterflies as they sampled are contrasted. One child, Maria, expresses disappointment that she didn't find any butterflies and she didn't think she should have looked where there are no animals. Anna, her friend, disagrees, saying finding no butterflies is just as important as findings lots of butterflies when you are studying an animal population. Elena has circled both Maria and Anna as ones she agreed with

> Elena: I agree with Maria and Anna, with Maria cause' you need to look where there are animals. We:::ll, actually… I should have circled Anna cause' she is saying what I'm trying to say, that it is important to look at many places no matter what… Hmmm, I liked the way Maria was deeply thinking about her site.

> Elena: I agree with Maria and Anna, with Maria cause' you need to look where there are animals. We:::ll, actually… I should have circled Anna cause' she is saying what I'm trying to say, that it is important to look at many places no matter what… Hmmm, I liked the way Maria was deeply thinking about her site.
>
> Author: You were appreciating [Maria's] thinking?
>
> Elena: I think it is good to fee::::l what you are doing ((*extending hand in grabbing motion*)), instead of just being a like (.) mindless ((*gesturing towards head*)) zo:::mbie ((*moving arms out limply in front of her body*)) just doing stuff.

Here, Elena fluctuates between the two fictional children's stances, perhaps in part because the questions present a narrow range of emotional expression (e.g., just disappointment or no emotional expression). She eventually selects Maria, arguing that it is "good to fee::::l" these sampling choices and results, but not before also agreeing that sampling at multiple sites irrespective of results is also important. At this moment, Elena appears to struggle between a disimpassioned and emotional sampling approach, ultimately siding with Maria's "deep thinking". In contrast to Elena, Alex did not talk about his emotions in this interview or in his explanation of the short question responses, only the emotions of Elena. In his conversational tone as well, Alex seemed to take a matter-a-fact approach to describing his site choices and rationales. Yet there is a lot we don't know about Alex's emotional experiences from the data sources, raising larger questions about how emotional expression provides only partial understandings of children's emotional landscapes at any moment and concurrently, how curriculum, teaching and classroom culture implictly shape what emotion is permissable.

5.3 | Across case comparison for the two pairs

For both pairs, emotion and place were ensnared in their sensemaking about what, where, and when to sample in their schoolyard. Children's existing histories and emergent relationships with the schoolyard, entangled in emotion, shaped how they engaged in select sampling practices. Simultaneously, the sampling practices themselves shaped new emotion and place relations. Contrasting the two pairs, we can also see varying pathways that emerge from these shifting emotional configurations, shaping different opportunities for learning about socioecological systems and the sampling practices themselves.

For Marie and Amir, their shared history with their tucked-away, "peaceful" spot initially supported considering multiple parts and interactions within the soil ecological system. Throughout the two cycles of sampling, their relationship with their sampling spot appeared to only deepen, with delight expressed from simply being in their sampling spot, seeing what animals lived there, and seeing how the place and organisms within might change. This, in turn, led to repeat sampling at the pairs' original site, attending to variation in their data and the broader system relationships due to seasonal changes. For this pair, the sampling practice of selecting a particular site opened the opportunity to physically and emotionally be in a place they really liked and knew well from their prior years at the school, deepening this emotional relationship with this particular locale over time.

In contrast, for Elena and Alex, their relationship with the schoolyard as places they knew and didn't know initially evoked excitement and curiosity in making new discoveries, leading Elena to advocate for spatially distributed sites and the importance of variation in sampling data. For Alex, this relationship with the schoolyard led to new considerations about how the built environment might be shaping earthworms' ability to thrive, particularly in response to the concrete wall in a "far away" spot. Yet as they headed out into the schoolyard and found few invertebrates, Elena's relationship with the schoolyard shifted to finding something, considering specifically what earthworms needed to thrive and where in the schoolyard this might happen. At the same time, the practices of quantifying organisms and collectively visualizing counts and distributions in the data gave rise to Elena expressing competitive emotion with the schoolyard shifting from a context for discovery of novel interactions and organisms into a series of numerical hotspots likely to yield the highest earthworm counts. Across the two cycles of sampling, Elena and Alex's shifting relationship with the schoolyard, engagement in sampling practices, and emergent emotion were at times at odds with one another, leading each to express frustration with the sampling process and with one another.

