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Embodied Pathways and Ethical Trails: Studying Learning in and through Relational Histories

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Studies of embodied cognition offer powerful accounts of the semiotic resources people use as they think together within different domains. Yet this research does not typically foreground the history of relationships within focal interactions—a history we have found to be consequential to the ways embodied actions unfold. Through ethnographic and interactional analysis of the assistance students received in a tinkering afterschool program and the forms of assistance they enacted over time, we show how children supported one another using embodied movements that were embedded in relational histories and imbued with pedagogical and ethical values. We substantiate these findings by introducing the range of embodied movements identified within the setting, followed by a detailed analysis of three cases spanning distinct time-scales (5 minutes, 1 week, 3 years). The cases help establish the construct of embodied pathways, which we define as courses of possible action involving participants’ bodies and voices that model particular relations. We argue that the experience of receiving embodied assistance creates...
resources for mediation in the future, as seen in subsequent acts of guidance and solidarity across children. More broadly, we argue for greater attention to how people learn to be in relation within research on embodied learning.

“Hands hold stories.”—Susan Elise Wilcox

This paper examines the role of embodied assistance in the moment-to-moment and day-to-day development of learning environments that aim to enact educational dignity. We define educational dignity as the multifaceted sense of a person’s value generated through substantive educational experiences that recognize and cultivate one’s mind, humanity, and creative potential (Espinoza, Vossoughi, Rose, & Poza, in progress). Through a close analysis of the forms of assistance students received in a tinkering afterschool program and the forms of assistance they enacted with others over time, we show how children worked to guide one another using embodied movements that were embedded in relational histories and imbued with particular pedagogical and ethical values. More broadly, we argue for greater attention to how people learn to be in relation (Nasir & Hand, 2006) within research on embodied learning.

In previous work, we studied the forms of embodied assistance that mediated joint activity within the Tinkering Afterschool Program (or TAP), and the ways educators’ reflections on photographs and video recordings led to shifts in embodied action toward deeper forms of co-presence and relationality with children (Vossoughi, Escudé, Kitundu, & Espinoza, in press). Focal examples included: a teacher using her hands and words to offer students the feel of working with a new tool, a student shifting their body so that a peer can better observe how they are approaching a task (or shifting their body to block others from seeing their work), educators encouraging young adult mentors to observe how children are using their hands to troubleshoot a problem before intervening or to keep artifacts close to children’s eye levels when explaining the workings of a mechanism. Though embodied forms of assistance are present in most learning environments, such guidance may be particularly salient in making and tinkering settings, which are typically organized around hands-on, project-based activities. Over time, we argued, patterns in these interactions shape the distribution of knowledge in a setting and the ways children experience themselves as competent and respected thinkers. Here, shifts in educators’ embodied actions were also aimed at addressing broader racialized and gendered inequities with regard to the distributions and qualities of assistance within making/tinkering settings (e.g. who is more likely to have an artifact taken out of their hands, or who is trusted to use a tool) (Vossoughi, Hooper, & Escudé, 2016). Drawing from and expanding studies of embodied cognition that emphasize the role of the body in the development of domain-specific concepts (Lindgren & Glenberg, 2013), we therefore use “embodiment” to refer to the physical, gestural and artifact-mediated dimensions of human
learning, as well as the kinds of ethical and pedagogical values expressed through such interactions.

Building from our prior work, this paper asks: how do relational histories and salient moments of embodied assistance mediate future action and meaning? Though research on embodied cognition offers powerful accounts of the range of semiotic resources people use as they think together within different domains (e.g. mathematics classrooms (Nemirovsky, Rasmussen, Sweeney, & Wawro, 2012); astronomy (Azevedo & Mann, 2017)), it has not typically foregrounded the history or genesis of the relationships within the focal interaction. In a recent review of literature on children’s making, Norouzi, Kinnula, and Iivari (2019) similarly found that histories of participants and the interactions between them are very rarely the focus of existing studies. We have found these interactional histories to be consequential to the ways embodied actions unfold and to the kinds of relations enacted within a setting over time.

Analyzing ethnographic and interactional information spanning 3 years of programming in TAP led us to see how particular forms of guidance across participants created embodied pathways that others then took up in future moments. We define embodied pathways as courses of possible action involving participants’ bodies and voices that model particular social, intellectual and ethical relations. We argue that the experience of receiving embodied assistance creates resources for possible action in the future, as seen in subsequent acts of guidance, collaboration, and solidarity across children. Put differently, moments of embodied assistance carry a double meaning: they serve as help to accomplish the task in the moment, and as models for how children might help others in the future. The notion of “pathways” is germane to the study of gesture and embodiment because there are literally paths through the air that may be seen as marked or accentuated by participants’ actions in ways that create potential openings for others to utilize and reshape.

We substantiate these findings by introducing the range of embodied movements identified within the setting, followed by a detailed analysis of three cases that illustrate how children drew from the assistance they had received to organize learning with and for others through subtle but traceable forms of embodied action. Our cases examine this phenomenon across distinct time-scales and include: 1) a five-minute interaction wherein forms of embodied assistance used by an educator to support one child to learn how to use a hot-glue gun were immediately used by that child to guide her friend’s learning in both resonant and novel ways; 2) a case in which two children were deliberately supported to learn how to collaborate or form a “we” within a marble machines activity in ways that were utilized by the pair 1 week later; and 3) a case spanning 3 years that considers how a 6-year-old child grew into the role of an expert facilitator, and came to organize learning for other children using key forms of embodied assistance valued within the setting.

Our analysis of embodied pathways offers one way to see learning—shifts in participation, new relations with others, materials and tools (Rogoff, 2003)—through
the movements of the body, and can support educators in being reflective and intentional about the forms of embodied assistance we model and enact in the moment. Our findings also attune us to the ways pedagogical movements are always ethically and politically laden (Bang, Faber, Gurneau, Marin, & Soto, 2016; Esmonde & Booker, 2016); they involve values and forms of power, and are enmeshed with processes of social reproduction, contestation, and transformation (Cruz, 2001; Erickson, 2004). Further, viewing present action as creating meanings that can shape future interactions in unanticipated ways offers a lens for perceiving real-time activity that is sensitive to the ethical trails we are etching in the air. We see in such everyday movements how the guidance children offer one another involves ethical stances and decisions about who they want to be in the world, what kind of thinker, teacher, or friend.

THEORETICAL LANDSCAPE AND TOOLS

Within the Learning Sciences, research on embodied cognition has focused on the ways cognition is related to physical action and interaction, the role bodies play in the development of conceptual understandings within disciplinary domains, and relevant implications for the design of multi-modal learning environments (Alibali & Nathan, 2012; Hall & Nemirovsky, 2012). This body of work has deepened our understandings of cognition as a situated, distributed phenomenon, and helped establish the idea that “human thinking and learning is intimately tied not only to the body but to a body that interacts with others” (Hall & Nemirovsky, 2012, p. 213–214).

Important debates and tensions mark this tradition. Stevens (2012) distinguishes between conceptualist perspectives, which emphasize the ways “ideas are organized in conceptual systems grounded in physical, lived reality” (Núñez, Edwards, & Matos, 1999, p. 50), and interactionist perspectives, which understand the body as an interactively organized and “public resource for thinking, learning and joint activity,” that produces meanings and actions through diverse means, including tool use, gesture, pointing, prosody, intonation, physical orientation, gaze and talk (Stevens, 2012, p. 338).

Another tension lies in the extent to which studies of embodiment treat historicity and relationality as central analytic foci. Often, careful analyses of the domain-specific understandings that emerge through the body, and the body in interaction with other bodies (human or more-than-human), tend to minimize or leave out 1) information on who the actors in the scene of interest are to one another relationally and historically; 2) if and how this history mediates embodied interaction in the present; and 3) how the goals or outcomes of learning may involve new forms of relationality (DiGiacomo & Gutiérrez, 2016; Goodwin, 1994; McDaid-Morgan & Bang, In preparation; Rogoff, Callanan, Gutiérrez, & Erickson, 2016). In other
words, research on embodied cognition tends to focus on subject-subject relations in so far as they support new subject–object relations, rather than as a domain of learning unto itself (Bang & Vossoughi, 2016).

Our analysis addresses this tendency by focusing on how children learn to support and be in relation with one another (Nasir & Hand, 2006), and the specific role of the body in such learning. This move resonates with recent scholarship on what people do together with their bodies as the “content” of some conceptual practices (as in the context of dance, team sports, and ensemble musicians) (Hall & Ma, 2011; Hall & Stevens, 2015), with a focus, in this case, on embodied assistance across peers. While the growing literature on embodied cognition has rightfully argued that overlooking the centrality of the body to thinking and learning occludes key modalities of human sense-making, it has not attended closely to the forms of thinking and learning we miss when we overlook the relational histories and ethical deliberations evident in the embodied actions of learners working to enact pedagogical relations with one another. This is where our work intervenes.

