Seeking Language*less*ness: Maker Literacies Mindsets to Disrupt Normative Practices

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ABSTRACT

This article challenges an over-reliance on language as the primary means to communicate knowledge by adopting a language*less*ness approach to maker pedagogies and maker literacies. Having conducted makerspace and design-based research for some time, we separately and together noticed a productive relationship between wordless relational makerspace and making moments focused on craft, tools, technologies, and materials, and ways that an absence of verbal and written communication opens possibilities within learning environments. After meetings and discussions, we co-wrote the article to examine ways that language-light, even language-free pedagogical spaces allow for a different quality of design work that motivates and fosters innovation. There are three international research projects that serve as research vignettes to investigate the efficacy of languagelessness. The theory foregrounded to anchor and interpret the three vignettes draws from maker literacies research and sociomaterial orientations to knowledge development.

> Things aren't all so tangible and sayable as people would usually have us believe; most experiences are unsayable, they happen in a space that no word has ever entered, and more unsayable than all other things are works of art, those mysterious existences, whose life endures beside our own small, transitory life. – from Rilke, "Letters to a young poet"

Introduction

Languages that people speak, read, and write communicate meanings one way, but this is by no means the only way to express intents, thoughts, and knowledge. This claim seems obvious, yet so much of formal schooling relies on language and linguistic systems to establish knowledge claims and to teach subject domains. The opening Rilke quote captures how language breaks down at a certain point during experiences and how other modes and matters that exist beside and beyond language are more intuitive for many people to express and communicate thoughts. This article seeks to disrupt the primacy of language in literacy, math, and STEM (science, technology, engineering, and math) educational research, shifting the emphasis more toward divergent meaning-making free from predisposing social categories and labels. Such research not only extends notions of multimodal literacy (e.g., Kress, 1997) by recognizing that communication in contemporary society extends beyond language to encompass various modes, such as visuals, gestures, and sounds, but also interrogates the agentive ways that matter and modes impact meaning-making. The article contributes to the RRQ special issue on gender and maker literacies by illustrating ways that craft and design have the potential to open more spaces for learning and communication.

There is a tendency to view makerspace, STEM, and STEAM learning as technical and exacting when, in fact, it often involves looser, more fluid DIY work, and there are researchers who actively seek to push against STEM and STEAM gender stereotypes (Buchholz et al., 2014). A point of departure for this article is to foreground the social and relational dimensions of maker literacies research by exploring the concept of *languagelessness*. To do so, we start by defining and framing maker literacies, then foreground the social and posthumanist dimensions of maker work, explain our individual research and joint data analysis, and then spotlight our three research vignettes with analytical conclusions.

Framing Maker Literacies

Emerging from a spirit of building, problem-solving, and learning through making and the German concept of *bildung* as in self-cultivation, makerspace pedagogies invite learners to learn by doing and through trial and error with materials. What we, as makerspace researchers, have observed first-hand are the ways that children, young people, and adults learn by trying out materials, tools, and technologies, making mistakes, and then trying out other materials, tools, and technologies (McLean & Rowsell, 2021; Wohlwend & Peppler, 2013; Wohlwend et al., 2018). This type of making has been described as a type of literacy (Wohlwend et al., 2018) that combines multimodality with design approaches to learning. Makerspace approaches to digital learning entail materials that are often non-digital, craft- and arts-based, and sometimes digital and immersive, and these material properties and affordances are key to problem-solving processes (Kajamaa & Kumpulainen, 2019, 2020). Makerspace research frequently centers on the social aspects of making processes and participatory structures driven by maker trial and error and experimentation with digital and non-digital materials and tools with people (Kafai & Burke, 2016; Riikonen et al., 2020; Wohlwend, 2008).

A central, guiding notion in makerspace research is learning through making/designing and reflecting on material-tool engagements (Marsh, 2017). Making as a verb and makerspaces as a place and hub for this activity give learners a modally and materially flexible way to communicate disciplines, ideas, and themes. Researchers have underscored the power of makerspace pedagogies for developing knowledge and knowledge creation for children and young people (Rouse & Rouse, 2022). Makerspace learning happens in formal schooling and in informal contexts, and the three analytical vignettes we present below display a range of informal and formal learning environments. What has been illustrated richly in literature are the ways that makerspace learning invites socialization, collaboration, experimentation, problem-solving, and, crucially

to our argument, a collapsing of stricter categories for learners (Marsh et al., 2017). Very often, prescriptive, performance-driven forms of learning reject failure, whereas makerspace work embraces failure – if this does not work, try this, and start again from scratch (e.g., Kafai et al., 2019). As well, makerspaces are relatively language-less in that they do not rely on spoken, written, or read words to complete elaborate projects but instead on a wide range of materials that could be arts and crafts or low-tech and high-tech tools. In this way, makerspace pedagogies decouple learning from words, profiling all modes and materials to communicate.

Maker literacies put making at the center of literacy practices, fitting with our argument about a movement away from language toward modally diverse forms of meaning making that, by extension, flatten hierarchies and push against social, gendered categories, as we present below. As Kumpulainen et al. (2020) maintain, maker literacies foreground the sociocultural framing of making, viewing it as operationalizing parts of identities. Kumpulainen et al. (2020) encourage an account of maker literacies centered on the social and cultural activities that people engage in and less about the tools and technologies, as is sometimes foregrounded in STEM and makerspace literature. Wohlwend was the first to introduce the term 'maker literacies' to the field, describing them as "sets of practices for making and remaking artefacts and texts through playful tinkering with technologies" (Wohlwend et al., 2018, p. 148). Wohlwend conducted several research studies on maker literacies with children (Wohlwend, 2011; Wohlwend et al., 2018) and with undergraduate students taking literacy teaching methods courses as a part of their teaching training program (Wohlwend et al., 2018). In these research studies with children and adults alike, they creatively played and hacked with toys to critically interpret social constructs and gendered associations, biases, narratives, and stereotyping that toys carry with them. After critically framing discourses and narratives, participants then redesigned toys, making them more subversive and syncretic modern narratives. Filming the toy hacking processes, student teacher participants (Wohlwend et al., 2018) interpreted material messages embedded in toys like Barbie dolls, asking questions like what is the toy intended for? What happens when material choices change? Who is silent in these toys and narratives? Making and remaking toys and their redesigning implicit discourses and associated narratives allowed children in Wohlwend's research (2009) and adults in the teacher education work (Wohlwend et al., 2018) to modify and provisionalize material features through play, design, and redesign. These material features signal ways of framing gender that can be redesigned, played with, and ultimately disrupted. Wohlwend et al. (2018) talk about ways that stories are told and circulate within design practices, and, as researchers, we ask similar types of questions during making: what happens when language is removed from the making, and how are

stories and narratives told through less language or limited language? Does it change things significantly? Do children and youth act, think, and engage differently?

