

Making sense and nonsense: Comparing mediated discourse and agential realist approaches to materiality in a preschool makerspace

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Abstract

Two approaches to materiality (i.e. mediated discourse and agential realism) are compared to explore their usefulness in tracking literacies in action and artefacts produced during a play and design activity in a preschool makerspace. Mediated discourse analysis has relied on linguistic framing and social semiotics to make sense of multimodality. Can a multimodal lens grounded in embodied histories of meaning-making unpack sensory exploration, silly repetition and free-wheeling nonsense in children's playdough play? Barad's agential realism seems promising for unpacking the sensory and the emergent produced in the materiality, fluidity and messiness of entangled bodies and things in a makerspace. We compare key constructs of mediated discourse and agential realism, comparing interaction and intra-action in video excerpts from two weeks of play with playdough electronics kits in three early childhood classrooms in a US university child-care centre. Mediated discourse analysis of multimodality identified collaborative interaction among players in a small group and tracked a collective flow of materialized knowledge that moved through children's sharing and collaboration. Agential realism tracked intra-actions among bodies, materials and spaces as transitory becoming and undoings that rupture definitions of sense-making as strategic design that manipulates materials into artefacts or as play that resemiotizes materials into roles and props in dramatized narratives.

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Keywords

Making, play, design, makerspace, mediated discourse analysis, new materialisms

A soft hum of chatter and laughter, punctuated by the thumping of fists into playdough, fills the preschool makerspace, a space set aside to tinker, invent, play, and craft with art materials and simple electronic tools. Scattered around the low rectangular table are opened mini-tubs of playdough, small square battery packs, plastic-covered electrical wire, assorted multi-colored beads, buttons, pipe cleaners, toy figurines, and white plastic LED bulbs. Nine preschoolers, heads bent over lumps of playdough, prod and poke the pliable clumps with the silver prongs of tiny lights. As they design, electric circuits light up the spreading array of their LED-studded sculptures, a glowing zoo of characters whose identities shift suddenly from “spaghetti” to “necklace” to “electric snake” and back again.

Making, sense, and making (non)sense

In this vignette, children’s activity with playdough and electronic craft kits might be interpreted as fine motor play at the science table. However, expanded definitions of literacies as embodied (Wohlwend, 2011) and artifactual allow us to see how children are moulding meanings as well as playdough. The child-friendly tools and materials of the Maker Movement (Peppler and Bender, 2013) merge familiar craft supplies with sophisticated electronics that enable very young children to make their own robots, apps or other e-toys. Making encompasses a range of activities that blend design and technology, including textile crafts, robotics, electronics, digital fabrication, mechanical repair or creation, tinkering with everyday appliances, digital storytelling, arts and crafts—in short, fabricating with new technologies to create almost anything. Early childhood makerspaces provide sorely needed access to contemporary literacies and address the need for meaningful experiences that recognize and position children as active digital literacy producers and not just consumers of technologies. When maker kits are supplemented with additional materials, such as toys situated in shared play histories in the classroom peer culture or media narratives in popular culture, the potential meanings and avenues for participation expand (Wohlwend and Peppler, 2015). We argue that an interdisciplinary approach that recognizes play and design as literacies that are both sense-making and sensory creates these possibilities, especially when combined with opportunities to collaborate with one another and innovative technologies.

Sense refers to making meaning with things (e.g. naming a strip of play-dough “spaghetti”, or “electric snake”) through sign-making representation, a key literacy in mediated discourse theory (Scollon, 2001; Wertsch, 1991). Mediated discourse theory draws on Bourdieuan practice theory (1977) to understand how engrained patterns enacted by bodies with things produce meaningful texts and make up tacitly expected and socially accepted ways of interacting. Texts are a key focus of mediated discourse theory: how are texts wielded and what shared sense is made of them in particular sites? Texts suggest a materially represented message constructed through a mediational means, a culturally constructed system of shared meanings, whether manifested on paper in print, bodies through gesture, objects through sound effect or music, and so on.