Important exceptions guide our thinking, both from within and outside the field. Goodwin’s seminal research historicizes embodiment by examining the ways people create present action through the use and transformation of prior action (Keifert & Marin, 2018). Central to this work is the notion of substrates: the resources or material provided by prior actions that are re-used and modified to create something new (Goodwin, 2013). Goodwin argues that building next actions using substrates is simultaneously structure-preserving and transformative (Ibid). One aspect of this simultaneity lies in the ways turns of talk or action gain meaning through prior actions while producing new meanings. This process creates “a distinctive form of sociality: it is one of the ways in which we inhabit each other’s actions, including those of no longer present predecessors” (Goodwin, 2018, p. 31, cited in Keifert & Marin, 2018).

The notion of inhabiting others’ actions through substrates is especially helpful for thinking about how the initial turns within an exchange—what we call “interactional firsts”—or the initial moments and days of a program or setting (Hansen, 1989), create value-laden movements that can endure, or become intentionally sustained, over time. This view looks forward from earlier moments and asks after what is carried over, renewed and reshaped. We also look backward from salient interactions (Goodwin, 2013) to see how participants re-traced prior movements. Acting as historians of learning, we aim to understand how future actions carry the trace of prior social relations (Bakhtin, 1981/2010; Vygotsky & Cole, 1978).

How do these traces take shape? Gallagher argues that “sustained and repeated interactions build ‘implicit relational knowledge’ and improve possibilities for greater fluency, flexibility and further successful interactions” (2010, p. 115). We interpret “implicit relational knowledge” as a kind of embodied shorthand that develops between people as they work together
over time, akin to Tulbert and Goodwin’s notion of “well-traveled paths through architecture that relate to practiced sequences of activities” (2011, p. 87), and Danish and Enyedy’s (in press) attention to the ways people learn to interpret other people’s body positioning, movement, and gesture over a lifetime. As relationality builds, “the intentions of the other person are visible in their movements” (Gallagher, 2010, p. 115).

While we share an interest in the ways implicit relational knowledge can open up increasingly generative educational interactions, understanding learning as political and ethical also leads us to consider the forms of implicit relational knowledge that accrue from ongoing experiences with structures of power. One need only consider how racialized bodies learn to interact with police to see how implicit relational knowledge can also function to maintain forms of repression and control. In Ghostly Matters, sociologist Avery Gordon theorizes these traces as hauntings, “organized forces and systemic structures that appear removed from us [but] make their impact felt in everyday life in a way that confounds our analytic separations” (2008, p. 19). Recent scholarship on movement and mobility has similarly conceptualized embodied learning as tied to the historical and power-laden dynamics of place and place-making (Taylor, 2017; Taylor & Hall, 2013), and as imbued with epistemological and axiological orientations toward land and the natural world (Marin & Bang, 2018). These ideas call attention to implicit relational knowledge as a context for social reproduction and transformation. They also move beyond a normative view of the conceptual meanings produced by the body, theorizing bodies in relation to other bodies and to place as representational sites where critique and resurgence can be developed and sustained (Marin & Bang, 2018).

Taking a political and ethical approach to the study of embodied learning also helps us interpret the idea that people’s intentions are visible in their movements in ways that support projects of educational dignity and justice. O’Loughlin (1998) asserts that “habitual antipathy to certain ‘others’ … manifests itself in a myriad of bodily positionings, gestures, orientations and verbal and non-verbal expressions” (1998, p. 201). Taylor (2017, p. 36) similarly challenges current theories of embodied learning to account for “the ways in which ‘the body is rendered … a visual display or text readable to an outsider’s gaze (Lefebvre, 1991; Nespor, 1997, p. 121).” We draw on these arguments to consider how assumptions about intelligence and capability are conveyed through subtle embodied movements (e.g. a male teacher taking a female student’s project into his own hands to solve a problem, rather than involving her in shared problem solving), and how students marginalized through hierarchies of race, class, and gender do the additional mental work of navigating the meanings tied to the various identities and histories housed in their bodies (Cruz, 2001; Nasir, Rosebery, Warren, & Lee, 2006).
Though the educational implications of research on embodied cognition typically speak to the forms of corporeal representation educators can model to support learning, and to ways of seeing the thinking in students’ embodied actions, less attention has been given to the role of the body in who gets help, how, and with what kinds of consequences for learning. As O’Loughlin writes, “bodies speak and are spoken to” (1998, p. 284). Bodies also listen (or not) in particular ways. An educators’ hand lingering back within a shared workspace to see what a child’s hand (and mind) might do next reflects a kind of patient receptivity that can generate trust and intellectual respect, what Rose (2018) calls “everyday gestures of justice.” Together, these lenses guide us in treating the mediation of learning through the movements of the body as a domain of pedagogical and axiological deliberation (Bang et al., 2016; Zigon & Throop, 2014), and to inquire into the relational histories through which such movements take shape.

METHODS

Setting & Methodological Approach

TAP was a partnership between a science museum and Boys & Girls Clubs serving working-class communities in a large metropolitan city on the West Coast. Participants in the program were primarily children (K-5) and young adult educators (ages 14–20), many of whom attended the clubs themselves as children. The focal club highlighted in this paper served Mexican, Central American, African American, Chinese, Vietnamese, Filipino/a children, and families. All program staff and researchers were also from immigrant and diasporic backgrounds. Questioning both the narrow outcomes that often define learning in schools and the tendency to focus on individual learning within the growing Maker Movement (Vossoughi et al., 2016), TAP privileged the relational dimensions of learning and worked to ground scientific and artistic practices in the developmentally rich contexts of play and everyday activity. Each program session began with a collective circle time that introduced the day’s activity and served as a space for community building, followed by participants working in pairs or ensembles on their projects. Over a three-year period, we worked collaboratively with Meg Escudé (program director) to develop a large corpus of ethnographic information, including 70 hours of video recordings, 30 extensive fieldnotes, and interviews with 15 focal participants.

The analysis for this paper focused on data that offered rich information on embodied assistance within TAP, and led us to develop three case studies of the phenomenon of embodied pathways across distinct timescales. Drawing from interpretive and interactional methodologies, a number of assumptions and goals informed our analytic approach and selection of the cases. First, analysis involves interpretive work attuned to the meanings that matter to participants as they engage in social action, themselves always shifting and poly-vocal (Erickson, 1986). These meanings
emerge explicitly and implicitly, through the texts and subtexts of embodied action (O’Loughlin, 1998). Attending to these layers of meaning involves gleaning information from within the scene of interest about how participants themselves are reading and responding to one another’s actions (Danish & Eneyed, in press), exploring multiple interpretations of the interaction, and treating the reader as a co-analyst of the data presented.

Second, interaction analysis is concerned with the ways people, in interaction, create environments for one another (McDermott & Raley, 2011). Analysts “move through transcripts turn by turn, seeking to see what one turn sets up for a subsequent turn and what those subsequent turns do with prior turns” (Hall & Stevens, 2015, p. 79). Using the aforementioned concept of substrates (Goodwin, 2013), our analytic lens prioritizes the ways conditions for interaction are continuously formed and renewed in ways that shape what happens next, as distinct from predictive models that may gloss over the situated contingencies of human interaction across cases. Interaction analysis has typically privileged micro-analysis of “hot spots” in the data (Jordan & Henderson, 1995), with a smaller number of studies looking at salient interactions as embedded in how individual or collective trajectories unfold (e.g. Ma & Munter, 2014; Vossoughi, 2014). Based on a theoretical commitment to the contextual and contingent qualities of human activity, as well as the labor-intensivity of interaction analysis, this approach has less frequently compared and connected “non-contiguous” events (Hall & Stevens, 2015) or studied learning over longer stretches of time. While our first two cases look closely at salient interactions to help establish and explicate the contours of embodied pathways, our third case mobilizes interaction analysis to trace longer trajectories of participation.

Natural History of Inquiry

We began our analysis by building a repertoire of the forms of embodied assistance present within TAP and working to understand the pedagogical and ethical values expressed therein. We pursued this goal through the micro-ethnographic tracing of five children’s trajectories within the program (Tania, Stefanie, Arthur, Aiden, and Zada).\(^1\) We intentionally selected children whose trajectories spanned distinct time-scales of participation in TAP, from 6 months to 3 years. Each member of our research team focused on one child, marking every time they appeared in the ethnographic record and the kinds of embodied assistance they received, participated in, or offered others. This process led us to develop a coding scheme of “embodied movements” that, once refined, was used to code the video recordings in which our five focal students appeared using StudioCode:

\(^1\)All student names are pseudonyms.
Codes such as *You do one part, I do the other* were developed to characterize moments when the educator and student each took on a portion of the task. Codes such as *I suggest something, you follow* and *I suggest something, you decide to do something else* were developed to sensitize ourselves to lines of contrast and discrepant cases. This process provided a “full range of variation in the organization of interaction,” and oriented us, analytically, to the “typicality and atypicality of the event types” (Erickson, 2012, p. 1463). Attuning to typicality/atypicality allowed us to see, for example, how the initiation of embodied assistance within Tania’s trajectory shifted from others using embodied movements to organize learning for her, to Tania enacting similar movements to support her peers (Case 3). Though we were particularly concerned with the ways “individual contributions were coordinated with each other during the activity” (Matusov, 1996, p. 27), we maintained a focus on pedagogy by defining the “I” as the person who was organizing learning in the moment, be they an adult, young adult, or child (Espinoza, 2011). A majority of the movements depicted in Figure 1 emerged one-on-one or in small groups during TAP workshop time, though some involved large group activity (such as *We observe something together and try and figure it out*).