As far as other maker literacies scholarship, Cheryl McLean and Rowsell (2021) co-edited a maker literacies collection that explores a spectrum of research projects and perspectives on the notion of maker literacies. From more traditional notions of makerspaces with specific stations, materials, technologies, and tools set up in schooling contexts to very open informal types of learning through objects, bodies, and movement – the collection opens up maker literacies to design and representation as much as senses and affect. Kumpulainen et al.'s (2020) point is that maker literacies, by their very nature, are more social, relational, and affective than they are operational, design-based, and technical. Though clearly technical design practices play a key role in maker literacies, which are drawn from our own research, all four of us have equally observed more ephemeral and fluid ways of making meaning that are affective and sensory (Rowsell & Shillitoe, 2019). These non-representational understandings of making specifically and literacy more broadly were underplayed for a long time (Leander & Boldt, 2013), however, there has been an acknowledgement of the informing role of the non-representational, felt, and sensed in what gets made and processes applied during making activities. Approaching makerspace practices from affective and non-representational perspectives (Rowsell & Shillitoe, 2019) resists children and young people (CYP) from taking a digital default to design (i.e., relying on technological affordances) to take on a dimensional and expansive approach to design work that balances physicality/materiality with digitality. The three vignettes illustrate a circulation of technical design with felt making that expands maker literacies.

Disrupting Language and Normativity

If maker literacies is the anchoring theory for the article, where does this position language, and how is language framed? In the article, where language is present in the vignettes that follow, it exists within social language practices as they are embedded in social contexts and shaped by cultural values and power relations (Scollon & Scollon, 2003). As such, language reinforces social expectations around gender roles, race, and other forms of identity. Language plays a formative role in constructing and negotiating social reality, shaped by multiple intersecting factors such as culture, history, and ideology (Fairclough, 2013). Brian Street (2003) showed how autonomous, single definitions of literacy root themselves in a tradition (e.g., British schooling in Iran), and these traditions carry with them assumptions that are often colonial, white, and that carry with them narrow social categories. Street's notion of ideological models of literacy development invites plurality – especially given his argument that literacy and meaning-making are always embedded in social practices (Street, 2003). Researchers who explore language across educational contexts have shown that these realities are rigid and challenging to disrupt (Gee, 2014) and that literacy needs more nimble, nuanced, and critical understandings of the ways that literacy is lived. The notion of making for us provides opportunities to observe and design alongside children and young people, and it has been relational in nature without the need for language.

Returning to the Rilke quote at the start of the article, moving away from language increases attention to other embodied actions, like the ways that hands craft or the feel of wool during crocheting. Moving beyond language and defined categories within makerspace environments sometimes has more potential to disrupt social conventions that have become sedimented through language over time (Pool, 2018). When we consider embodied and sensory aspects of design, we come to understand how non-representational (i.e., both feelings and senses during making and what feelings design processes and products elicit) and representational (i.e., what materials, modes, and design features to include to make a design look good and function well) aspects of learning coalesce through making (Leander & Boldt, 2013; Lewis & Tierney, 2013; Rowsell & Shillitoe, 2019).

There is a secondary goal of our thinking together, which concerns gender. We admit that this dimension is not yet fully developed and has a smaller presence in the article, but there are inflections of gender implications that come from our own observations about how social categories develop in school. In our experience, makerspace learning blurs fixed social categories in school time and space. In her work with Springgay, Truman probes 'school time' as a marker of particular routines, assumptions, and practices tied in with race (whiteness), gender and sexuality, and neoliberal notions of time: "Whiteness and a particular notion of humanism becomes the standard marker of time which functions to create a sense of belonging, relating, and evolving that are equated with narratives of progress and success" (Springgay & Truman, 2019, p. 10). This quote resonates with our co-thinking for this article because there are instances across vignettes we analyzed when materials create a sense of belonging for youth (see vignette 2 about Tracy and crocheting) or conversely, when materials, tools, and experimentation are equated with particular gendered practices (see vignette 3 for gendered framings of what is meaningful design work vs a young person tinkering). Springgay, Truman, and others write from a postqualitative research-creation lens on text blending theory, art, and research and focus on practices with matter and materials and the material configurations of compositions (Truman, 2016). Approaching arts practices from a new materialist lens, research-creation theorists push against the idea that data are separate from

theory and interpretation. Materials can become forceful like language, which tends to dominate, and it takes work and active arts engagements to not only have criticality about the power and force of materials and matter but also to view intra-actions and relations between people and materials, modes, and matter. In Truman's research, data and researcher intra-act during research processes and, therefore, are never the same, but instead, data and researcher mutually entangle as a result of research processes. Truman argues convincingly about the materiality of language through her research on *Intratextual Engagements*. Asking 33 adults to annotate the same text in the margins, Truman asked them to "intratextually entangle" (2016, p. 92) in the margins and either email or hand-deliver their annotated versions to her after completing the research assignment. In some instances, individuals then intra-acted with an already-annotated text by another participant's intratextual entanglement as a second phase. Truman gathered 60 annotated texts to analyze and developed an intra-action theory of intratextual becoming between people and their textual materials. Implementing Barad's notion of diffractive readings, Truman then interpreted all of the intratextual engagements as writerly-infused texts – that is, readers coming into the agency of the text intra-acting with their own agency. This type of data analysis looks at language as **a material element** (Truman, 2016, p. 97). Quoting MacLure, Truman's research attempted to move language "out of its imperial position as mediator of the world" (MacLure, 2013, p. 663). Truman thereby showed us that there is a productive, emergent quality to language that can move and become and, most importantly, that can be seen as material. Truman's intratextual engagement research gives researchers ways to look in-depth at language's mutability and at ways that it can and does normalize and narrow definitions of communication. The spirit of Truman's research inspired us for the present research because it aligns with Wohlwend's foregrounding of playful creativity in maker literacies and engaging with matter as speculative and as provisional, allowing for freedom of expression and a loosening of norms and tighter framings of communication.