Sense can refer to physical perceptual abilities that link tightly to modes (e.g. the sense of sight links to gaze and image; the sense of hearing links to sound and music; etc.). In social semiotics, a mode is the product of the cultural shaping of sensed experience into semiotic systems or language (Kress, 2009). Modes represent the cultural meaning we apply to sensory information from interaction among physical bodies, places and objects which index previous identities and social practices sedimented into artefacts during their production and use (New London Group, 1996; Rowsell, 2013; Rowsell and Pahl, 2007). In this perspective, designers manipulate material aspects of their designs to emphasize particular cultural and sensory meanings. But *sense* also suggests a bodily response to histories with the material environment (e.g. engrained muscle memory); and in this way, mediated discourse theory is interested in not just social interactions and cultural histories but also in the sense our bodies make of experienced materiality.

Taking a mediated discourse theory perspective on crafting as multimodal sense-making, we ask,

How does a young designer read and wield the multimodal affordances of material resources to make a meaningful design and also to wield it as capital to participate in peer culture? What meanings are expected, played with, enacted and embodied as action texts?

A mediated approach to materiality interprets the opening vignette as multimodal design by agentic subjects who manipulate material objects to realize the meaning potential of materials, produce a cohesive social space, and use these materials to negotiate their cultural and material worlds.

However, perhaps there is more agency here than is visible through the lens of sense, multimodality and representation. What do we miss if we do not look for non-representational experience and unpack the free-wheeling non-sense in children's play and making? New materialisms such as Barad's agential realism offer a way to track bodies and things in unfolding relation within the emergent flows that play produces. The concept of intra-action reframes materiality from design affordance to a cycling interplay produced by the physicality, fluidity and messiness of entangled bodies, things and places. In this way of thinking, the child playing is simultaneously "play playing" with the child.

Playing creates opportunities for addressing and experiencing our being human in congruent and nonsensical ways, thus highlighting openings for improvisation, transformation, and flexibility of our perceived 'selves' or subjectivities. In complexly relational play we can both explore the kinds of subjectivities we take on (e.g., 'friend', 'child', 'adult', 'knower') and to challenge them with the help of unplanned and unexpected contributions from other entities in play with us. (Rautio and Winston, 2013: 8)

We wondered if thinking about play and design as intra-activity among humans and materials could reveal (non)sense-making we may have missed with mediated discourse analysis and open up more possibilities for participation in literacy learning.

What is made visible in a mobile, multi-centred view of bodies, materials and spaces that might be hidden in a view of design as human strategic manipulation of materials to create aesthetically pleasing message-bearing artefacts or of play as actors' dramatized action texts that can be filmed, saved and shared? In this article, we seek to more expansively consider both sense and nonsense in children's literacy learning in play and design activity, such as in the playdough making in the opening vignette. To do this, we compare two approaches, first considering interaction as collaborative design mediated by modes in human bodies, environment and texts through mediated discourse theory. We then analyse the same data to understand this activity as intra-action and enactment (Barad, 2003) within moments of play and experimentation. Barad's notion of an "agential cut" rejects Cartesian binaries that separate mind/body or abstract/physical. Rather, people, things, places and ideas are entangled with one another, producing and shaping one another as subjects and objects that share responsibility and agency within an activity. An early childhood makerspace is an ideal site to

explore patterns of play and sense-making with materials, bodies and discourses and to look within and through actions that entangle playdough, fingers, silliness and snakes.

In the next section, we compare mediated discourse theory and research on children's enactments of engrained nexus of play and making practices with agential realist theory and research on iterative intra-actions of materials, makers and a makerspace as entanglements that are continuously emerging and being reconfigured.