As is often the case, these qualitative codes provided structural blueprints of what the interactions looked like, while our analysis continuously revealed their contextual nuances (Rogoff et al., 2016; Talero, 2008). For example, we coded a number of instances as *I narrate while doing the task*, a movement that can serve to make one’s

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2See Appendix 1 for a version of the coding scheme that includes definitions of each movement. Throughout the remainder of the article, reference to these codes will appear in (italics) within parentheses to support the reader in seeing how tracing these movements over time supported our analyses.
thinking visible, inviting others into a shared conceptual project (Hutchins & Nomura, 2011). Within real-time activity, however, these instances involve their own subtleties (an adult or child could be narrating the task, this narration could be explicit or implicit, both participants could be doing the task while one narrates, etc.). The contextual specificity of these movements is important to understand how they emerge and are accomplished—a central focus of this paper.

We navigated the tension between the inevitable generalizing that coding demands and the contextual specificity of embodied assistance through a number of decisions. First, we shifted from referring to this family of codes as “embodied configurations” (a snapshot view) to naming them as “embodied movements” (a more filmic view that conveys a sense of process while retaining a description of their structural organization). Second, mindful of the affordances and limitations of coding software, we wrote play-by-play accounts of each interaction within which the child appeared in a separate analytic memo, creating the space to engage in more extensive interaction analysis. Pieced together, these analytic memos offered a narrative account of each child’s trajectory over time. Third, we met weekly to discuss the coding process for each child, with each team member surfacing moments of embodied assistance that they were unsure how to code. These discussions helped us clarify the definition of each code, ensure greater consistency in their application, and use the analytic memos to calibrate between marking the presence of particular codes and analyzing each instance as embedded in the evolving substrates within each students’ trajectory.

A few months into our analysis, we began to notice embodied movements that were qualitatively unique. This was first seen in Stefanie’s trajectory: Stefanie and Shirin (lead researcher and co-educator) were coordinating their movements to unscrew the cover of an answering machine during a tool take-apart activity. We had already observed the ways children often pulled their hands away from a tool or material when an adult’s hands entered their work-space, particularly early on in their trajectory (my hands enter, yours pull away). We interpreted this trend as tied to children’s attribution of power to the educator, and a possible remnant of experiences when adults do things for—rather than with—children. In this particular instance, Shirin noticed Stefanie pulling her hands away from the screwdriver and explicitly invited her to “put your hands back on” while Shirin unscrewed in order for Stefanie to get a feel for how the tool worked (your hands pull away, I tell you to stay connected). Later in the interaction, Stefanie placed her hands on the tool alongside Shirin’s without explicit direction (Your hands enter to work together). One week later when the two were on a field trip at a local pinball museum, Shirin placed her hand on the pinball machine launcher to show Stefanie how it worked and Stefanie placed her hand on top of Shirin’s without any explicit prompting (Your hands enter to work together). This renewal of embodied movements over time indicated to us that an important form of learning was happening and that the lifespans of the movements depicted in Figure 1 were embedded in relational histories. We had yet to
conceptualize the notion of embodied pathways but expanded our coding scheme to account for this phenomenon if and when it happened (see bottom right of Figure 1). We also began to use the notion of “choreography” to name explicit forms of guidance around embodied movements (such as “put your hands back on”) and inquire into the ways such movements were taken up by students more organically over time.

We pursued this question through a deeper analysis of a resonant interaction between Stefanie, Shauna (another child) and Meg during an impromptu lesson on hot-gluing (Case 1, below). Our codes supported us to mark the different forms of embodied assistance as they were introduced within the interaction and to recognize how they were being revisited and utilized by participants within the span of a five-minute exchange. In other words, we began to see how the various movements named in Figure 1 traveled through an interaction, accruing particular meanings and evolving based on the needs and responses of participants in the moment (Lemke, 2013). The idea of embodied pathways grew from these observations and led us to recognize other cases when such pathways were at play. Within Arthur’s trajectory (Case 2), we saw the take-up of embodied movements across 1 week; for Tania (Case 3), we found the appropriation of key movements developing across multiple years. Based on this temporal variation, we conceptualize embodied pathways not only as the moment-to-moment renewal and reshaping of particular forms of embodied assistance, but as ways of being and relating that can also be evidenced in children’s long-term trajectories. Though the detailed analysis of this phenomenon presented within the three cases supports future inquiries into the prevalence and predictability of such interactions, our goal in this paper is to establish the construct of embodied pathways across distinct time scales. Tania’s case (Case 3) also offers a method for pairing frequencies and interaction analysis to connect “non-contiguous” events (Hall & Stevens, 2015).

A challenge in presenting the cases lies in translating visual meanings from the video record to written form. We address this tension by pairing written narratives with visual portraits of salient interactional moments. We utilized screenshots drawn from the video to render specific embodied movements and worked with Walter Kitundu (an artist who also taught in TAP) to create visual portraits from the screenshots. We stylized the images to accentuate relevant movements of the hand or body, to ensure children’s anonymity, and to support a reading of acts of embodied guidance or co-thinking as aesthetic moments, “made for living persons, by living persons” (Greene, 2001).

FINDINGS

Before presenting the cases, we summarize the findings this analytic process led us to develop. First, embodied movements or forms of assistance (Figure 1) hold and generate particular pedagogical and ethical meanings. I shift my body or the materials...
so that you can see better is a subtle but significant action that can convey a sense of care, co-presence, and intellectual respect; in dynamic tandem with other embodied movements, such actions can work to ensure that students are not experiencing the activity from the outside. Where relevant, our analysis highlights the ways children were reading and responding to the ethical meanings of embodied movements—what we see as an undertheorized dimension of embodied cognition. This attention to children’s readings of others’ actions amplifies the perceptive work involved in building from the resources or material provided by prior actions (Goodwin, 2013- ). Second, our three cases illustrate that the experience of such value-laden movements can create embodied pathways: courses of possible action that are revisited and appropriated in the immediate and distal future. We view the notion of a pathway as useful for conceptualizing how embodied movements (present activity that doubles as a resource for future interactional work) may be experienced on the part of the child—as particular routes through time and space with proximal others, tools, and materials. Thus, pathways are not simply metaphorical, they are materially experienced interactional trails—akin to the ways a gesture moves through the air, leaving a semiotic trace.

Our interest in understanding how these movements contribute, over time, to the creation of settings also led us to foreground when and how they are explicitly named or choreographed. Important here is that particular embodied movements may be experienced in a heightened way when attention is called to their value or significance. When educators supported a child to help another child, embodied movements were sometimes explicitly narrated in ways that conveyed particular values (e.g. “could you tell him what you are doing while you do it?”), and seeded possibilities for future enactments. Whereas a person may first encounter an embodied movement as an example of a way of being and relating in the space, they may later sense the need to make use of these movements as resources for opening up particular kinds of experience with and for others (Engeström, 1990).

Case 1: Stefanie, Shauna & Meg

Our first case illustrates the ways embodied movements created courses of possible action for others to ply and re-create within a five-minute interaction between Meg, Stefanie, Shauna. Stefanie (7-years old) identified as Mexican, Shauna (7-years old) as Black and Northern European, and Meg as Latinx and White. Our description of the interaction highlights the specific forms of embodied assistance Meg offered Stefanie, and how these movements were promptly taken up by Stefanie to organize learning for Shauna. Illustrating how particular embodied movements traveled through the interaction over time (what we are calling pathways), we also draw on information visible in the scene to interpret how participants were reading and responding to their pedagogical and ethical implications.
The exchange occurred on Stefanie’s fifth day in TAP, though she had a longer friendship with Shauna through the Boys and Girls Club and their elementary school. During a pinball machine-building activity, Stefanie and Shauna decided to affix their two wooden boards to make one “double machine.” Initial moments of building involved their frequent use of the word “we” (“What if we …” “How about we …”). These relational histories help contextualize the ways Stefanie and Shauna were able to move in and out of each other’s actions (Goodwin, 2018). Stefanie and Shauna moved to the hot-glue station with their double machine, where Meg began helping them glue down wooden alphabet blocks, creating touch-points and obstacles for the pinball. Shauna was seated between Stefanie (on her right) and Meg (on her left).