Intra-Active Agencies through Sociomateriality and Posthumanism

The three vignettes that support our argument about moving beyond language rely on materialism and humans intra-acting with matter (Barad, 2007). Posthumanism, the study of more-than-human phenomena (Barad, 2003; Kuby et al., 2018), entreats us to question the role of materials as not simply mediators of learning but also – and importantly – as actors of planned and serendipitous activity that allows for spontaneous moments of material and human learning. Unlike the observation of interactions between separate entities that always remain separate, posthumanism views the action-productions between humans and physical materials as 'intra-actions,' where the coming together of different component parts forms something beyond each part (Barad, 2003), such as an algorithm that is performed across people and crafting materials (Ma, 2016, 2017). In this way, human thought and the patterns produced through tangible manipulatives co-evolve throughout the learning process and can have a profound impact on one another (Keune & Peppler, 2019).

Taking a posthuman stance in this article means that the vignettes foreground bodies and matter as equally agentive within flattened ontological landscapes. Posthumanism is not a perfect match for our joint analysis (i.e., we came together to interpret our vignettes from a posthumanist stance). This is mostly the case because at least one vignette comes from an ethnographic tradition (vignette 3) that focuses on humans (in this case, children and young people) making and their agentive practices as playing a role. The extent to which posthumanist perspectives can be productive for the field of education remains emergent, and the existing understanding has been furthered by scholars in literacy studies, indigenous scholarship, and political ecology, to name a few (Bennett, 2010; Taylor, 2016). These perspectives position materials and human beings on an equal plane, each informing the production of the other (Coles & Sinclair, 2020). Decentering humans as the recipients of knowledge is useful for education research because it makes it possible to focus on natural patterns, the role humans play in these patterns, and what this means for the nature of education. These perspectives make it also possible to consider a broader range of actants as well as configurations of actants that are not human but play an active role in what can be learned and how.

The notion of becoming together is useful for analyzing whether and how instantiations of people and materials bring about materialized patterns of what can be conceived of as domain learning. Think back to the section on Truman's *Intratextual Engagements* research and the becoming that happens between people and matter. For example, viewing the act of crochet from a posthumanist perspective, crafters think in and through assemblages of material patterning and relational moments of crocheting that teach math skills during the making and design work. There is not a privilege of the child as the agent or math concepts as the product, but instead there is a becoming together as an assemblage (de Freitas & Sinclair, 2014). This becoming entails concrete and physical features within materials as much as it involves humans becoming during meaning-making. Becoming and knowing are conjoined because they are both called upon and insist on the role of bodies, feelings, and emotions, as well as minds, thoughts, and problem-solving (Nemirovsky

et al., 2013). Changes in learning and how learning happens can be introduced through new materialities in learning across a range of domains (Kelton & Ma, 2020; Ma, 2016).

This article explores how posthuman perspectives can uncover something about ongoing maker literacies that would otherwise remain hidden in plain sight. We look across three vignettes in international studies to illustrate how words were used, but only as secondary modes to reinforce or direct. Posthumanism plays a role in our argument; as you will see in the vignettes, we had to surface layers of intra-actions that could teach us about math, literacy, science, and arts education in ways that go beyond lock-step developmental practices. Our vignettes will show that the material basis of many literacy, math, science, and computing activities is important to provide alternative material contexts for exploring the material-specific pattern that underlies disciplinary concepts.

Conducting Materialist Ethnographies

All four of us have conducted makerspace research. As well, to varying degrees, we approach research from an ethnographic gaze, accounting for the culture of research contexts and analyzing participant identities and how they intra-act with matter and materials. The vignettes below are from separate research studies with their own respective research designs – all materialist in scope and nature but with varying degrees of ethnography. Vignette numbers one and two have more of a design, STEAM, and makerspace focus, and vignette number three is more ethnographic makerspace research. For the first research study, the original research analyzed the programming experiences of urban youth using the Scratch visual programming platform, uncovering how youths' projects demonstrated self-directed learning of programming concepts without formal instruction. For the second research study, the original research sought to investigate traditional low-tech fiber crafts as contexts for high-quality mathematics learning. In the context of a USA-National Science Foundation-funded project granted to Kylie and Anna, along with a team of fellow researchers, designed and facilitated the activity presented in vignette 2, crocheting a project using multiplicative proportional reasoning. The design is based on longer term ethnographically inspired inquiry with crafting communities across the Midwestern United States, which aligned a range of crafting practices with mathematical conceptual doing (Keune, 2024; Keune et al., 2021; Peppler et al., 2020, 2022; Saxena et al., 2023; Thompson, 2022). For the third research study, the research took place over the 2023/2024 academic year, examining how 10 makerspace schools involved in a knowledge exchange research project with the Maker{Futures} Team have taken

up and sustained maker pedagogies. A key dimension of this research is a group research blog shared across a team of maker experts (Alison Buxton, Emma Horton, Elizabeth Jansen, Sarah McGoldrick, and Saman Qarni) and makerspace researchers (Angela Colvert, Louise Kay, and Jennifer Rowsell). Alison leads this research and oversees and analyzes all of the makerspace practices. Jennifer co-researches with Alison with a focus on ethnographic dimensions (i.e., school culture, surrounding community, nature and demographics of students, types of digital literacy practices and connections with student interests, etc.) and a focus on maker properties that are representationally present (e.g., choice of materials) and that are non-representational (e.g., senses in play). In this way, all three vignettes are separate but have cross-over strands, conceptual parallels, and a common commitment to maker literacies and posthumanism (McLean & Rowsell, 2021).

Approaching artistic expression as a form of inquiry thus involves examining the connections between doing (making) and learning, not in terms of relations between technology, language, and intelligence but between craftsmanship, song, and imagination (Rowsell & Shillitoe, 2019). Alison directs Maker{Futures} at the University of Sheffield and hosts hundreds of makerspace, STEM, and STEAM events throughout the school year. Kylie, Anna, and Jennifer collect large repositories of artifactual data during their fieldwork, and student-produced materials and photographs of students making are instrumental in getting a more granular view of making practices, processes, and the unfolding of social positions within contexts. Kylie, Anna, Jennifer, and Alison also take video footage of children working on makerspace projects to capture bodies and patterned intra-actions of young people and craft materials as projects emerge from materials, like strings of yarn into crochet baskets. The documentation of these practices and processes serves as a detailed record of literacy and craft engagements.