Two perspectives on childhood play and making

Mediated discourse, multimodality and interaction

In mediated discourse theory, play and making are semiotic practices or cultural tools for meaning-making. These tools are materialized as social practices and enacted by players and designers who collaborate to make shared meanings with artefacts in multimodal environments (Scollon, 2001; Scollon and Scollon, 2004; Wohlwend, 2008, 2014). In this view, a mediated action is a physical bodily action with tools and materials that alters the cultural meanings of the surrounding material environment (Wertsch, 1991). Actions with artefacts are semiotized through language and literacy and recognized as a social practice when categorized with other mediated actions and imbued with a set of meanings, identities and expected uses for belonging in a particular culture and location. In this way, an artefact can be a pivot that switches the context, from a here-and-now reality to an imagined scenario or narrative (Vygotsky, 1978). For example, kindergarten players used a mediated action (i.e. tapping on one another's coloured markers) as a pivot from real to imaginary, pivoting from a writing workshop classroom reality to a Star Wars media imaginary (Wohlwend, 2008). One player's tap on a friend's marker signalled a shift from writing tool to toy weapon and initiated a pretend light sabre duel. The mediated action wielded and emphasized the modal affordances of the marker (e.g. slender, cylindrical shape, hand-held ease) to change a school culture nexus of writing and colouring literacy practices to a peer culture nexus of play practices for shared enactments of favorite popular media scenes. But their play transformation was surreptitious, lasting only seconds and leaving no material trace; the durable text from these moments of kindergarten play is a paper page covered with letter Gg handwriting practice. Rowsell and Pahl (2007) combine multimodal analysis with ethnographic methods, using artifactual analysis to trace an object's multi-linear trajectories (chains of action, histories and projected

futures). The cultural context makes particular modes and histories relevant and more or less foregrounded through multimodal interactions in a particular site of engagement, expressed by bodies and materials in and through a real-time action.

A mediated discourse approach to materiality takes a critical orientation to access and use of materials. The growing research literature on play and design literacies in early childhood settings shows that tracking action and multimodality can reveal how routines and placed objects materialize discourses that justify disparate access, creating material barriers that prevent some children from accessing modes and materials as semiotic and cultural resources (Thiel and Jones, this issue). As literacies, play and design engage the space between material and imagined (Rautio and Winston, 2013), providing tactics for teachers and children to mitigate material barriers and create slippages where children can take up more empowered identities. Ruptures and improvisation happen in the intersecting trajectories of social practices, historical bodies and interaction orders (Goffman, 1983) that converge in a mediated action (Medina and Wohlwend, 2014). Possibilities for new imaginings happen in the slippages among discourses, people, practices and interaction patterns that circulate through trajectories that run on different scales, both temporal and spatial, with historical and imagined, global and local, coming together in a here-and-now experienced mediated action. The cycles in and out of a mediated action are retrospective and prospective, conveying expectations for future performances in histories of an action's prior shared meanings, identities and uses in particular locations and cultures and its anticipated meanings, identities and uses that emanate from the current moment (Scollon, 2001).

Agential realism, materiality and intra-action

The material turn in literacy studies research makes visible some limitations of a mediated, multimodal framing of play and design as multiliteracies. Leander and Boldt's (2013) post-structural analysis of a 10-year-old boy's passionate manga play reveals action that was intensely experiential, entangling image, body and space as he leapt off furniture, wrapped up in a robe, and created impromptu props. His play was a production of pleasure and sensation that eludes explanation as planful design or rational representation. This move beyond multimodality or sensory ethnography is concerned with how actors use materials to produce cultural signifiers or how bodily sensations shape perceptions of culture (Hurdley and Dicks, 2011).

Ehret et al. (2016) draw on agential realism and intra-action (Barad, 2007, 2003) as well as notions of vibrant matter and feeling bodies (Bennett, 2009) to theorize adolescents' "literacy in the making" of book trailers and playing with new media. Barad (2012) notes:

First of all, agency is about response-ability, about the possibilities of mutual response, which is not to deny, but to attend to power imbalances. Agency is about possibilities for worldly re-configurings. So agency is not something possessed by humans, or non-humans for that matter. It is an enactment. And it enlists, if you will, "non-humans" as well as "humans." . . . I know that some people are very nervous about not having agency localized in the human subject, but I think that is the first step—recognizing that there is not this kind of localization or particular characterization of the human subject is the first step in taking account of power imbalances, not an undoing of it (Barad, 2012: 55).

In other words, agency can be thought of as a remixing of power relations that are always/already collectively formed. This onto-epistemology premise in Barad's (2003) materialist perspective explains the fuzzy being/doing interplay among not very determined components that produce—rather than are produced by—actors, things and places in an early childhood makerspace. In this way, the playdough, fist, table and pounding action can be examined as a momentary production in a dynamic flow of action where materials, meanings, makerspaces and learners themselves are continuously emerging and under construction. This recognition of emergent entanglement foregrounds the present moment and appreciates the tenuous and sensuous connections children are making with their physical surroundings and with one another. Rather than tracking sense-making or strategic wielding with tools, a materialist lens maps the wandering spread of children, materials and sensations in here-and-now moments of play. Learning as a recursive and loopy unfolding opens up more space for exploratory play and diverse kinds of learning to emerge within classrooms, moving from a human-oriented meaning-making and intentional representation that rationally fashions meanings through the manipulation of things and material realities.