As they sat down, Shauna announced, “I’m not gonna do the hot glue.” Referring to the wooden blocks, Meg then asked both girls, “Where do you want the first one?” Stefanie responded by placing a block on the board (without glue yet). Meg’s right hand then moved towards the block with the hot glue gun while Stefanie held the block with her right hand (Figure 2). Meg did not tell Stefanie to bring the block forward. Stefanie was holding it, Meg was holding the glue gun, and their hands came together to complete the task, a movement we coded as You do one part, I do the other. Meg then said “not too close to the edge” (I narrate while doing the task):

As discussed above, Stefanie’s history in the setting included key turning points when educators explicitly encouraged her to keep her hand(s) connected to the tools or materials as they demonstrated a task (such as placing her hands on the screwdriver that Shirin was using to take out screws). We view such relational histories as crucial for illuminating how the seemingly choreographed joint accomplishment of the task (Stefanie and Meg each doing their part to apply hot glue to the block (Figure 2)) came to be.
Stefanie then turned to consult with Shauna about where to place the block. Shauna gestured towards the top right corner of the board, where Stefanie set the block. Meg intimated that Shauna might try gluing (holding the handle of the glue gun in her direction) and Shauna shook her head. Meg then asked Stefanie if she wanted to “do the glue gun part too.” Stefanie’s hand reached over to grab the glue gun as Shauna observed (We do together, then you do on your own):

FIGURE 3  We do together, then you do on your own.

Stefanie applied the glue and placed the block down on the board. She then said, “Are you nervous [Shauna]?” A few seconds later Meg said: “It’s ok to be nervous when you are first learning something. And then when you get good at it you won’t be nervous anymore.” Stefanie then picked up a block, pointed to where it could go on the board and said “see,” encouraging Shauna to hold the block while Meg applied the glue, as she had just done (in Figure 2). Stefanie held the block out in front of Shauna and shook it a little:

FIGURE 4  Stephanie encouraging Shauna to hold the block while Meg glued.
Shauna seemed to be deliberating. She then took the block from Stefanie’s hand, while taking Stefanie’s hand off the block with her right hand.

We pause here to explicate the first example of embodied pathways. Meg supported Stefanie to learn to apply the hot glue by 1) applying the glue herself while Stefanie held the block, and narrating what she was doing; and 2) handing Stefanie the glue gun so she could do both parts of the task. After expressing a palpable concern for Shauna’s nervousness, Stefanie picked up the block and encouraged Shauna to engage in the first movement: holding it while Meg applied the glue. In line with the notion of substrates (Goodwin, 2013), Meg and Stefanie’s initial *You do one part, I do the other* (Figure 2) became a resource for Stefanie to encourage Shauna to engage in a similar movement by suggesting that she holds the block while Meg glued (Figure 4). The notion of a pathway also helps capture how Stefanie returned to the first movement (holding the block) rather than encouraging Shauna to do both parts of the task, as she had just done. This decision may reflect how Stefanie was deducing the pedagogical wisdom involved in doing one part of the task first, particularly in light of Shauna’s expressed nervousness.

Though Shauna took the block, her subsequent response required some additional calibration on the part of Meg and Stefanie:

Shauna (block in hand) pulled back in hesitation and shook her head. Meg then said, “where do you want the block to go?” Shauna showed Meg the side that she wanted the glue on. Meg placed the block on the ground in front of Shauna and put the glue on the side she had selected:

FIGURE 5 Meg creating a low-stakes entry-point for Shauna.
She then asked Shauna if she wanted to place it on the board. Shauna shook her head. Stefanie picked up the block and held it in front of Shauna. “Come on Shauna,” she added. Shauna took the block from Stefanie’s hand and placed it on the board. Stefanie then smiled and gently patted Shauna on the back.

This exchange illustrates a second key idea: though Stefanie sought to create a pathway for Shauna that was similar to the one she had just experienced with Meg, Shauna pushed back in hesitation. Meg immediately created an alternative route, placing the block on the ground and sustaining joint activity by asking Shauna which side to glue. Stefanie pushed further and encouraged Shauna to hold and place the block, which she ultimately did. Stefanie expressed pride in her friend’s bravery, and continued with her own hot gluing:

Stefanie took the hot glue gun from Meg and started to glue the next piece while Shauna observed closely. Without prompting, Shauna then handed Meg another block to glue. She pointed at the side that she wanted facing up and Meg began to glue the opposite side. She handed it to Shauna who took the block (without hesitation) and placed it on the board:

Here, both Stefanie and Shauna re-traced the pathways they had, respectively, experienced with some newfound surety. Stefanie did both parts of the task again, followed by Shauna handing Meg a block to glue and pointing to the side she wanted facing up. The fact that Shauna then took the block and placed it on the board without her prior hesitation suggests that rather than putting undue
pressure on her friend, Stefanie may have appropriately assessed the threshold Shauna was about to cross. Thus, Stefanie’s decision to encourage Shauna to hold the block also became a resource—a course of possible action rooted in the immediate interactional history—for Meg’s decision to hand Shauna the block a few moments later (Figure 6). This reading of events reminds us that embodied pathways are not simply initiated by adults and picked up by children. Noticing the ways adults re-trace children’s pathways offers a more democratized view of the kinds of pedagogical and ethical actions documented here.

At this point, Stefanie began pressing Shauna to try the second movement within her own pathway: holding the glue gun and applying the glue to the block. This time Shauna clearly expressed her boundary, refusing to hold the glue gun itself. Here we see a recurrence of the two big ideas discussed above: Stefanie drew from her experience of different forms of embodied assistance to organize learning for Shauna, and Shauna responded in ways that required additional pedagogical and ethical deliberation:

Stefanie held the glue gun towards Shauna and said, “Want to do it Shauna?” Shauna said “no” and leaned away. Meg said, “It’s ok.” Stefanie suggested that she just “hold the handle.” Shauna shook her head “no.” Stefanie turned to gluing another block herself.

Whereas Stefanie had previously intervened to push Shauna when Meg was ready to pull back, here Meg intervened to pull back when Stefanie was ready to push. Stefanie responded by calibrating her invitation (suggesting that Shauna just “hold the handle”) similar to the way Meg had found a lower-stakes entry-point by placing the block on the ground (Figure 5). Though Shauna ultimately refused to “just hold the handle”, and may have experienced Stefanie’s assistance as a form of pressure, we see in Stefanie’s action a resonant pedagogical attempt to create a different entry point into the task. This exchange therefore suggests that people may recognize and draw from the underlying values of prior movements to support others’ learning, though the new forms may look distinct and require additional ethical calibration.

Looking across the interaction as a whole, we see that embodied movements have multi-vectored and often unanticipated temporal pathways; experiencing these forms of assistance not only shapes the next moment but also how events unfold further downstream (Erickson, 2004). Stefanie moved from doing part of the task, to trying both parts of the task, to more assuredly doing both parts of the task without Meg’s prompting. Here, we see that when the person who participated in the initial movement re-traces a given pathway herself, a certain kind of learning may be occurring: the gradual growth of competence or skill. Stefanie then drew
on her experience doing both parts of the task to encourage Shauna to hold the handle. When the person who experienced a given movement organizes a similar movement for another person, a different kind of learning may be occurring: the borrowing or plying of specific forms of assistance across participants, as well as the distribution of know-how and value within the setting—in this case, both Stefanie’s knowledge of the different components of the task, and her commitment to encouraging her friend to share in the learning. We therefore see the embodied movement in Figure 3 as a reservoir for different kinds of future action.

Movements enacted early in the exchange (Figures 2, 3, and 5) were also revisited and retraced a number of times. We ponder how such “interactional firsts” may create grounds for what’s to come and return to the pedagogical implications of this observation in our final discussion. Lastly, this case illustrates how decisions to intervene pedagogically are tied to ethical interpretations and deliberations. Consider how else the interaction could have gone: Shauna’s expressed nervousness might have led Stefanie and Meg to pass the tool back and forth between the two of them, as a way to respect her hesitation. Though Shauna’s observations would have constituted a form of learning, this approach may have risked Shauna feeling outside the thinking and making unfolding before her, potentially excluded from decisions regarding their project (note that Stefanie consistently sought her input on where to place the blocks), and overlooked the opportunity Stefanie saw for Shauna to overcome her fear. For the first time within her recorded trajectory within TAP, Stefanie was also able to step into the shoes of a facilitator in a powerful way. This involved her keen attention to the ways Meg was helping her, and her decision to intervene in the unfolding of events by utilizing those forms of assistance to organize learning with and for Shauna. We are particularly interested in what it means for a person to sense when such opportunities for ethical action arise, a question we carry into the ensuing cases.