We met online in January and March 2023 to discuss our interpretations and operationalizing of posthumanism in our research studies and decided to co-write this article. The strong appeal for us of post-qualitative lenses like posthumanism and sociomateriality from feminist methodologies (Barad, 2007; Braidotti, 2013) is that they isolate processes and practices by exploring entanglements across tools, technologies, bodies, matter, humans, and contexts. Inherent to this methodological orientation is the belief that the world is always in a state of "becoming" (Barad, 2003). More-than-human ethnographies stretch our thinking and analysis beyond matter and material foci to ask how people and their design become together across spaces and contexts. For instance, it has been fruitful and enlightening talking across American and British contexts – not to mention urban and suburban contexts. Taking a materialist ethnographic method moves away from a focus on voices, talk, and language

more broadly to move more into emergent understandings between humans and more-than-humans.

We draw inspiration about material methods from Sophie Woodward's (2020) material methods book. A material-oriented ontology is one that does not prioritize people or 'the social' or 'culture', but instead sees social relations as being simultaneously social and material and things as playing an active role in the materialization of personhood and culture. She explains that "As people and things interact, they can change each other – a process which opens new affordances" (Woodward, 2020, p. 25). There are obvious connections with posthumanism, as described above, and all four of us would describe our research in material terms. Though authors 3 and 4 might be more deeply rooted in design work with materials, authors 1 and 2 gravitate more to affective, non-representational research, so we are by no means the same in our research stance, but we all have experience conducting materially oriented research. What brought us together was a common curiosity and commitment to making and the force of materials to communicate.

Data Analysis

What strongly informed our joint data analysis are the ways that maker literacies move beyond the frame of language to open new possibilities for understanding subjectivities in the context of media and making – particularly how making transforms a sense of self through materialities. There is a posthuman commitment to our work that we share about becoming witnessed as children and young people improvise with materials and matter (Rowsell, Keune, Buxton, and Peppler). Additionally, Peppler and Keune use body studies in math learning (e.g., de Freitas & Sinclair, 2014), where the analysis of craft gestures, material proximity, and movement was used to analyze how the bodies at the table intra-acted, became a part of, and produced mathematical patterning. Jennifer and Alison examine literacy and STEAM from ethnographic approaches, getting to know children and young people and by speaking with them about their designs and then analyzing designs through a nexus account. So, yet another form of data analysis that we share is nexus analysis.

Though we met on three occasions, we jointly worked on shared Google Docs to cross-reference languageless moments and their significance for our argument. What was thrown into relief across this analytical work were the ways – particularly through our joint investigation of the Tracy vignette – that materials have a shaping force that offers tremendous possibilities for understanding subjectivities. We admit that gender was most certainly a lesser force across our vignettes and tends to maintain more of an anecdotal insistence that makerspace work blurs gender and the identity work that happened has some gender components. What we

specifically identified were moments when language was not superior and that it played a lesser role compared with the robust potential and speculative possibilities of actual matter and materials.

For all four of us, we interpret our materially oriented fieldwork on video analysis first focused on identifying relevant mathematical and literacy moments with matter. These moments allow us to get inside crafting and making, which is why Wohlwend's theorizing is so helpful and generative. Moments are identified by each of us, and the analysis centers on the construction of multimodal texts and compositions. Looking across moments makes it possible to identify patterns that we can extrapolate and start to develop broader implications for practice. The analysis of children's projects through photographs and videos presented in the next three vignettes adds another layer of sense-making. The analysis involved takes a close look at these projects and relates their patterns to layers of abstractions to identify similarities and differences between examples and children and youth projects.

Vignette #1: Nascent Desire for Peace in the "Hell Zone"

The first vignette from a California-based research study sharpens the article's focus on moving away from language during design work and letting youth be guided by intra-actions between them and materials. The vignette spotlights Jorge and how his steady design of "Hell Zone" presented an outlet for reflection on the limited options for performing masculinity as an undocumented youth in south Los Angeles. Beginning in the early 2000s, during the initial study and design of the visual programming environment, Scratch (Maloney et al., 2008), the young people testing the platform understood that they were doing something more than coding as they created interactive art, video games, and other genres of media. However, there was always a tension between the valued ways of what was being produced – number of lines of code – that aligned well with our text-based understandings of the world. Projects with complex uses of code, or those with clear storyboards and well-written dialogue were most likely to receive attention by staff, researchers, and outside viewers who have a vested interest in either language studies or computer science (Peppler & Kafai, 2007). However, when youth's work was taken to media artists, it was clear that the best work transcended the simple transcripts and indicators of what was being produced (Peppler, 2010). In fact, the pieces that were rated the highest from a media arts standpoint were from young people who were not overly interested in traditional literacies like reading, and they produced something novel (Peppler, 2010).

One of the youths that we observed in the initial design and study of Scratch was a 15-year-old Latino software designer named Jorge, as he created a shooting platformer game, "Metal Slug Hell Zone X." Closely modeled after the videogame Metal Slug, Jorge worked on "Hell Zone X" over the course of 7 months in the afterschool hours in a Computer Clubhouse in South Los Angeles. Jorge had been coming to this Computer Clubhouse regularly to avoid gang affiliation in the local community. Though pacifist by nature, Jorge had recently enlisted in the military in an effort to gain US citizenship, a move that made him both optimistic for his future and conflicted. In this context, Jorge expressed that one of the reasons for coming to the Clubhouse included the sense of focus and calm that he received when he worked on his projects.

To conform to the Metal Slug series' trademarks, Jorge downloaded sprite sheets online, drew background elements to match the original, and participated in online fan communities to understand the specifics and nuances of video game programming. As a demonstration of his attention to detail and programming prowess, much of Metal Slug Hell Zone X looks and feels virtually interchangeable with Metal Slug, from the splash screen and character selection navigation down to the polished visuals, smooth animation, and character actions. What is striking about Jorge's game, however, is that over the course of several iterations, he intentionally removed all enemies from the game, seemingly playing on the "run and gun" videogame genre itself. There is no one to kill (or be killed by), no blood, no aggressive music, and no violence at all. Instead, he focused on creating a smoothly animated protagonist and a space for this character to dwell, accompanied by floating clouds and rolling, purple mountains.

The overall effect of this stripped-down re-envisioning of Metal Slug brings to mind the work of professional media artists like Myfanwy Ashmore or Cory Arcangel, whose installation artwork (created around the same time as Jorge's "Hell Zone", though Jorge was not aware of their work) involves modifying a Super Mario Bros. game cartridge so that only a blue background with white, pixelated clouds slowly scrolls across it. While it is tempting to interpret Jorge's game protagonist, armed but exploring the world in peace, as a metaphor for his complicated feelings about joining the military, this is not something that he ever put into words.