6 | DISCUSSION

Considering larger questions in science education research on how to support the emergence of disciplinary practices, I set out in this article to examine how emotion and place were entangled in children's emerging sampling practices. To accomplish this, I drew on Jaber and Hammer's (2016a, 2016b) understanding of emotion emergent *within* disciplinary practices and Vea's (2020) conceptualization of *emotional configurations*. By extending these conceptualizations to encompass place, it became visible how emotion configures place and practice and simultaneously, how place and practice reconfigure emotion, in turn, shaping what was learned and how it was learned. As such, this is an initial step into understanding the entanglements of emotion, place, and practice, aiming to initiate further conversation and study about emotion and place in science education research and practice.

The comparative case study methodologies central to this analysis were conducive to examining these entanglements, revealing not only dynamic variability between and within pairs but also how emotion opened or constrained children's sensemaking about socioecological systems. This study extends work by Jaber and Hammer (2016a, 2016b), by offering new insights into the variability inherent within the same classroom communities and notably, the divergent pathways for learning that emerge over time. Additionally, by focusing on the two pairs' activity within a multiweek curriculum, it became possible to see how children's emotion, practice, and understanding of ecosystems were co-developing in relation to the curriculum design. Tracing *emotional configurations* across the weeks revealed how design decisions such as centering the schoolyard as the focus of inquiry into ecological systems and supporting student autonomy in selecting sampling sites were navigated by children. With this grain size for analysis, it made visible some of the complexities and possibilities of centering science within everyday locales, as well as designing in more uncertainty for young learners.

Notably, wide-ranging emotions were central to children's engagement in their emergent sampling practices, encompassing not only joy and delight but also envy and frustration. Given how emotion is both meditated and regulated in K–12 school contexts (Boldt et al., 2015), it will be important for researchers and practitioners to nurture and affirm a broad spectrum of emotions emergent in science pursuits. Especially for emotion evoking competition or liking a special tucked-away schoolyard spot, it will be generative to acknowledge and support these complex and varied emotions as part and parcel of "doing" science (Jaber & Hammer, 2016a). By broadening what emotions can be part of science learning for children, we can not only affirm a more accurate depiction of disciplinary pursuits but also, most importantly, affirm the fuller humanity of children as they engage in such pursuits.

Emotion was always occurring *somewhere*, in reciprocal and dynamic relationships with and within the schoolyard. As science education ideally becomes more rooted in the places and causes central to young people's lives, it will be important to attune to and sustain these emotional relationships, understandings, and histories children have within their daily locales. Given that science education research and the related reform documents draw heavily from western, laboratory-based depictions of practice (Stroupe & Carlone, 2021), scholarship further centering emotion and field-based studies will be important in ensuring multifaceted understandings of how science practices are sparked and sustained. Existing work in ecology studies offers a strong grounding in this area already, elevating the reciprocal relationships among practice and place possible for children, families, and scientists alike (e.g., Kimmerer, 2013; Marin & Bang, 2018).

6.1 | Implications for science education

The study raises several considerations for science and environmental science education. First and foremost, place and emotion, co-emergent, were shown to be powerful elements in instigating disciplinary practice. Existing work by Manz (2016) has elevated the importance of the materiality, complexity, and puzzlements offered by local spaces, as integral to providing requisite uncertainty and complexity for science practices to take hold (Metz, 2004; 2008). Findings in this study extend this scholarship elevating emotion and place relationships as integral to emergent practices as well. For educators, curriculum designers, and researchers, it will be generative to further elevate these multiple, intersecting dimensions inherent to place in children's emergent practices.