Early childhood research from materialist perspectives shows children are not subjects wielding tools and bending materials to their will, suggesting that children are as much effects of the intra-action as the artefacts and the surrounding space. Agency in agential realism is mobile and enacted across all elements, human and non-human. Thiel's (2015b) analysis of vibrant matter

in literacy shows that materials and children co-construct stories together, in mutual reconfigurations that create superhero costumes, excited bodies, enactments in the action texts of play and artefacts of making. Learners are produced in ongoing reconfigurations formed as components respond and react to one another, in ways that defy tidy categorisation as they connect and re-configure fields of subjectivity, representation and reality. Rautio and Winston (2011) explain how “things play with children” . . . “and children play back” (pp. 4, 6) as subjectivities emerged and were produced in child-matter intra-actions during making with crayons, sandpaper and little boxes. Intra-actions entangled tools, bodies, crayon shavings, sawdust, a “dustey” invention, an inventing competition and subjectivities as a happy/friendless child/inventor. Kuby et al. (2015) use the term literacy desiring to capture the movement, immediacy and excitement with bodies, modes, space and playful literacies in second graders’ construction of a 17-foot paper giraffe.

It’s important to recognize that a materialist approach to materiality also takes an ethical orientation to access to and use of materials. Exemplary work by Thiel and Jones (Jones et al., 2016; Thiel and Jones, this volume; Thiel, 2014, 2015a, 2015b) deconstructs and disrupts the stratified inequities worn into bodies, action and materials, but also maps the reconfigurations in these entanglements that expand possibilities with immediate and promising impact on life chances and liveable spaces. Researching with children, families and teachers in under-resourced rural communities in the southern United States, Thiel and Jones incisively expose the classed, raced and gendered underpinnings in “institutionalized practices of perceiving children through a developmental lens and in need of surveillance and adult-formed structures. These circulating ideologies about children, childhood, and education seemed to have become embodied in each of us . . .” (Jones et al., 2016: 28). They argue for decentring institutionalized practices by engaging actively in “place and space-making for and with children and youth” within a neighborhood makerspace (p. 28). They advocate for “childhood geographies” as a deliberate move away from controlling indoctrination pedagogies and towards more community-based, vibrant and fluid learning grounded in commitments to social justice (p.29).

In the following section, we examine instances of makerspace play to parse the differences and similarities of materialist and mediated perspectives in flows of sense and nonsense, following moving bodies and materials and looking for ways to disrupt well-worn ruts that determine knowledge and expertise at school.

Tracking action in a preschool makerspace

Approximately 60 three-to-five-year-old children and six teachers in three preschool classrooms in a university nursery school centre in the Midwestern United States participated in the study. In each classroom, a makerspace (e.g. table with circuitry kits, playdough and assorted art supplies and toys) was set up as a play centre option over a two-week period, totalling about seven hours per classroom. In each classroom, one researcher facilitated the activity at the table and a second researcher video-recorded the session. Children chose to come and leave as they wished, forming small groups of up to eight children. The *Squishy Circuits* electronics kits (Johnson and Thomas, 2010) contained conductive playdough, instead of traditional wiring components, that enables young children to safely create a working electrical circuit. The kits included a battery pack, 10–15 light emitting diodes (LEDs) that turn red, yellow, green and blue when lit, two small buzzers and a gearless motor capable of spinning. In order to complete an electrical circuit, components must connect so that electricity flows in a loop without a break or a short-circuit, from the battery pack through the leads, playdough, LEDs and back to the battery pack (see Figure 1). Children were also encouraged to add additional classroom materials (e.g. rolling pins, biscuit cutters, plastic dolls, animals, straws, sticks) easily accessed from nearby shelves.