The challenge of talking about this work in academic circles is that, unless the youth can verbally describe their intentions around the work, the underlying interpretations can get easily dismissed. Does Jorge need to verbally articulate a critical analysis of his own game for his artifact to demonstrate evidence of learning? It's worth mentioning that Arcangel, whose work was most analogous to Jorge's game, described Super Mario Clouds very differently than the "quietly animated fusion of Pop, Minimalism and giddy innocence" analyses that accompanied its installation debut at the Whitney Biennial:

> I'll say, 'that's an Internet art piece,' and they'll say, 'What are you talking about? That's an installation.' But the first version of the piece was a Web site that I made that explains to people how to make it.

While we often allow others to speak for the artist in the world of professional art, the primacy of language in K-12 settings makes it difficult to accept expressions that are not articulated into words. And, yet a posthumanist perspective on Jorge's work acknowledges the agency and influence of non-human actors, highlighting the co-constitutive relationship between humans and non-humans in the design and consumption of media. Jorge's iterations of the game over the course of 7 months demonstrate a clear pattern of reflection: From an almost parodic supersizing (from Metal Slug to "Metal Slug *Hell Zone X*") of an already-hypermasculine game genre to a meditative media art piece due to the intentional removal of obstacles that would incur violence. A posthuman perspective on this case allows the artifact to take on a life of its own, not insomuch an encapsulation of a clear and intentional idea of Jorge's but rather a complex entanglement between humans, technology, and media. Thinking beyond the frame of language opens new possibilities for understanding subjectivities in the context of media and making, particularly in how media technologies and practices transform and reconfigure our sense of self, identity, and embodiment. When we consider posthuman perspectives on making, we can deepen our understanding of the complex interplay between humans, media technologies, and the socio-cultural contexts in which they are situated.

Vignette #2: Crocheting into Mathematical Concepts

The second vignette from a Midwestern United States-based research project speaks to the article's disruption of the importance or 'imperial position' of language – especially to explain and demonstrate math concepts. In our work on the learning of math concepts through fiber crafting (Keune, 2024; Keune et al., 2021; Peppler et al., 2020, 2022; Saxena et al., 2023; Thompson, 2022), we explored how mathematical elements in fiber arts can provide a unique perspective on mathematical concepts, making them more tangible and applicable to real-world contexts. Through the introduction of fiber crafts as a valued and appreciated material for mathematics performance, we brought in gendered material discourses that question the norms and practices of maths learning. The vignette tells about the rich production of maths happening when activities are designed based on non-traditionally

used materials of mathematics learning opportunities. Correspondingly, this surfaced the tension between crafting-as-maths, which is a form of maths articulated and necessarily employed in a produced artifact, and maths as written formulas. In other words, are affective, embodied, or performative dimensions of "mathematical doing" enough to signal learning, or is it only measured when this learning is transferred into written abstractions or verbally summarized? With the following vignette, we illustrate how language is not only incidental and add-on; it does not help the youth, Tracy, figure out math principles in the same way that yarn does. The posthumanist lens on making in the sense of languagelessness makes room to value patterned relational movements as a substantial aspect of learning conceptual ideas.

As part of a 3-day fiber crafts course at a Midwestern public library, Tracy, a 14-year-old girl, learned to crochet a pink circular bag. The resulting artifact, in addition to gestures that she used to teach others her process, demonstrated evidence of multiplicative proportional reasoning, a higher-order thinking skill that allows individuals to make sense of situations involving ratios, rates, scaling, and proportional change. However, like Jorge's vignette above, Tracy did not refer to the process of crocheting her bag as being inherently mathematical; her speech and gestures referred to repetitive actions (but not necessarily mathematical calculations) or they addressed determining gauge and scaling patterns (without referencing concepts like ratios, fractions, and conversions). In short, although numerical and spoken language are often associated with 'mathematical doing', we show here how little numbers and words featured in her mathematical performance without compromising the complexity of the engagement. In doing this analytical work, we employed numerical and written formalisms, illustrating the necessary language to make visible the complexity of mathematical doing that Tracy produced while crafting.

Tracy's bag was composed of four rows: a magic circle (i.e., a technique used to start a crochet project that begins with a round shape) of six stitches, a row that increased the circle, and two rows that produced the bag's wall (see Figure 1). The six-stitch magic circle presented the basis for stitched multiplicative proportional patterning, as the circle had to scale proportionally with relation to sectors per row and within-sector relationships of proportional growth as Tracy built the bag. As her crocheting hands looped yarn around hooks to increase the number of stitches per row and distributed them across the outer edge of her bag, they repeated a nested pattern: Go through the stitch, yarn over, go through the stitch, yarn over, go through one, yarn over, go through two, and so on (see Figure 2).When Tracy's neighbor asked her for help in how to increase the circumference of their magic circle, Tracy produced the steps by hand instead of verbally articulating the parts of the stitch. She took the project and looked closely at it to identify the progress of the pattern and the stitch before she demonstrated how to continue, suggesting that felt and tacit learning happens because of the assemblage of wool, needles, bodies, thoughts, fingers, movements, etc. This is rather a commonplace phenomenon of early understanding demonstrated by the manipulation of materials, like the difficulty of explaining how to tie a knot only with words as compared to demonstrating the technique to others.

Did identifying the pattern in her neighbor's project and knowing how to create a "relationship" between the initial pattern to multiplicatively scale the project signal that Tracy had learned and applied the concepts of multiplicative proportional reasoning? We analyzed the relationships involved in the nested expansions of her three-row-wide flat circle (see Figure 3, left). Row one was a magic circle with 6 stitches, row two had a circumference of 12 stitches, and row three had a circumference of 18 stitches, producing a $1/6 = 2/12 = 3/18$ relationship, which

FIGURE 1
Tracy's Project (Adapted from Keune & Peppler, under Review)