Second, this study points towards new repertoires for educators, designers, and researchers alike. Given that emotion is already integral to teaching and learning science, shifting roles emerge for teachers to attune to and guide learners through such emotionality. Take Elena's expressed emotion of competition, shifting her approach to sampling from attending to spatial distribution out of concern for variation in her data to a myopic focus on ensuring the highest earthworm counts in the class. In her final reflection, she mentions that it was "weird" what she felt and tacitly acknowledges that she shouldn't have felt that way, in turn recommending that the teacher decide sampling sites for her and her classmates. Looking to practicing scientists' memoirs and biographies, they too frequently express competitive emotion, in ways that advance or derail their scientific methodologies and collaborations. How might educators explicitly support learners in navigating emotions such as competition or jealousy? Alternatively, how might educators further sustain and nourish children's emotions full of delight, affection and care towards local ecosystems, nurturing relationships with places and organisms within similar to what Amir and Marie expressed? Recent work by Davidson et al. (2020) and Jaber (2021) reveals teachers benefit from opportunities to encounter, understand and appreciate emotion inherent to science sensemaking, by engaging first-hand in science inquiry with scientists and children alike. For researchers, this study points to important shifts in how we might study science learning, with deeper inquiries into the intersections of our own emotion, those around us, and design elements drawing on innovative methodologies (e.g., Curnow et al., 2021).

6.2 | Limitations and future research

This retrospective analysis was focused on understanding the interplay of emotion, place, and children's sampling practices. Although the study reveals important insights, there are several limitations of the study. First, there are the inherent challenges of studying emotion. Although a range of data sources were triangulated (interviews, artifacts, small- and whole-group video activity, reflective field notes) to examine emotion expressed in numerous forms (e.g., spoken and written language, gesture, and body positioning), there are inherent challenges in inferring emotion in another person (e.g., Barrett et al., 2019; Linnenbrink, 2006 for discussion of several methodological challenges). As Davidson et al. (2020) and others note, emotional experience is not the same as emotional expression. Additionally, expression and subsequent interpretations of emotion, in turn, are shaped by cultural and powered dynamics of the classroom community and researcher contexts (Boldt et al., 2015; Boler, 1999; Leander & Boldt, 2018). As such, findings reflect the focal pairs' expressed emotion at particular moments but are not reflective of children's full emotional experience at those moments. Future work might further explore how emotion is regulated and mediated in ways that are expanding or constraining for the emergence of discplinary practice, in relation to gendered, raced, and classed interactions within science education settings and designed activities.

Second, this was a retrospective analysis focused on understanding the interplay of emotion, place, and practice, as it emerged within a broader design-based research project centered on late-elementary students' engagement in science and data science practice using digital GIS technologies. As such, additional data sources would have been helpful in this analysis centered on emotion and place, including having researchers interview impromptu in the midst of activity and children wearing mobile cameras to capture more of their in-the-moment perspectives, movement, and discussions to see how emotion and place co-emerged. Additionally, it would have been helpful to have more insights into children's connections to and relationships with the schoolyard itself, drawing on methodologies used by Lim and Barton (2010) that centered on children's emergent and historical place relationships within and about local places. In future work centering on emotion, place, and practice, it will be generative to keep listening to and learning from children's exiting and emergent relationships with place, refining research methodologies and design-based research that make these relationships more visible. Additionally, it would be useful to have more complete data sources as children moved within the school and schoolyard, to see how emotion, always in motion, unfolds across changing landscapes and how movement shapes emerging emotion and practices. In particular, how might the ambulatory methods developed by Marin and colleagues (e.g., Marin & Bang, 2018; Marin et al., 2020) be generative to deepening the field's understanding of emotion, place, and practice as co-emergent and on the move?

Third, the comparative case study analysis offers thick descriptions (Tracy, 2010) of four children's emotional expressions within one fifth grade class. As such, these findings offer a glimpse into the interplay of emotion, practice, and place but cannot be generalized to the entire class or other contexts. Findings can only point to particular *emotional configurations* unfolding for these four children. Yet what is lost in breath and generalizability is countered by a detailed description of emerging practice for young learners, generative for further theorizing on the entanglement of emotion, place, and disciplinary practice. This study also offers initial insights into the variability and heterogeneity within and across a curricular design. Future work, exploring how this variability is sustained or tamped down by educators, peers, and the curriculum itself is needed to further support science learning opportunities.

6.3 | Conclusion

As science education and related fields continue to focus on supporting the emergence of disciplinary practices, it will be crucial to center an expansive depiction of practice, elevating emotion and place in broader processes of engagement and learning. Ideally, through further accounts of children's science learning that attend to social, emotional, and emplaced dimensions of science practice, researchers and practitioners will be posed to not only better support meaningful emergence of disciplinary practices but also acknowledge and affirm the fuller contours of children's and scientists' knowledge-building pursuits.