In the next two sections, we first use mediated discourse analysis to theorize maker activity within nexus of practice (Scollon, 2001), framing to identify valued goals, practices and user expectations for practices and materials. Within each practice, we identified frequently occurring mediated actions that meaningfully transformed (e.g. changed the meaning or, moved the project in a new direction, or altered a peer relationship) child-made artefacts (e.g. playdough decorated with LEDs, fans, or other materials). We used video analysis software to filter and code dense moments of action (e.g. frequent active participants, multiple materials, for sustained periods) and to locate trajectories of practices within and across sets of practices. Close analysis of mediated action illuminated the moment-to-moment unfolding of learning processes in each domain (playful exploration and joking, collaborative sharing and peer teaching, circuitry concepts and problem-solving, crafting ideas and skills). We used multimodal analysis to reveal changes in the shared meaning of children's actions and artefacts, children's relational identities (e.g. helper/maker) and patterns of participation that offered equitable access to opportunities to learn and engage over time and space.

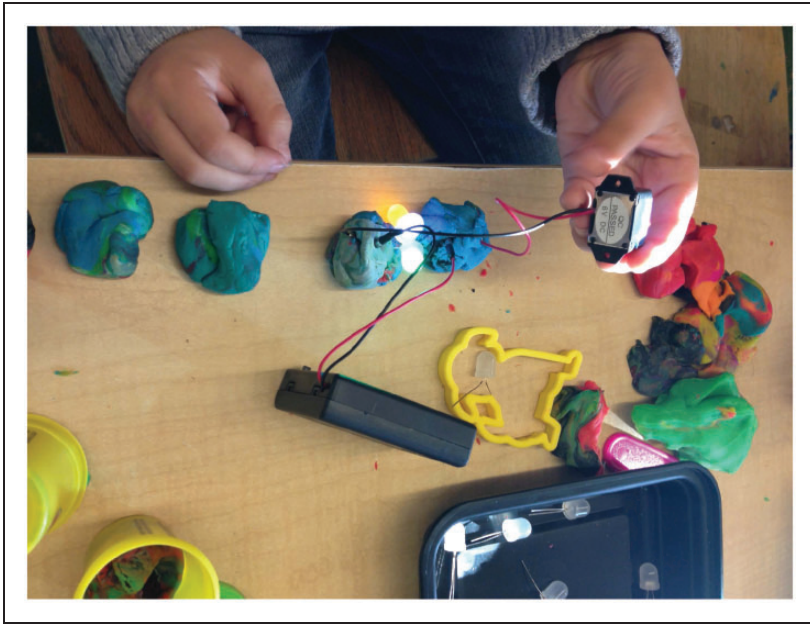


Figure 1. Photo of components: Hands, biscuit cutters, battery pack, leads and LEDs.

Finally, taking a materialist perspective in the second section, we re-examine these dense moments but also reclaim previously overlooked moments that seemed chaotic or meaningless from a mediated perspective (e.g. cacophony of sing-song repetitions, piercing buzzers, playdough pounding). Conceptualizing these instances of intra-actions among bodies, materials and places, we follow the trajectories of their becomings and undoings to understand how this emergence affected the making of children, artefacts and the possibilities of (non)sense.

Interactions and intra-actions with Squishy Circuits

We pause here to examine maker activity and parse the differences between interactions in mediated discourse and intra-actions in agential realism. *Interaction* is defined as actions that are materially mediated in relations among subjects and objects that constitute social practices in a cultural environment (Scollon, 2001). By contrast, *intra-action* is defined as actions that emerge from within unspecified, entangled and changing phenomena of bodies and give rise to possibilities and transformations (Barad, 2003).

We will examine how each perspective allows us to view the same activity in unique ways.

On the first day Nate came to the makerspace table, his experimentation focused tightly on achieving a working circuit by sticking two battery pack leads and various LEDs into one lump of playdough. Nate systematically removed all but one LED, then experimented by spreading the playdough pieces further apart, until finally the short was avoided and the LED lit. The on/off or right/wrong lighting effect of the LED supported this subtractive approach to remove and control variables. The connections among components became more consistent and stronger through repeated hypothesizing and varied experiments, with multiple configurations tried, tested and adjusted, followed by his verbal and nonverbal explanations. Nate showed another child at the table how to both create a working circuit as well as how to turn off the LED by interrupting the circuit with a short circuit by having the two balls of dough touch one another:

Oh, and let me tell you one thing. If you do it . . . you have to make two balls and stick one [LED] in one ball and the other in another ball. It won't work if you put it into one ball. – Let me show you something. [He takes his listener's playdough and wires as he explains] You have to make these little balls and then stick [the wires] in. You do that and make another ball and put that in . . . Oh, and when you put it very close—I didn't explain this—it will turn off [creating a short circuit]. And when you take it apart, it will light up.