FIGURE 2
**Step-by-Step Breakdown of Tracy's Crochet Stitch (Adapted from Keune & Peppler, under Review)**
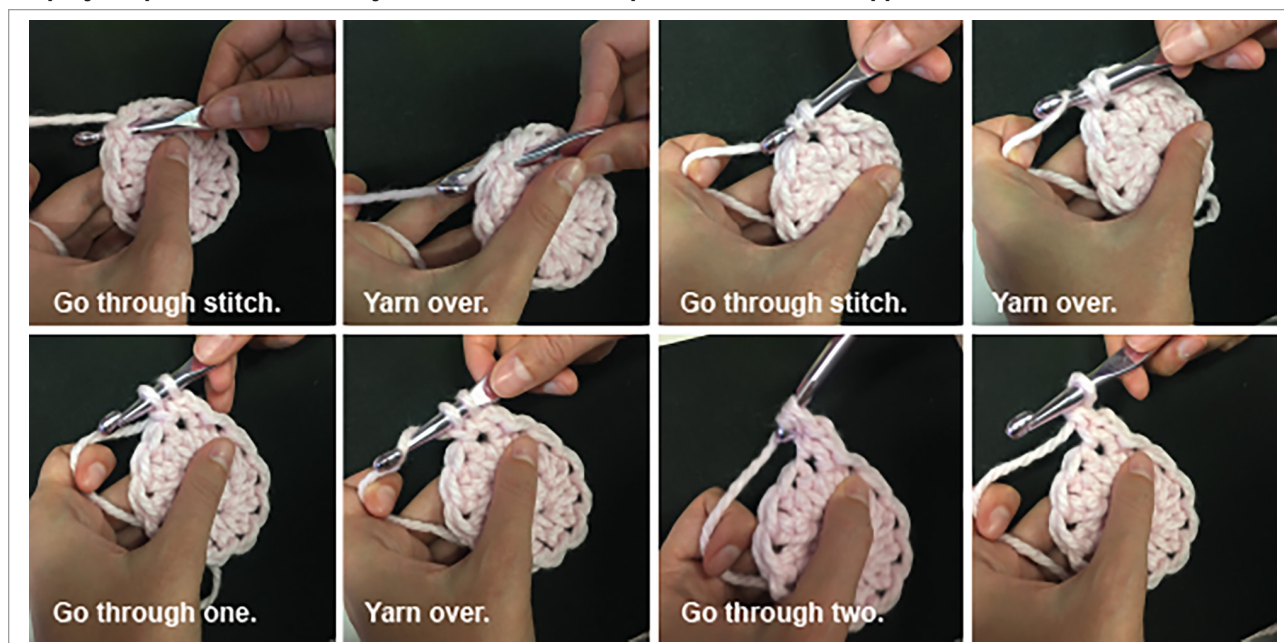
stands for 1 stitch per sector with 6 sectors and the total number of stitches per row, and so on. The resulting 18 stitches required equal distribution across sectors for the circle to lie flat. This ended up not being the case in Tracy's project, as her stitches were malleable enough that hyperbolic curvatures emerged, as more fabric was produced that could not spread apart in space without curving and curling.Even though the interplay of youth–hook–yarn produced stitches that varied in terms of being loose or tight, taking up more or less space, the resulting project demonstrated units with nested relationships that followed within-sector relationships of proportional growth. Focusing only on Tracy's lack of verbalizing the formalism of a stitch (i.e., translating multiplicative proportional reasoning into verbal articulation) overlooks the fact that her project utilized the exact distribution of stitches per row and sector as evidence of becoming without primacy of the language. With the fact that the intra-action of Tracy, yarn, and hook produced material traces and an understanding that is not yet verbalized, we can see how the plane of knowing began in this knowing-through intra-action. At no moment was Tracy a "docile body" (Foucault, 1977), rather her many movements, distortions, and re-doings signaled wisdom and awareness of matter and learning through matter.

This is not to say that language did not play a tangible role in Tracy's learning process. For instance, it formalized the stitch pattern into something that could be identified, pointed to, repeated, corrected, and praised. Yet, the translation did not lead to transformative social interactions. In fact, we argue that the making of the stitch without words, the patterning of the stitches into a bag shape, made it possible for Tracy to become a living part of the multiplicative phenomenon, to make it come real through a felt sense of material increase, decrease, and directional growth.

The analysis of the patterned relational movements shows how the youth and the crafting materials (including crochet hooks and yarn) have to work together toward the production of a mathematical artifact. The analysis closely aligns traditional low-tech fiber crafts practices that are socio-historically connected with the practices of women (Plant, 1995) with a mathematical concept that is core to future maths success. Constructing alignments like these holds implications for inclusive STEM learning, including gender inclusion, because they illustrate how a wide range of cultural practices can be associated with learning maths and, in this way, broaden who might feel like they belong. What is more, such alignment of crafts with maths expands how maths is done and what educational stakeholders may consider as mathematical doing, therefore expanding the domain of learning itself toward more inclusive knowledge practices. Designing with fiber crafts in mind altered what we need to recognize and appreciate as mathematical doing and, ultimately, learning as distributed across the material performative practice. We understand this mathematical crafting as a subversion based on gendered sociomaterial discourses associated with crafts that subvert not only how maths is done but also suggest that we have to start to question how we might capture maths learning.