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CONFLICT OF INTERESTS

The author declares that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article because it is protected under Human Subjects protocols.

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ENDNOTES

[1] Socio-ecological systems is defined using the definition provided in "Learning in Places Collaborative (2018). Learning Brief: Issue 3: Seeing and Reasoning about Complex Socio-Ecological Systems in the Early Grades. Bothell, Seattle, WA & Evanston, Il: Learning in Places."

[2] All names and places are pseudonyms.

[3] Transcription using the Jeffersonian approach as described in Jefferson, G. (1984) Transcription notation. In J. Atkins & J Heritage (Eds.), *Structures of social interaction*. Cambridge University Press. This includes: *((make italics))* describes non-verbal activity; ALL CAPS describes shouted or increased volume, underline describes speaker is emphasizing or stressing speech, ;::: indicates prolongation of utterance; ↑ indicates rising pitch; ↓ indicates falling pitch; (.) shows a micropause; >text< indicates text was delivered more rapidly than usual for speaker, <text> indicates speech was delivered more slowly than usual for speaker.

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APPENDIX A: SEMISTRUCTURED INTERVIEWS

Interview protocols (with focal dyads, interviewed individually)

- Interview #1: before first-round data collection (with paper map only)
- Interview #2: after first round of data collection (with aggregated paper maps)
- Interview #3: after second round of data collection working (with digital maps)
- Interview #4: at end of multiweek curriculum (with all data/map formats)

(***Note: Children's responses to the italicized questions were the focus of this study***)

Interview protocol #1: Before the first-round data collection

Materials:

- binder with plastic map of schoolyard
- image of parts of ecosystem (with above and below ground student identified variables)
- prior student's work: initial site selection sheet (where children described sites of interest and their rationale for why they want to study those sites)

Prompts:

- Tell me more!/I am interested in your thinking!/Why do you say that?

Assent:

- While walking to interview room, gain assent: I would like to talk with you for about 10 min about the **paper maps** we have been using in science class. Would you be okay to talk with me for about 10 min?

Introductory statement:

- I am interested in your thinking! There are no right or wrong answers!

Child's background at the school

Q1: How long have you been a student here? What grade did you start in?

Interpretation of representational form (color photographic map of schoolyard)

Q2a: Show me __ classrooms?

Q2b: Are any parts of the map confusing or hard to figure out what they are?

Q2c: How do you enter and leave the school each day?

Site selection rationale (based on child's earlier written responses)

Q3: Can you tell me more about why you thought ____ was a good spot to study?

Sampling and amount (emergent based on earlier site selection discussions in class)

Q4: I noticed as I looked through everyone's ideas about where to study that most kids choose places where there were LOTS of plants or animals. I was curious if you thought it would be useful to study places where there are NOT many plants or animals? Why?

Specific site selection rationale and predictions (color photographic map of schoolyard)

Q5a: Will you show me on the big map, where did you and your partner decide to study? Why did you decide on this spot to study?

Q5b: What do you expect to find at your site? Why?

Q#5c: What do you think the soil will be like? Why?

Wrap up

Q6: Do you have any questions for me or any comments or feedback?

Interview protocol #2: After first round of data collection

Materials:

- Six focal students' binders with small, aggregated paper map copy
- Large class aggregated paper data map propped up

Prompts:

- Tell me more!/I am interested in your thinking!/Why do you say that?

Assent:

- While walking to interview room, gain assent: I would like to talk with you for about 10 min about the paper maps we have been using in science class. Would you be okay to talk with me for about 10 min?

Opening statement:

- Today I am interested in learning more about your thinking and using the **aggregated paper maps** we've made in science class. There are no right or wrong answers—I am just interested in what you notice and having you share your thinking and questions with me! Do you have any questions or comments before we start?

Interpretation of form (aggregated paper map)

Q1a: Take a look at the map! Can you show me where is your classroom? the school garden? your site?

Q1b: Choose one site and tell me what they found there.

Prompt if stuck: What do the different numbers and color stickers show here [pointing to one site]?

Identification of relationships and explanations

Q2: Now let's look at the whole map! Do you see any patterns or relationships? Why do you think that is? Or do you see any patterns and then something that breaks the patterns?