The intra-actions connected each part of this assemblage, producing connections, repetitions, circuitry components and playdough that produced Nate's circuitry expertise and his subjectivity as a "little scientist", as described by a teacher. They also circulated explanations and demonstrations that inspired repetition of the same artefact design and procedures for creating a simple circuit among participants at the table. In this child-matter assemblage, components were visibly entangled and interdependent; if a component was missing or misaligned in the circuit, the intra-action could not light an LED, prompting repositioning components and further action.

Where intra-action in materialist framing suggests an unfolding multi-directional interdependency among components, interaction describes a social relationship between human actors or a designer's use of tools and materials that shapes and is shaped by physical properties and cultural worlds. In this framing, Nate's circuitry activity began and ended with his interest in completing the goal of designing a working circuit, albeit with

much experimentation and debugging. Through this process, he refined his design skills as he enacted the “little scientist” and discoverer identity, and demonstrated key concepts important to early circuitry understanding, including current flow, electrical shorts and connectivity. The malleable qualities of playdough made it easy to make slight changes to test his ideas independently and the visible evidence from lit LEDs allowed him to claim credit and get recognition for his discoveries. When his circuit was successfully completed on his first day at the table, he showed his parents this accomplishment and described the steps in his process for creating a working circuit. In summary, Nate briefly and intensely engaged with circuitry practices and quickly achieved the goal of making a simple working circuit, impressing adults and peers with his independence, systematic hypothesizing and detailed explanations. But after the first day’s success and acclaim, his interest faded quickly and he did not return to the table. In the next sections, we look at two children who were not recognized as experts but nonetheless engaged every-day with peers and materials: Lisa as a collaborative maker and Aamir as an inventive player.

Mediated discourse: Interaction, making and collaboration

At one end of the crowded art table, Lisa regularly eased her way into a large number of projects with offers of help, briefly taking over other children’s projects to debug and to demonstrate her emergent understanding of circuits. These interactions with tools and other interlocutors also expanded and deepened Lisa’s own circuitry knowledge and ability to make more intricate artefacts with working circuits, including two snowmen connected by a motorized fan, one of the most complex artefacts created in this preschool makerspace.

When working alone on her own projects, she focused on moulding playdough and attaching decorative albeit non-electronic materials, to make an elaborately decorated sculpture, singing and playing with them as she selected and added colours. However, she paused often during projects, stopping her own work to help other children in a pretend teacher/student interaction order. When Lisa constructed her first circuit and it failed to light the LED, she attentively watched as a boy took over her project and assembled the circuit for her. When the LED lit up, she beamed up at him, delighted. A few minutes later when another boy across the table was similarly stuck, Lisa called, “Would you like me to do it for you? Would you like me to help you?” As she helped him, she noted, “It is lighting up. You have a circuit.”

When we tracked shifts in multimodal interaction among children's shared gaze, proximity and movement around the layout of the physical environment, we found that children (and facilitating adults) paid the most attention in gaze and proximity to the boy who first solved the problem of lighting the LED and, had connected the circuit for Lisa, and then returned to working on his individual artefact. Meanwhile, Lisa moved around the table, problem-solving, debugging and demonstrating as she worked on five additional projects with other children. Each time, she followed a similar routine: (1) she asked if the child required help, (2) she moved in to take over and debug the circuit and (3) she deferred credit for problem-solving, "You figured out the problem. You are making light", before leaving the child with a working circuit. When we initially catalogued children's playdough artefacts, we noticed that despite the very elaborate but non-electric snowman, Lisa had completed very few projects: her own projects were often interrupted or abandoned when she left to help others problem-solve their projects. However, when we analysed her video data using the modes of movement and layout, we saw a radically different picture.