Case 2: Arthur and Robert

Our second case illustrates how Meg’s explicit choreography of embodied movements during a marble machines activity created resources for Arthur and Robert to enact more ethical forms of collaboration with one another—later that day, and in the following week. Both Chinese American boys, Arthur (7-years old) and Robert (9-years old) might have been drawn to working together due to their shared identities. However, those shared backgrounds alone were not responsible for the bond they ultimately formed, as seen in the

4Marble machines involve affixing various materials (with tape or wooden pegs) to a wooden pegboard, creating a track on which a marble can travel. Due to the number of boards available, and to the ethic of collaboration valued within the program, children were invited to work in pairs to construct their machines.
sustaining of their partnership beyond marble machines (the first documented instance of working together) into future TAP activities. As detailed below, their interactions during marble machines involved conflicts around unequal participation rights that the two had to resolve in order to form a “we,” a relation of mutual attunement that is qualitatively distinct from two “I’s” engaging in the same work-space (Espinoza, 2011; Shotter, 2015). By choreographing movements that redirected Arthur and Robert’s activity toward the formation of a “we,” we illustrate how Meg’s efforts to resolve conflict in the moment seeded future moments of learning. In line with the notion that dignity is always at stake within educational activity (Espinoza & Vossoughi, 2014), we show how across 2 days (1 week apart) embodied movements became tools that participants could appropriate to re-organize moments when power dynamics threatened to position someone on the outside of meaningful participation.

**Day 1**
The first moment of conflict emerged when Arthur and Robert had different ideas for which materials to use on their marble machine. At this point, they had already made a ramp halfway down the board:

![Figure 7](image)

**FIGURE 7** Robert and Arthur’s conflicting ideas for the marble machine.

Arthur (to the right when facing the board) picked up a slim metal pipe from the ground and proceeded to tape it to the board. Robert (to Arthur’s left) then said, “No! You got to do this first!” Grabbing the end of the metal pipe opposite Arthur’s hand, Robert held up a wooden platform in front of Arthur’s chest (Figure 7). Robert pushed the metal pipe away and positioned the wooden platform against the board and said, “Wait! Wait! Yes!” Arthur replied, “No! I’m trying to … ” as he continued holding up the metal pipe in front of Robert. Meg
then intervened. Crouching down behind them, she said, “Let’s make a decision together. Let’s hear both ideas.”

Robert’s exercise of relative power in this moment was likely shaped by differences in age and experience in the program, as Arthur was both younger and newer to TAP. In this context, Robert’s response to Arthur’s attempt to attach the metal pipe—pushing it away in favor of the material he had chosen—risked communicating that Arthur’s contribution was unwanted or less valuable. Arthur’s resistance to this positioning (insisting on keeping the metal pipe in Robert’s view and explaining what he had in mind) suggests that he was reading such potential diminishment in Robert’s actions. Rommetveit (1991) writes, “to deprive one’s conversation partner of epistemic co-responsibility is thus to disregard and exclude [their] concern from a shared directed openness toward future possibilities” (p. 26). Observing the forms of epistemic exclusion emerging between Arthur and Robert, Meg intervened by explicitly naming a movement that could open up space for both participants’ ideas to be heard: “Let’s make a decision together. Let’s hear both ideas” (You and I disagree, we negotiate). Meg’s suggestion also encouraged them to slow down and take time to understand each other’s perspectives, rather than feeling like their individual voices and gestures must override the other’s in order to be acknowledged.

In response, Arthur and Robert made budding attempts to re-organize their interaction. Specifically, Arthur tried to negotiate by melding their two ideas while Robert made new efforts to include Arthur in the process of testing their machine:

Arthur held the metal pipe on top of the wooden platform, piece of tape in his right hand, and suggested taping them together. Robert then dropped the wooden piece he had previously insisted on using. He pointed at the metal pipe and said, “Wait, hold that, Arthur.” Arthur continued trying to tape down the metal pipe while Robert picked up a marble from the ground and ran it through the machine, saying, “I want to try it out a bit first.”

We interpret Arthur’s efforts to incorporate both the wooden platform and the metal pipe as an embodied attempt (using actions alongside words) to enact Meg’s “let’s hear both ideas.” Meanwhile, Robert assigned Arthur the role of holding the pipe (“hold that”) and himself the role of running the marble (“I want to try it out …”), a budding attempt at You do one part, I do the other and I narrate while doing. While Robert did not enact the same movement Meg had previously named (“Let’s hear both ideas”), the movements he did enact reflected similar underlying values: to include another’s ideas, and to make visible one’s own thinking. Though Robert might have simply wanted to move forward with the project, he knew moving forward needed to involve Arthur somehow.
Robert’s emergent shift co-existed with moves that continued to sideline Arthur:


Though Robert worded his idea as a suggestion (“How ‘bout …”), his attempt to adjust the position of the metal pipe without waiting for Arthur’s response reflects his exercise of decision-making rights not yet afforded to Arthur within the exchange. Arthur resisted again, saying “I know, I know,” his hand following the pipe as it left his line of sight. Meg’s second intervention encouraged Robert to slow down and share his thinking.

Though they initially exchanged no words after Meg’s “tell him what you’re going to do,” Robert moved the pipe back within Arthur’s reach, while Arthur vocalized a solution that they could try together (“We can take this off!”—referring to the tape on the pipe). Then, Arthur put one hand on the bottom of the metal pipe as he watched Robert run the marble through the pathway they had constructed (Figure 8). Their bodies seemed to be moving toward a tenuous formation of a “we” that was not present before. Consider the contrast between the prior interaction from Figures 7 and 8, below:

![Figure 8](image)

**FIGURE 8** You do one part, I do the other.

For the first time in this activity, Arthur and Robert coordinated their bodies such that they were doing different parts of the same task (You do one part, I do another), testing the marble’s trajectory. Though Robert’s and Arthur’s attempts
to attune to one another on this first day of building did not yet afford Arthur
equal influence on their decision-making, they represent growing efforts to work
with the pedagogical and ethical values introduced by Meg.

Day 2
One week later, Arthur and Robert chose to partner up again, suggesting they
sustained some positive rapport. When the two experienced a conflict nearly
identical to the one they had encountered before, they responded in ways that
carried a strong trace of the movements Meg had choreographed in their
previous interaction, this time without Meg’s direct mediation:

When Arthur held the wooden track up against the board, Robert held out an arm
to stop him, “No, no, don’t do that.” Arthur put the platform down and asked,
“Does the track go like that?” Robert replied, “just do this!” He held something up
against the board as Arthur followed along with his gaze. Arthur responded,
“Ohhh, like that.” Arthur looked at an octagonal structure made of wooden tracks
taped together, then bounced up and down as he said, “Oh wait! Oh wait!” He held
the object against the board in two different positions saying, “See? See?”

Finding himself again in a situation where Robert was at risk of making
a decision without his full participation, Arthur prompted Robert to verbally
explain what he was doing (“Does the track go like that?”) while physically
showing Arthur where the track would go (I narrate while doing the task).
Considering the strong similarities between this moment and the conflict
on Day 1, and the qualitative differences in the way the interaction unfolded,
we consider how Arthur’s prior witnessing of Meg’s (“Tell him [Arthur]
what you’re going to do”) became a resource for encouraging Robert to
make his thinking visible, allowing Arthur to share his idea in return (“See?
See?”). Although Arthur’s attempts did not yet lead to co-decision-making
(Robert’s “just do this” continued to reflect unequal participation rights), his
efforts to redirect their interaction and Robert’s willingness to go along
evidence how prior experiences with embodied movements—in this case
those that were explicitly choreographed by Meg—create substrates for
building more generative relations further downstream.

By the end of Day 2, Arthur and Robert further coordinated their embodied
actions as they explained to Shirin how they had constructed the octagonal
tunnel structure Arthur had excitedly posited (above). The ease with which
they coauthored the explanation of their machine’s mechanics exemplifies
the sense of a “we” they had developed. In response to Shirin asking “How did
you guys develop this part?” Arthur and Robert used the language of “we,”
and coauthored their response (You do one part, I do another). In contrast to
the earlier moment when Robert was the first to narrate his idea, this time Arthur led the narration.

Picking up two wooden tracks and holding them side by side, Arthur said, “We put it like this and then …” He and Robert finished the sentence almost in unison, “… we put two more on top.” Shirin then asked, “Why did you make it? What’s it for?” Robert replied, “Because we want to make a tunnel!” while Arthur immediately raised his index finger to trace the pathway a marble would take through the tunnel:

![Arthur and Robert co-authoring their description of the tunnel.](image)

Robert’s and Arthur’s coordination of their words, actions, and gestures (Robert explaining the function of the tunnel [“we want to make a tunnel!”] while Arthur gestured to the part of the machine in question [Figure 9]) offers evidence that they were “inhabit[ing] a shared conceptual world” (Hutchins & Nomura, 2011, p. 29). Had Meg initially responded by making Arthur and Robert work alone, or even by telling them to “work together” without offering specific interactional tools, Arthur and Robert may have missed opportunities to deepen their collaboration, their approach to building the marble machine itself, and the intellectual and relational practices required in both. In addition to tracing these shifts to Meg’s explicit interventions, Dewey’s argument that “‘we’ and ‘our’ exist only when the consequences of combined action are perceived and become an object of desire and effort” (as cited in O’Loughlin, 1998, p. 296) suggests that the felt experience of working as a “we” may have led Arthur and Robert to organize similar relations in future moments. Their collaboration was further reflected in the creation of a machine that was ultimately different from either of their individual ideas. Here the ethical valence of embodied pathways can be seen in the subtle ways Arthur and Robert were
learning to do the relational work of repair (Booker & Goldman, 2016), attuning to one another’s ideas and addressing tensions resulting from differential power.