Prompt if stuck (or only offer one pattern): Do you see any sites that are the same? In what ways are the sites the same? Why do you think that is? [Do you think any of the sites are the same in other ways? Where? Why do you think?]

Prompt if stuck (or only offer one pattern): Do you think any of the sites are different? In what ways are they different? Why do you think that its? {DO you think any of the sites are different in other ways? Where? Why do you think?]

Puzzles? Surprised? Questions? Uncertainty?

Q3a: Does anything look puzzling or confusing in this data?

Q3b: Did anything surprise you? What? Why?

Q3c: We all gathered data at our different sites over these last few weeks. Do you think our data could be wrong in any ways? If yes, in what ways?

Example and counter example

Q4a: Looking at the pond area, one child noticed that few earthworms and other invertebrates were found in this space? Why do you think that is?

Q4b: Why do you think this one group did find lots of organisms (pointing to a spot in the pond area that had a higher earthworm count)?

Next step site selection

Q5a: Based on the patterns and puzzles you are seeing here in your data map, what new places would you want to explore next? (Show me on the map)

Q5b: Why would you think these are good places to study further?

Prompt: What makes you interested in studying these spots?

Sampling and amount

Q6: Do you think it is useful we are finding places where there aren't a lot of earthworms and other invertebrates? Why or Why not?

Wrap up:

Q7: Do you have any questions for me or anything else you want to share?

Interview protocol #3: After second round of data collection

Materials:

- computer with *Local Ground* digital map
- image of parts of ecosystem (with above and below ground variables)

Assent:

- While walking to interview room, gain assent: I would like to talk with you for about 10 min about the **digital maps** we have been using in science class. Would you be okay to talk with me for about 10 min?

Prompts:

- Tell me more!/I am interested in your thinking!/Why do you say that?

Introductory statement:

- Today I am interested in learning more about your thinking and using the digital maps we've made in science class. There are no right or wrong answers—I am just interested in what you notice and having you share your thinking and questions with me! Do you have any questions or comments before we start?

Interpretation of form (digital data map)

Q1a: Take a look at the map! With the mouse, can you show me where is your classroom? your first site? your second site?

Q1b: Choose one other site and tell me what they found at their site!

Prompt if only look at one variable or just variable layer: Is there any more you can find out about this particular site?

Identification of relationships and explanations

Now let's look at the whole map! We have been talking a lot about the parts of the schoolyard we have studied and explored how the different parts might be interconnected.

Q2a: As you look at this map of everyone's data, do you see any patterns or relationships? Why do you think that pattern is happening?

Prompt if stuck (or only offer one pattern): Do you see any sites that are the same? In what ways are the sites the same? Why do you think that is? [Do you think any of the sites are the same in other ways? Where? Why do you think?]

Prompt if stuck (or only offer one pattern): Do you think any of the sites are different? In what ways are they different? Why do you think that it's? {DO you think any of the sites are different in other ways? Where? Why do you think?]

Q2b: As you look at this map of everyone's data, do you see a pattern and then something that breaks the pattern? Why do you think this break in the pattern is happening?

Prompt if stuck (or only offer one pattern): Do you see any sites that are the same? In what ways are the sites the same? Why do you think that is? [Do you think any of the sites are the same in other ways? Where? Why do you think?]

Prompt if stuck (or only offer one pattern): Do you think any of the sites are different? In what ways are they different? Why do you think that is? {DO you think any of the sites are different in other ways? Where? Why do you think?]

Puzzles? Surprised? Questions? Uncertainty?

Q3a: Does anything look puzzling or confusing in this data? Tell me more!

Q3b: Did anything surprise you? What? Why?

Q3c: We all gathered data at our different sites over these last few weeks. Do you think our data could be wrong in any ways? If yes, in what ways?

Example and counter example, involving human activity

Q4a: Looking at the pond area, one child noticed that few earthworms and other invertebrates were found in this space (pointing to high traffic area)? Why do you think that is?

Q4b: Why do you think this one group DID find lots of organisms (pointing to a spot in the pond area that had a higher earthworm count and less foot traffic)?

Next steps and site selection

Q5a: Based on the patterns and puzzles you are seeing here in your data map, what new places would you want to explore next? (Show me on the map with your mouse).

Q5b: Why would you think these are good places to study further?