Mapping multimodal interaction among children's shared gaze, proximity and movement onto the physical layout of the makerspace centre showed that as Lisa regularly moved around the table, while children watched her work intently, their shared gaze focusing collective attention on her hand movements. Putting modes into motion by looking at modal maps across dense moments in chains of actions (Scollon, 2001) drew our attention to the flow of materials and concepts in the trajectories of the social practice of helping within the timescale of a daily makerspace session. This multimodal analysis highlighted the need to consider not only the impact of Lisa's extended reach on her own learning but also how her brief but frequent interactions contributed to other children's learning, the complexity of their artefacts and the distribution of knowledge. In one session, she problem-solved over nine projects, extending the range of her circuitry exploration as she tackled and debugged other children's problems. Collaboration expanded her access to projects and also deepened her circuitry expertise while also sharing knowledge and showing skills that opened up more design options for her peers.

Agential realism: Intra-action, entanglement and repetition

Rather than planful intention and production through which makers manipulate material objects, an agential realist lens reveals the possibilities of intra-actions among materials and humans around the preschool table as emergent

and transient flows. From this perspective, the jumble of materials and the table invited children who played with assorted meanings every day, produced circuits, animating pretend playdough animals, and attracted spontaneous onlookers-makers-friends were drawn in by the sparkling lights, excited voices and droning buzzers. The assemblages that emerged pulled in researchers as well as peers, created toys for pretending, moulded from playdough warmed by pounding hands and electrified circuits with multiple buzzers and LED lights.

How is literacy stretched through the recognition that materials produce actions and meanings as well as humans? For example, materials generated and reacted to numerous hypotheses about component intra-actions when Aamir playfully attached and detached globs of playdough, electronics and meanings in a morphing response within the changing assemblage. Repetitive word play created jokes: “What? What? What?” while sliding playdough bits together and apart to close and open a circuit, turning LEDs on and off. For example, the spaghetti-snake-maker assemblage emerged through the intra-actions among a round lump of playdough, a playdough press that reshapes the dough into a long cylinder, hands that tug and stretch the dough away from the press, the jabbing wire prongs of a tiny LED, and a child who chants, “Spaghetti, spaghetti, spaghetti.” Seconds later, this becoming is undone and redone as “spaghetti” morphs to “snake” through more word play and a battery pack that lights up LED eyes and scales. Improvised pretend meanings were quickly attached to the long thin strings of playdough extruded through a playdough press, then quickly detached and replaced: first “Stick, stick, stick,” then “Pasta, pasta,” then “Spaghetti, spaghetti, spaghetti,” and finally “Snakes!” After inserting LED lights into the playdough wires, Aamir animated the playdough by wiggling the “snakes”, which became sing-song repetitions of “electric snake” as more LEDs and a buzzer were pressed into the playdough snake. The lights, buzzer and repetitive word play attracted onlookers who clustered around Aamir, “Look what I made. Snaaaaaake,” stretching out the word to emphasize its length. In this way, additional humans as audience were pressed into the assemblage along with more LEDs. Play added further layers of becoming through multiplayer animation, as the tactile attraction of the squishy playdough and the assemblage’s noisy nonsense, hissing and giggles attracted more hands to help wiggle the electric snake along the tabletop. In this way, the noisy and fluid meanings in this assemblage (which might be filtered out as nonsensical play in a mediated discourse analysis) led to generative engagement with materials.

What did these becomings and undosings mean for the assemblage, including the child? Literacy was stretched here to recognize the fluid meaning

production in scientific discovery, comedic improvisation and imaginative play. Strands of meaning emerged in this entanglement, as in the initial intra-actions among playdough, hands and the press that extruded multiple strands. Meanings emerged through the assemblage's spontaneous co-production, rather than through a designer's strategic intention: Aamir did not intend to create "spaghetti" when he used the dough press, but he made the connection through emergent discovery instead of intentional design. Finally, the child was pressed into its assemblage and expanded its physical shape through intra-actions among his body, materials and peers in the space, as playful improvisation and exploration sustained his interest in following one project into the next, in constant refreshing of new challenges and ongoing recruiting of an audience of friends and fans.