Case 3: Tania

Our final case builds on the insights developed thus far to illustrate the role of embodied pathways in shaping one child’s trajectory over a 3-year period. We analyze how Tania appropriated particular forms of assistance to organize learning with and for her peers by first examining the range and frequency of embodied movements she experienced and came to initiate across her first year in TAP. Pairing these frequencies with interaction analysis, we then zoom in on two particular moments: an interaction with Aiden that represents the first time Tania was explicitly positioned as a peer facilitator in TAP, and a subsequent interaction with Aniyah that shows how Tania learned to adjust her assistance by attuning to the specific needs of her peers. We then look ahead to Tania’s third year in the program. Looking closely at the forms of assistance she offered a younger student (Zada), we illustrate the role of embodied movements and their underlying values in Tania’s long-term development as a highly skilled peer facilitator.

Tania (6-years old in 2012) identified as Black and Mexican, and was a regular participant in TAP from 2012–2019. Currently 13, she now works as a young adult educator in the program. During Tania’s first year in TAP, we documented 41 interactions through which she experienced various embodied movements, depicted below in Figure 10. As evidenced by the changing color across the timeline from lighter to darker hues, we observed a visible shift from adult-initiated movements toward movements initiated by Tania and her peers. Notice, for example, how movements that were organized by others early on in Tania’s trajectory (such as You do one part, and I do the other on 9/24/12 and 10/29/12, or I narrate while doing on 10/29/12) appear later in her trajectory as either utilized by Tania to help a peer, or mutually initiated by Tania and a peer (3/4/13–4/15/13).

Though adult support did not completely fall away (see 4/1/13), tracing specific forms of embodied assistance across her first year (Figure 10) evidences Tania’s shift in role from receiving help to helping other children, and the role of embodiment in supporting this shift. To further substantiate this finding, we focus in on two key interactions during Tania’s first year, showing how the explicit choreography of embodied movements helped lay the ethical groundwork for students to sense when and how they could be fruitfully enacted.

5Though a majority of these early movements were initiated by adults, we also want to highlight the role of the peer-initiated movements Tania experienced early in her trajectory. The instances highlighted on days 11/5/12 and 2/25/13 were led by Felix, who was friends with Tania through the Boys and Girls club.
FIGURE 10  Tania year 1.
**Tania, Aiden, and May**

As depicted in Figure 10, 3/4/13 involved a high density of embodied movements and served as a turning point for Tania. Before this date, none of the documented instances of embodied assistance were initiated by Tania, while after this date there were 7 documented instances of Tania-initiated embodied assistance across 4 days. Tania was also overtly positioned as a peer facilitator for the first time on this day. Students were making scribbling machines and Tania was gaining familiarity with motors and circuitry, having explored many of the scribbling machine prototypes in the space. May, a relatively new adult educator in TAP, noticed and leveraged Tania’s growing expertise with motors to position her as a source of support for her peers. When Aiden (7-years old) asked May for help, she responded, “Tania can you help Aiden, can you show Aiden how to make the motor work with the rubber band? And where it needs to touch?” Importantly, May did not just ask Tania to help Aiden or to “fix” his motor, but to specifically show him how to put the motor together using the rubber band (which held the wires in place on the battery). This framing (“can you show Aiden how …”) may have helped orient Tania to the distinction between doing for and doing with—a pedagogical value often discussed among TAP educators. Tania accepted May’s invitation:

Tania took the battery from Aiden and removed the rubber band. She then said, “you have to put the wire on these” and pointed to the ends of the battery. Aiden, watching Tania’s actions, leaned on his hand and responded, “yes … that’s what I was doing.” Tania repeated, “yes,” while she put the rubber band on the battery.

In her first attempts to help Aiden, Tania enacted two movements—I narrate while doing and I do while you observe. Aiden’s response (“that’s what I was doing”) combined with a skeptical lean on his hand suggests that the help Tania was providing may not have been the help he needed. Consider the interaction that followed:

Aiden picked up the cone he was using for his machine and said, “something has to be able to hit—” May intervened, “yeah, but Tania’s just showing you the motor right now.” Aiden quietly responded, “I know” and set down the cone.

Aiden attempted to refocus the interaction on his vision for the machine, while May redirected attention to the motor, perhaps in an effort to support Tania’s learning as a facilitator. This interpretation is further supported by May’s subsequent efforts to guide Tania in effectively narrating while doing, posing

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*A tinkering activity in which students learned about circuitry, balance, symmetry, vibration, and motion through the building of machines with motors, various everyday materials, and markers as “feet” that drew compelling designs on butcher paper.*
questions such as, “can you talk about where the wires need to touch?” Though Tania had experienced the movements May was highlighting as a learner through previous encounters (Figure 10), May explicitly supported her to make her cognitive strategies visible for Aiden—a kind of lamination (Goodwin, 2013) or layering of assistance.

Tania then encountered an issue in getting the motor to work. She was having difficulty getting the rubber band to secure the wires on the ends of the battery, as it kept sliding off or not extending enough to hold the wires in place:

![Image of Tania working on a motor](image)

**FIGURE 11** You do one part, I do the other.

As Tania continued to manipulate the wires, Aiden watched while also shifting his gaze and observing other people in the room. Tania then brought the motor back towards Aiden, perhaps signaling to him that she was having difficulty. Aiden stood up, brought his hands in and tried to lift the rubber band for her so she could place the wires on the battery. While doing this, he said, “that’s what I needed, I needed someone … ” and began to focus intently on the motor:

This excerpt marks the emergence of a new movement within the interaction—*you do one part while I do the other*—which was mutually initiated by Tania and Aiden. Tania implicitly invited Aiden to help her by moving the motor directly in front of him (Figure 11), and Aiden took up this invitation by bringing his hands in to help Tania situate the battery (*Your hands enter to work together*). Aiden’s “that’s what I needed” indicates he likely knew how to put the rubber band on, he just needed an extra hand to do it. In light of the disconnect between the kind of support Tania initially offered and the support Aiden needed, we note that it wasn’t until Tania experienced the problem herself that Aiden became more involved in the problem-
solving, forming a momentary “we” similar to the interactions between Arthur and Robert. Through you do one part, I do the other, Tania and Aiden collaborated in the troubleshooting process through an authentic need, rather than through the narrating moves Tania had enacted earlier. This is not to say that I narrate while doing the task is not a productive movement; rather, all embodied movements find meaning and value within the situated intellectual and relational milieu of the moment. As we turn to next, such nuanced pedagogical perception and action are themselves part of the learning that emerged for Tania over time.

**Tania and Aniyah**
The interaction that follows represents the first documented instance when Tania helped a peer without prompting by an adult. Two weeks after the interaction with Aiden around motors, students were building Nature Bots. Tania was working on her project when Aniyah approached her and asked, “can you help me? ... I need help putting on the feathers.” Aniyah’s request signals that other children in the setting were beginning to orient toward Tania as a source of support. Similar to the ways she worked with Aiden, there were multiple moments within the subsequent interaction with Aniyah when Tania enacted the movement I narrate while doing; however, this narration took on a new form through clarifying questions and the re-voicing of decisions. When Tania picked up a pink feather and set it on Aniyah’s bot, she asked, “pink hair like this?” Here we see a principled modification (Goodwin, 2013) of the prior movements Tania enacted with Aiden, with particular attention to the ways she made efforts to first clarify and prioritize Aniyah’s goals.

Tania also utilized movements she had experienced with adult educators such as I suggest something (Figure 10, 10/22/12) and you and I look at something to try to figure it out (Figure 10, 11/5/12) while adapting these movements to attune to Aniyah’s needs. Consider how Tania verified and responded to Aniyah’s decision about how to keep the feathers on the bot:

Tania, fiddling with a roll of tape, asked Aniyah, “but how are we gonna keep it?” Aniyah stated matter-of-factly, “glue,” to which Tania quickly replied, “you wanna glue it?” Tania then set the tape down and walked with Aniyah to find some glue.

By asking “how are we gonna keep it?” and “you wanna glue it?” Tania ensured that decisions around Aniyah’s robot were made by Aniyah, while offering the support indexed by the term “we”—a combination of moves common among educators in the setting. Despite the fact that Tania seemed ready to use tape had

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7Similar to Scribble Machines, the Naturebots project involved building machines with motors this time with materials found in nature (twigs, feathers, branches, etc.).
Aniyah given the green light, Tania quickly let the tape go once Aniyah decided to use glue, and searched jointly with her to find what she needed. Toward the end of this day, Tania approached Meg and announced, “I’m helping people!”, demonstrating the value she placed on supporting her peers, and that these instances may have *felt like* a shift in role for Tania.