FIGURE 3
A Circle with Equal Stitch Distribution (Left) and One with Lopsided Stitch Distribution (Right) across Six Sectors and Three Rows
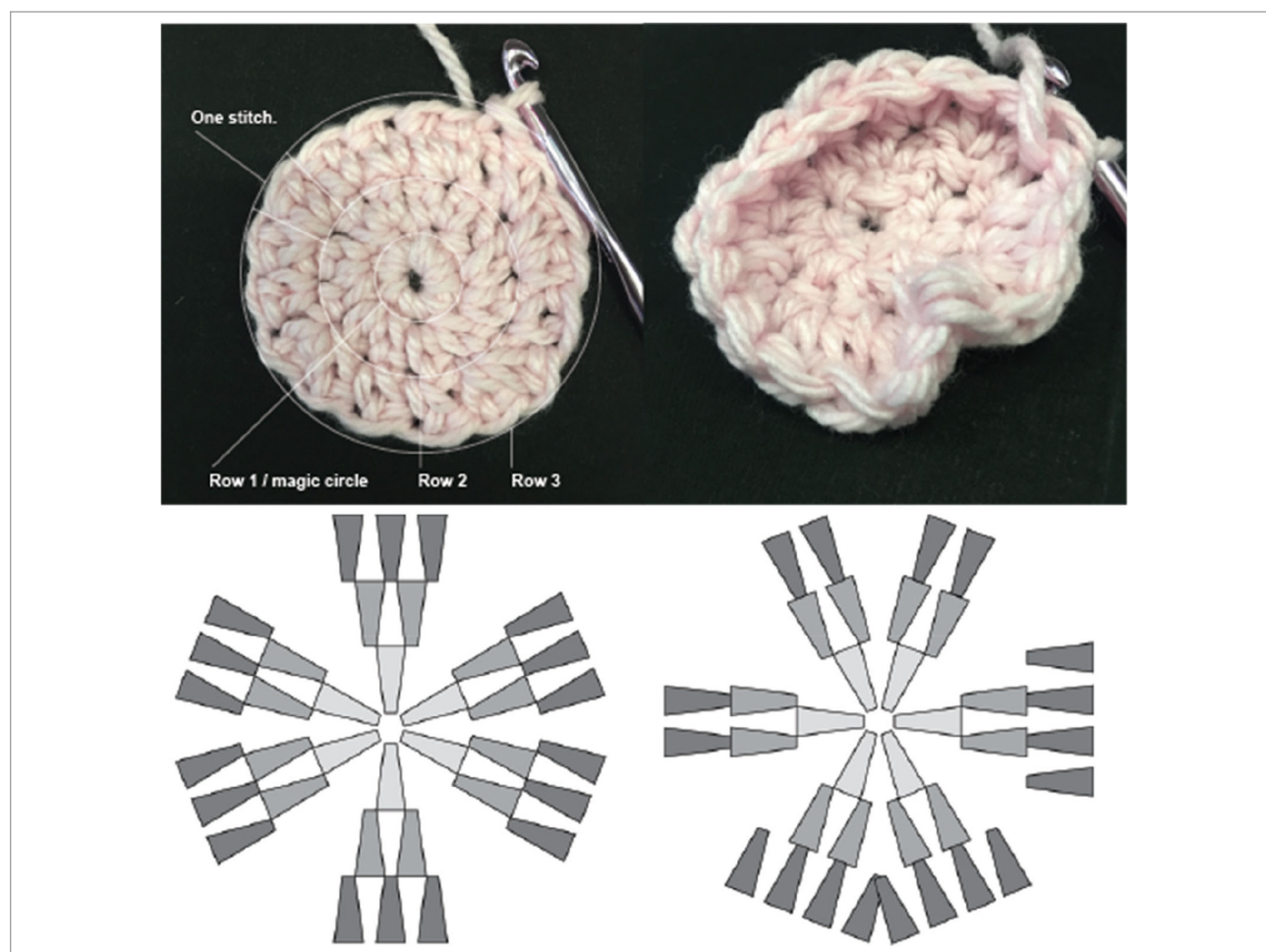
Vignette #3: Making it Work, beyond Words and Instructions

The third vignette centers on a makerspace program that is part of the University of Sheffield in the United Kingdom. The program provides makerspace sessions for primary and secondary schools around the city of Sheffield. During the 2023/2024 academic year, Jennifer, Alison, Louise Kay, and Angela Colvert conducted a one-year exploratory study with Maker{Futures} on ways that teachers adopt a maker philosophy that Alison calls 'maker spirit' which is embedded into all content areas across primary and secondary grade levels. This vignette took place in the middle of the academic year, in January 2024. Like vignette one, this moment spotlights a male youth (a 12-year-old) during what Alison calls a Skill Builder session that ran over an afternoon. The focal school is a special school, which in the United Kingdom refers to a special education school in North American terms. There

were 15 children in this classroom who ranged in age from 11 to 13 in attendance on the day that we came in, and some of these young people are neurodivergent, some have social and emotional needs, some have physical disabilities, and others have speech, language, and communication needs. Tobey, our profile learner, is non-verbal and neurodivergent. Alison sat with him for an afternoon, and what became clear after her time with him is that words were not only unnecessary for his design work, but actually, words (spoken, written, and read) did not serve him well during many learning encounters in his secondary school. Alison identified this after speaking with Tobey's teacher and the teacher support worker.

Alison sat in on a lesson taught by Liz (another makerspace expert) about designing with recycled materials. The lesson centered on making designs out of everyday recycling like plastic bottles, cardboard, milk bottle caps, egg cartons, and plastic butter or margarine containers. The session began with Liz reading a picture book entitled, *The*

Adventures of the Plastic Bottle, and then she asked students at each table (four students at each table) to sort recycling in bags into categorized piles (e.g., hard plastic pile; soft plastic pile; hard cardboard pile; and soft cardboard pile). Then, she asked students to construct something that they can use or that is meaningful to them out of the recycled cardboard. Tobey listened for part of Liz's lesson, but he was often distracted, and Alison decided to create her own activity with him.

When Alison watched Tobey sorting through the parts, bits and pieces, and technologies to make something, he quickly and efficiently worked with his hands. It was not always orderly or comfortable watching him struggle a bit with tasks. Noticing how much Tobey enjoyed taking things apart and putting them back together, Alison went over to an electronics kit and gathered a handful of components, including battery packs, batteries, crocodile clips, LEDs, a buzzer, and wire connectors. Alison deliberately decided not to pick up pre-fab electronics kits with visuals saying how to put components together and instead, presented Tobey with bits and pieces – batteries to put into battery packs, crocodile clips, connectors – knowing that what Tobey likes most is the culling, assembling, and completion of a task. And it worked; Tobey quickly picked up the battery pack and slid in the two batteries. He then picked up the cover for the battery holder and studied the sliding mechanism. Without hesitation, he slid the lid into position. Alison noticed this particular action because it was not obvious how it attached, and, in Alison's experience, it often takes a few attempts. Tobey then picked up a plastic rocker switch, which is a wire connector, a solderless wire connector, and attempted to push the wires into the connectors. This was not easy either, and it took him many attempts to get it right. Alison physically showed him how to press down on the battery connector, and then she showed him that they were mini-rocker switches. It took Tobey a while to get the wires into the connector. Tobey didn't get frustrated and was very happy to just keep trying and changing his technique each time and try something different. He tried approximately 10 to 12 times before getting the wires in the correct place. He seemed a little lost at what to do next, and author 3 suggested he could use the crocodile clips as another way to connect the battery to the LED. Now, the key thing to note here is that no words were spoken during this 30-minute interaction. It was purely digits moving, looks exchanged, moving parts, nodding, and clapping.

It was completely languageless and, in the end, it was clear to Alison (who is an engineer herself) that Tobey had a very good understanding of each component and how they work together as a system. It was also clear that he worked through each circuit area systematically to find faults. This is a competent skill in electronics. Toward the end of the session, Tobey looked up and saw one of his peers on another table with a small cardboard helicopter. He had used a motor to make the blades spin. Tobey was interested in this and took his electronics over to show his friend. He looked carefully at his friend's helicopter; he didn't have the words, but it was clear he was making links between what he had made and what his friend made, and the other materials (cardboard and plastic) laid out on the table.