Prompt: What makes you interested in studying these spots?

Sampling and amount

Q6: Do you think it is useful we are finding places where there aren't a lot of earthworms and other invertebrates? Why or Why not?

Wrap up

Q7: Do you have any questions for me or anything else you want to share?

Interview protocol #4: Post instruction

FUNCTION of this INTERVIEW: I would like this interview to engage the focal dyads in using and reflecting on multiple data forms simultaneously (or one right after the another), not in isolation like the prior three interviews. I also would like to engage children in “meta” reflections on participating in the instructional design, specifically what changes they would make to the science inquiry structure, procedures and the related representational forms.

Assent: (Walking to interview space) I would like to talk with you for about 10 minutes about the project we have been doing. Would you be okay to talk with me?

Prompts: Tell me more! I am interested in your thinking! Why do you say that?

Opening: Today, it is our last interview together. As before, there are no right or wrong answers. I am excited to hear your thinking about the questions I have. Do you have any questions *for me* before we start?

SECTION I: Project review and redesign (form/function)

This spring, we have been exploring your schoolyard over many weeks, looking at the parts underground and aboveground, and talking about the ways they might be connected using paper and digital maps as well as different bar charts.

Recall that we were focusing on learning more about several “big” questions over these weeks. Working in pairs of two or three, everyone spread out, choosing sites of interest to study more. You and your classmates collected information about the **animals** that lived in different spots underground, by digging in the earth (show picture of kids digging) and by setting pitfall traps (show image of pitfall traps). You also recorded the amount of **moisture** in the soil by squeezing it, noting wet, moist, or dry (show picture) and how **compact** the soil was, by pouring water through a cup and timing how long it took to sink into the ground (show picture). You also observed what the soil was like, including the **color** and **composition**, by looking closely and describing what was in it (e.g., rocks, twigs, sand, and woodchips). You took sketches and photographs of what you saw.

As we worked, we explored our data in lots of ways, using a map, sticker map, invertebrate post-it chart, sticker bar charts, and the digital *Local Ground* map (point to timeline image that shows different rep forms).

• Q1: Imagine now that YOU could lead the design of this science project, changing the design in places to better support students exploring the big questions here at _______ school. What would you keep the same? What would you change?

Site location

• *Q2a*: *We looked in over 20 different spots, with one group repeating at the same site twice*

Do you think it is important for kids to be able choose their spots like you and your partner did? Why or Why not?

• Q2b: *If answer YES, would you recommend any spots in particular? Where? Why? If answer NO, where would you assign them?*

• Q2c: *During this project, some kids might only want to look in places where they would find LOTS of plants or animals. What do you think about that? Do you agree or disagree? What if all the students wanted to look in places with lots of animals? Do you think this might be a problem for answering the big questions? Why?*

Methods and tools:

We gathered lots of data using different tools and techniques.

• Q3a: Would you gather ALL of this data again? or only some of it?

Follow-up: Was some of the data more useful to you than others?

• Q3b: Is there any data that we didn't collect that you think would be useful? Why?

• Q3c: We gathered two rounds of data. How many times would you recommend having kids collect data at a site?

Follow-up: Once, twice, more than that? Why?

Representation prompt:

We used many different visual images to think about the different parts and relationships

• Q4a: Which ones would you use again? Why?

• Q4b: Would you use them in the same order or different?

• Q4c: When we look at everyday places like the schoolyard and your soil data in different ways, we can sometimes see different things. Were any visual images particularly helpful? In what ways? Where any not very helpful? In what ways?

• Q4d: Which data forms helped you think best about the different parts and relationships? What kinds of relationships did you see?

SECTION II: WRITTEN SURVEY

Ask students to explain their responses to Questions #2–4 on the written assessment administered in the last class.

SECTION II: WRAP UP

• Q5a: As you think about another class doing this project, what did you like best about this project? Follow up: Anything else that you really enjoyed?

• Q5b: What would you recommend improving or changing?

Prompt: Were there any parts that didn't make sense? or you would do differently?

Follow up: Anything else to improve or change?

• Q5c: Did this project feel different than what you usually do in school—and science?

Follow-up: If yes, in what ways did it feel different? If no, in what ways did it feel the same?

• Q5d: Anything else you want to share with me or ask me before we end?