In so far as Tania’s consistent attunement to Aniyah’s goals signals a shift from the ways she had initially helped Aiden, embodied pathways may also function dialectically; movements that were experienced as less productive may be remembered as a conceptual resource for developing alternate action in the future—another way of seeing the structure-preserving and transformative qualities of substrates (Goodwin, 2013). Tania’s efforts to privilege Aniyah’s goals could have also stemmed from her interactions with educators who prioritized Tania’s goals while engaging in a joint effort on her projects. Indeed, our analysis of pedagogical practice across the data set identified *making efforts to understand children’s ideas/goals* as ubiquitous and routine (334 instances coded). In either case, Tania enacted movements that carried the trace of prior moments, making use of locally contextualized resources to organize learning with and for others. These interactions demonstrate the first time Tania employed specific movements that she would come to use with even greater skill 2 years later with Zada, a younger participant in the space.

**Tania and Zada**

In what follows, we describe how Tania (now 8-years old) took on the role of a facilitator with Zada (6-years old), utilizing a range of embodied movements she had previously experienced as a learner. Our analysis emphasizes the ethical subtleties of her pedagogical practice, and the ways Tania grew to employ a deeper quality and density of embodied movements over time.

Tania and Zada—both Black girls—had worked together on various projects in TAP and in the Boys and Girls Club, with Tania often taking on the role of someone older who was looking out for Zada. One month after Zada’s first day in TAP, students were working on making costumes for Halloween. During circle time, Meg asked students what advice they would offer others about costume-making. This setup further contextualizes Tania’s decision to support Zada later in the session:

Tania was sitting on the table and Zada was standing beside her as they sorted through fabric for Zada’s costume. Zada then asked Tania, “can you help me now?” Tania immediately let go of the fabric she was playing with, scooted off the table, and said “yeah.” Similar to the movement Tania utilized with Aniyah, Tania came around the table to Zada’s side and asked, “so what would you like to use?” Though Zada did not respond verbally, Tania found the measuring tape and pulled it out.
As Tania pulled out the tape, she said quietly to herself “so let’s find out how much you … ” and then turned to Zada and said, “c’mon! So let’s find out how much is your length” as she wrapped the tape around Zada’s waist. Zada held one end of the measuring tape as Tania simultaneously crouched low, looking closely at the measurement (Figure 12). Tania said “we want to go by your waist” (I narrate while doing the task) while Zada observed intently:

![Image](image_url)

**FIGURE 12** I narrate while doing the task.

Tania then stood up and put the measuring tape back on the table as Zada began to walk away. Tania caught up with Zada and said “remember, remember the number 27” (I do one part, you do the other).

Returning to the argument that social relations comprise a domain of learning unto themselves, we see that Tania was doing cognitive work on at least two levels: 1) figuring out what needed to happen next for the task to be accomplished, and 2) figuring out how to go about organizing that task in a way that was developmentally generative for Zada. Similar to Meg’s use of “let’s” with Arthur and Robert, Tania’s use of “let’s” throughout the interaction indicates a focus on meaningfully involving Zada in the process. The intentionality of this practice also becomes visible in the shift from Tania saying “So let’s find out how much you … ” to herself, to saying “C’mon! So let’s find out how much is your length” to Zada. The first “let’s” seemed to function as a way for Tania to organize her thinking (a kind of pedagogical rehearsal), while the second “let’s” turned her attention toward involving Zada in the task.

We also draw attention to the density and quality of pedagogical moves through which Tania worked to bring Zada into the whole activity of costume-making (Griffin & Cole, 1984): crouching down to work closer to Zada’s eye level, using “let’s,” re-voicing, and describing her actions to Zada. One can imagine Tania
measuring Zada’s waist while Zada waited but without feeling like she was fully in on the task. However, Zada kept her gaze fixed on the measuring tape and voluntarily brought her hands in to help accomplish the task, gaining an experience of what it felt like to take the measurement. Though Tania could have remembered the number herself, she also made efforts to share the cognitive task with Zada by saying “remember … remember the number 27” (moves present throughout her own first year in TAP (Figure 10), including May’s prior encouragement to make her thinking visible to Aiden). Similar to the ways Stefanie understood herself as responsible for Shauna’s learning, we argue that the ethics of this interaction live in the careful ways Tania treated her relative knowledge as a shared resource, and brought Zada into the practice as a legitimate participant (Lave & Wenger, 1991), a positioning we see as conveying a sense of Zada’s competence and worth.

After Zada and Tania gathered their materials, they began to work at the sewing station, with Zada sitting in the chair in front of the sewing machine. Earlier we stated that tracing embodied movements allowed us to see how they mediated and substantiated Tania’s development as an expert peer facilitator. Looking closely at this final interaction helps illuminate the values, forms of thinking, and skill that define such expertise. Shirin asked what they were working on and Tania responded, “now we are going to sew them together.” This “we” was evident in their embodied movements as well:

Tania, holding her own hands back, gave Zada a moment to touch the buttons and the machine while she observed (I observe as you try something). Tania’s hands then moved towards the sewing machine and she asked Zada, “Do you want me to choose it?” Tania pushed the button for pattern #1 with one finger and removed it. Zada responded “actually let’s do four” as she clicked the button on the sewing machine to get the pattern she wanted. Tania then placed her arm on the table alongside Zada’s:
With Zada’s setting of choice selected, Tania brought over the cloth pieces they had been working with. Figure 14 highlights how Tania placed the cloth on the sewing machine while Zada watched (I do the task, while you observe). Tania then quickly let go of the cloth to retrieve the second piece and Zada’s hands entered (on the right of Figure 14), mimicking the motion that Tania had just done, placing her hands on the white cloth and moving it gradually closer to the needle.

As Zada began to push the cloth forward she turned towards Tania and asked, “Now?” Tania did not verbally respond but Zada understood to push the pedal with her foot to start sewing. Both sets of their hands were touching the cloth with Tania’s hands closest to the needle as she guided the cloth through (We do the task together; My hands enter, yours stay.). As they got close to the end of the cloth Zada asked, “Do you want me to stop?” (referring to her foot on the sewing machine pedal).

Tania first observed Zada tinkering with the machine. This practice is reflective of our attention throughout the paper to the ways participants were reading one another’s embodied actions, and of the routine ways TAP educators noticed children’s thinking through the movements of their hands before intervening. Tania then carefully positioned her body so that she did not block Zada’s view (Figure 13), responded affirmatively when Zada asserted the pattern she wanted—“actually let’s do four”—and proceeded to coordinate and calibrate her actions with Zada’s as they sewed the cloth together, both their hands and eyes on the materials. In a more involved version of the You do one part, I do the other movement that first emerged in measuring Zada’s waist, Zada was working the foot pedal while Tania was slowly pushing the cloth forward, with both their eyes intently on the material.

Tania also sensed when it might be generative to intervene more directly, placing the cloth on the sewing machine while creating room for Zada to first observe her actions before trying them herself (Figure 14). We see Zada’s tracing of Tania’s actions (Figure 14) as evidence of how Zada was experiencing
these movements as invitations to observe and join-in, rather than as Tania sewing the piece for Zada. Evidence, in other words, of a “we” having been formed. Illustrating the intentionality with which she was organizing and thinking about Zada’s learning, Tania (now 13) reflected back on this interaction as follows: “I was standing over her holding it while she had her foot on the pedal controlling it and then I realized that by the time … we were almost done, she was like: ‘now I want to do it by myself’ and she sewed very straight and that’s how I knew she was learning” (Interview, 10/18).

Looking across Tania’s trajectory, we see the value of time in the study of embodied action. Cases 1 and 2 showed how particular embodied movements (and the values therein) were picked up within the interaction itself, or within the span of 1 week. Observing Tania’s emergent efforts to support her friends as a 6-year old, and the skill and attentiveness with which she organized learning for Zada as an 8-year old, we also see how these pathways support the long-term development of dynamic and nuanced forms of pedagogical expertise, including the ways Tania considered what would be generative for Zada’s growth on a moment-to-moment basis, and made decisions about how to support her peers by first gaining a sense of their ideas and goals. Tania’s development also reminds us that the fruits of children’s increasing dexterity with tools and materials (such as the sewing machine and motors) are not only cognitively or technically significant; deepening competence can also seed new forms of relationality (Bang & Vossoughi, 2016).

The week after Tania supported Zada with sewing, Meg asked the group about their costume-making process. Tania expressed her frustration with “wanting to give up on” her own butterfly wings. Meg asked, “what did you do to get through it when you wanted to give up?” Tania responded “well first, one day I helped my friend Zada. I was helping her when I was halfway done with my wings. So I just worked at it.” Like the artist who might break from a frustrating moment to work their mind from a different angle, Tania’s reflections suggest that helping Zada was not a one-way exchange, and that it was not something Tania felt she could only do when she was done with her own project.