Literacy, agency, sense and non-sense

To compare the differences in mediated representational and materialist non-representational framing, we have played with the notion of sense and nonsense as a way of considering meaning-making and literacy. Although we have compared the two approaches, we quickly saw these delineations blur and undo themselves. Mediated discourse analysis tracked how children approached and engaged with the Squishy Circuits materials and with one another in ways that produced artefacts, enacted learner identities and wielded materials to extend their reach and engage with more materials. While Lisa began as an individual learner, she extended her reach by enacting combinations of play, design, collaboration and technology practices. Her discourse crediting other children with solving the problem paradoxically deflected credit but increased her access to novel problems and the ability to temporarily take over more projects. Lisa regularly moved around the table sharing and helping, debugging projects for nine children, nearly all the projects at the table. Her circulation as a helper around the table connected circuits but also connected children's knowledge of particular problems into a more accessible and collective flow. We can see now that re-conceptualizing her pattern of interaction from a new materialist framing might allow us to watch how materials, actions, projects and children were folded into an emergent intra-active indeterminacy that was continuously adding and dropping projects in wandering trajectories around the table.

Agential realism revealed the interdependent nature of components' connections in an entanglement that was dramatically and concretely evident in the playdough circuitry materials, where loose connections could prevent a bulb from lighting. Agency is cross-cutting as all parts of the intra-action must connect

to create its tangled effects: a completed circuit, a subjectivity as expert or learner, a morphing artefact, a growing assemblage and so on. Furthermore, intra-actions are in constant motion and flux, with each action altering components and opening up new possibilities. Becomings and undoings were evident in morphing playdough, verbal word play and design revisions, and hypothesizing, testing and debugging. Rather than a linear progression, it is the messy loops of tangles and jumbles that open up space for diverse approaches and inventive production. Analyzing intra-actions reconceptualized Aamir's joking, repetitions and nonsense as becomings and undoings that ruptured expectations for adult/children power relations, literacy expectations for sequenced, non-repetitive narratives and logical organisation, and opened up space for exploring human/material relations. Materialist framing made visible the sensations and flows that are often overlooked ways of sustaining engagement, enacting and sharing knowledge with materials, creating new subjectivities and proliferating access points for participation.

Both approaches to materiality drew on expanded literacy definitions for embodied and artefactual texts, broadening what counts as literacy and as successful participation; both helped demonstrate a broader range of achievement as innovation and knowledge moving across projects as children engaged in play and making together. Teachers' interpretations of children's actions created "little scientist" expert subjectivities for (male) individuals who worked independently and who were first to solve the circuitry problem, overlooking Lisa and Aamir who achieved proficiency by engaging repeatedly over longer periods of time in ways that involved more children and materials. Sustained engagement meant children had more time to explore, resulting in more opportunities for repetition and variation that produced more complex artefacts and spread flows of learning: hypothesizing and testing, playful invention, innovative artefacts and peer-sharing. Both mediated and materialist perspectives reframed achievement from individuated knowledge evidenced through verbal explanations and completed projects to collective knowledge mobilized and spread by working with others across a series of multiple projects, or *achievement as a collective flow*.

Implications

Looking at connections within and across actions—as intra-action or inter-action, entanglement or nexus—expanded the view of children's access to and engagement in learning. We also examined our own entanglement, looking at the impact of our research decisions in providing materials and in what we chose to analyse. This critical self-examination challenged our assumptions

and prompted us to adapt familiar patterns of curricular implementation. For example, through systematic daily researcher debriefings and reviews of video data, the research team realized early in the project that we had inadvertently privileged technology learning by tending to encourage children to engage in problem-solving in circuitry and ignoring other components and practices—at times even unthinkingly interrupting and redirecting children’s play, collaboration or design practices. Our privileging of technology conceptual learning enacted tacit acceptance of the cultural histories of dominance in science and technology fields over play and design curricular domains. However, the interactions among nexus practices and intra-actions among components created ruptures that made the cultural expectations in our own pedagogical assumptions visible and available for critique and revision (Medina and Wohlwend, 2014). Exploring posthumanist perspectives on materiality in making and makerspaces not only acts on and alters the mediation and expands the view of children’s literacy learning, but also opened up new ways to understand the interconnected actions that produce literacy, designs, learners, teachers and researchers.

Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

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