Tania’s case also illustrates how embodied movements lived beyond the moment, and served the collective. A few weeks after making her costume with Tania, Zada was working with Yanira (a young adult educator) on circuit boards. Zada was having trouble getting the alligator clips to open and Yanira’s hands entered her work space to offer support. Similar to Zada’s assertion with Tania at the sewing machine (“Actually let’s do four”), Zada gently pushed back Yanira’s hand and said “wait, wait”—creating more time for herself to figure out the clips. In so far as such moments carry the trace of Tania’s prioritization of Zada’s needs, we can also see how children’s efforts to support one another may (in this case through Zada’s later assertions) offer older educators a similar sense
of attunement and subtlety—what Matusov (1996) referred to as a “communal intersubjectivity … a coordination of contributions separate from any individual participant” (pp. 32–33).

DISCUSSION AND IMPLICATIONS

Taken together, the three cases presented above expound our understandings of embodied pathways as relational encounters through which people experience historically shaped forms of assistance and courses of possible action. We have argued that identifying and tracing various embodied movements over time (across 5 minutes, 1 week, and 3 years) illustrates how children were utilizing forms of guidance they had experienced as learners to support other children, and doing so in ways that suggest keen attention to the pedagogical and ethical values expressed therein. To close, we reflect on the theoretical, methodological, and pedagogical significance of these findings as interwoven with possibilities for future research.

We frame our theoretical contributions through the metaphor of light painting. Light painting was a TAP activity in which participants used small LED lights to trace figures in the air which were cumulatively captured by a camera with a long exposure. When observing people in the midst of creating light paintings (lights and bodies moving quickly through the air), one cannot often tell what the image will be. Movements that seem ephemeral to the eye become visible through the image created by the long exposure as a shooting star, or a name. Our analysis across the three cases has led us to consider how children were attuning to the movements of others similar to the camera’s long-exposure. Salient experiences with particular movements (you do one part, I do the other; I narrate while doing) resonated beyond the moment as resources for future action. Stefanie was reading Meg’s actions not only as a source of help for her to learn how to hot-glue but as a potential resource for how she might help Shauna. May’s explicit choreography with Tania also worked to encourage such readings.

In a study of the ways pilots use their bodies to “imagine or pre-enact the actions they expect to take” in a simulator, Hutchins and Nomura (2011) suggest that “while the space implied by the previous gestures and talk was completely invisible and imaginary, it endured as a resource that could be exploited by the subsequent meaning making activities” (p. 24). While our analysis resonates strongly with this idea, it has also led us to question the notion of invisibility. Future studies of the role of perception and memory in embodied action might help us to see how seemingly ephemeral movements can, through the experience of their pedagogical and ethical saliency, endure more vividly over time. Young children are particularly adept at such noticing, as so much of learning how to
engage in the social world involves keen attention to the cultural practices and movements of one’s communities (Rogoff, 2003).

Building from prior work on substrates (Goodwin, 2013, 2018), we have also argued that the process of re-using and modifying embodied actions to create something new involves various forms of ethical perception and deliberation. In line with growing attention to power and historicity in research on embodiment (Ma & Munter, 2014; Marin & Bang, 2018; Taylor, 2017), expanding the scope of embodied cognition to include how people interpret the ethical meanings expressed through embodied actions can support novel understandings of the cognitive work involved in how people learn to be in relation (Nasir & Hand, 2006). Further, renewals of embodied movements using substrates can emerge not only in “next” moments (Case 1), but over longer stretches of relational time (Cases 2 & 3). Our findings suggest that research on embodied cognition would benefit from attending more closely to the relational and temporal histories between participants as consequential to how interaction unfolds.

Methodologically, Gordon suggests that understanding these phenomena requires “a different way of seeing, one that is less mechanical, more willing to be surprised, to link imagination and critique, one that is more attuned to the task of ‘conjuring up the appearances of something that [is] absent’” (2008, p. 24). Gordon and others have employed these lenses to accentuate the ghosts of history, the ways brutal socio-political systems leave material and experiential traces (Wolfe, 2016). Our cases show how hegemonic forms of learning (“I” vs. “we”, the power dynamics of age producing unequal discursive rights) can carry over into alternative learning environments, and how concrete experiences of the possible can shape future actions in generative and potentially emancipatory ways (Gutiérrez, 2008; Yates, 2015; Zavala & Golden, 2016). Initially, Arthur and Robert were pursuing individual goals, and Arthur was positioned as less than a full epistemic partner. Through the appropriation of movements introduced by Meg, Arthur and Robert were learning how to interact in ways that supported a budding sense of solidarity. Tania expressed a sense of responsibility for Zada’s learning and used key forms of assistance she had experienced in the setting to create a generative learning experience for her younger peer. Analytically, “linking imagination and critique” therefore involves asking after the genesis of rich moments of learning and collaboration, inquiring into the ethical antecedents of present action.

We have also shown how the creation of embodied pathways is a creative practice, one contingent on the how of movement. Tania’s I narrate while doing felt one way to Aiden, and another to Aniyah—a difference we ascribe to the subtle distinctions in how Tania was engaging in this practice, and one that highlights the importance of contextual analysis within qualitative
coding. By itself, tracing substrates across interactions does not reveal how and why particular forms of embodied action were reused or modified. Paying closer attention to the axiological (ethical and esthetic) dimensions of such interactions (Bang et al., 2016) is therefore central to the ethnographic imperative of understanding student’s subjective and affective experiences of learning (Erickson et al., 2007; Lemke, 2013). Building these forms of perception—changing the exposure time—also requires data representations that privilege the sensation and poetics of learning. Our efforts to create multimodal sketches of interaction that foreground the experience and feeling of assistance offer one attempt at such rendering, though we see much room for methodological creativity here.

Finally, our cases prompt us to consider the pedagogical significance of embodied pathways. Our prior work has illustrated how mediated reflection with educators around embodied assistance opened up deeper forms of co-presence and relationality with children (Vossoughi et al., Accepted). Here we extend this view to consider the kinds of pedagogical intentionality that can emerge when educators approach the guidance they offer children not only as important sources of help in the moment but also as models of ethical action that children might use to support one another. May’s positioning of Tania as a source of support for Aiden or Meg’s efforts to help Arthur and Robert learn how to attune to one another are explicit examples of what it looks like when educators work to build pedagogical community among students; our findings show that more subtle and implicit forms of modeling function in similar ways.

In developing our understanding of embodied pathways, we re-traced the life-spans of particular movements to see when they first appeared in an interaction, or in a child’s trajectory. We noticed that those movements that appeared early in an interaction (what we call “interactional firsts”) were sometimes more likely to be taken up over time. Whether these interactional firsts served as reservoirs for actions that were built just a few seconds later (Case 1) or over the course of a few years (Case 3), students may be attuning most intently to the forms of assistance introduced early on in an interaction, or in the first hours and days of a program. Recognizing that the ethical readings of embodied action discussed above may occur in heightened form at the outset of relations implies the need for careful attunement on the part of educators to interactional beginnings. Future work might also consider if the forms of assistance experienced early on in an interaction are more likely to be picked up downstream, though predictive inquiries would need to account for the relational contingencies we have foregrounded here. Rather than being applied or replicated over time, we see embodied movements as co-constructed, and sensitive to the responses of participants in the moment: Shauna resisting
Stefanie’s invitations to hold the glue gun, the give-and-take between Arthur and Robert, and the ways Aiden’s response to Tania may have had a role in her later facilitation with Aniyah and Zada. All of these instances required ethical calibration, both as a means to help others in ways that would be received, and as a way to sustain joint activity.

By interactional firsts, we also don’t mean that these are necessarily the first times children have ever engaged in these embodied movements, or that they were only encountered in TAP. Zada’s grandmother, for example, was an expert seamstress, a history her father shared with us when he saw Zada using the sewing machine. It is possible that Zada observed her sewing similar to the ways she observed Tania. Both Stefanie and Tania are older sisters, a role that may help to contextualize the support they provided peers within the program. Indeed, future work might fruitfully consider congruencies and/or tensions between the embodied movements children experience across different settings, and the pedagogical implications of these interconnections. Our focus in this paper has been on tracing the ways these pathways took hold over time within the setting itself as tied to shifts in both the children and the practices (Rogoff, 2003).

Commenting on renewed efforts to study the “everyday-ness” of ethics in anthropology, Zigon and Throop call for a shift from emphasizing first-person experience toward “relational being,” a specific facet of which is “caring, in interaction, for relations” (2014, p. 7). Across the three cases, students worked at micro scales to attune to the subtle ways social hierarchy and epistemic exclusion can be reborn, and to care for relations. As researchers of embodiment, we see great potential in foregrounding the role of the body in such care. As learning scientists, we see such efforts as ethical acts worthy of greater attention, details primary to the human experience of learning.

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