Alison sat beside Tobey and watched everything that he did. Alison, Jennifer, the teacher, and teacher's aid (TA) discussed how Tobey and other learners in the classroom are not linear learners and struggle with too much direct teaching and not enough active learning. The discussion touched on a gender element to these observations in that many of the male learners they work with tend to like open, participatory types of learning activities. In terms of Tobey, he much preferred to work independently on sorting tasks and figuring things out. When Jennifer and Alison debriefed about their day in the school, they agreed that he was not causing mischief or disruption, but really it was more for Tobey about making things work and giving the room order. When Alison spoke with a teacher about Tobey after the lesson, he shared, "because he tries to take all of the cables out of the computer sometimes. Then he is trying to drag the cables and plug them into the lights because he just wants to know how everything works." So here, there is a stated objective to let him roam about as long as he is monitored for safety.

Tobey understands how things work. The TA showed Alison other electronics around the classroom with sticky labels that said, "Tobey do not touch and he then explained that they were quite often having to stop Tobey from disconnecting the class computers and try to connect the wires into the whiteboard." Jennifer and Alison discussed how this habit of connecting wires, fixing things, etc. displays skills that are often hidden and unacknowledged. What Alison noticed is that Tobey wants to make things work, make things work better, and most importantly, understand how things work.

Debriefing about the day and what they both observed, sensed, and learned, Jennifer and Alison talked about different learners, and Alison talked about lessons learned from Tobey. It would misrepresent the research moment and mischaracterize Tobey to put a normative and gendered framing on the afternoon. There is likely a gendered and normative lesson to be learned from Tobey, but it would take far more observations about how he learned in the classroom context. However, what is clear from this specific afternoon and subsequent visits to the secondary school is that Tobey, as a non-verbal learner, flourishes when he makes and experiments, when he moves beyond the often restricting confines of scripted, rote, written, and spoken learning, and when he moves into active making and tinkering.

Conclusion: Making More than One Language Possible

The vignettes are different in nature, scope, population, and subject domains, yet there is a common commitment to matter and making and to the ways that children and young people become through materials. Jorge, Tracy, and Tobey did not require language to figure out what they were doing, making, and discovering through materials, tools, and technologies. A question at the heart of the article is, if you take language completely out of the picture in each vignette of making, how are these learning events different? While language serves as an important medium through which individuals can communicate and shape their understandings, there are reasons why the primacy of language does a disservice to the ways in which we observe and assess learning in maker activities. This contributes to work in digital literacy and the learning sciences that expand language as the primary form of evidence for reasoning and learning (e.g., Kumpulainen & Kajamaa, 2019; Mehto et al., 2020) as we show what is being produced that the children and young people in our work are part of producing. When the translation of making into language is the *a priori* indicator of learning, children and youth descriptions of making that do not align with intended learning outcomes are seen as indicative that they may not fully grasp or comprehend certain concepts or ideas.

Yet there are several factors that can contribute to children and youths' sparse verbal articulations of their learning, particularly when attempting to describe complex entanglements between their mind, bodies, and the physical world. For one, children and youth descriptions of their learning can be influenced by their personal perspectives, unintentionally emphasizing certain aspects of their learning (e.g., designing a bag that reflects their personal taste) while relegating others to be of secondary importance (e.g., the math required to construct it), leading to an incomplete or biased representation of their actual learning experience. Children and youth's descriptions of their learning can also be influenced by external factors, such as peer pressure, gendered expectations, or the desire to present themselves in a certain way. Jorge's zen-like game modifications, for instance, markedly contrast with the hypermasculine presentation of the rest of *Metal Slug Hell Zone*. This may lead them to provide inaccurate or under-embellished descriptions that do not truly reflect their actual learning. Additionally, some youth may struggle to critically reflect on their learning experiences or may have limited self-awareness regarding their own learning processes, resulting in superficial or oversimplified descriptions that do not capture the depth of their learning. Alison had a front-row seat on how generative and energizing it was for Tobey to have free will with stuff (crocodile clips or battery leads), and this increased the convictions of the research team about silence

and language-free work. In assessing the kinds of learning that transpire during a maker activity, it is important to recognize that the process of conveying intricate or abstract concepts using language is a discrete skill separate from the creative, physical, and domain-specific concepts engaged during making, involving carefully selecting and organizing words to effectively communicate the complexity of an idea to others. Considering only youth's verbal articulations as the extent of their learning assumes that clarity, precision, and the ability to break down intricate concepts into understandable terms are assumed skills and not ones that require the honing of metacognitive skills, critical thinking, and the giving and receiving of constructive feedback apart from youth's making.

As the Rilke epitaph at the start of this article suggests, words sometimes fail to capture the essence of experiencing life (Ehret, 2018). Building on a rich history of new literacies research, there are various ways beyond language through which we can recognize learning, especially in activities that involve tinkering with physical materials, tools, one's body, and one's creativity to bring an idea (which may be emergent to begin with or change mid-process) into tangible existence. Making is a hands-on experience that entangles multiple senses; learners feel the texture of materials, experience their weight and resistance, and manipulate them directly, providing an intimacy between the mind and the physical world. Through making, learners transform abstract concepts or intangible thoughts into concrete objects that reflect their unique perspectives. As learners encounter obstacles during the process, they are prompted to find creative solutions, experiment with different approaches, and adapt their methods. The vignettes above feature the ways in which children and youth transformed raw materials into finished products that they crafted with their own hands, providing them with a tangible representation of their skills, effort, and dedication and fostering a sense of personal achievement. Engaging in making can provide a sense of continuity and appreciation for the knowledge that has been honed over time within one's family or heritage. Additionally, maker culture frequently emphasizes collaboration and knowledge-sharing between people or within communities. By participating in maker activities, many individuals learn to collaborate with others, share expertise, seek advice, and communicate their ideas effectively. In sum, the experience of making combines artistic expression, problem-solving, creativity, and a tangible connection to the physical world, allowing learners to engage their senses and create objects that hold personal meaning and value. By considering maker culture as a form of literacy, we acknowledge the value of hands-on, experiential learning, problem-solving skills, digital literacy, collaboration, creative expression, and adaptability in an era when creating and making are becoming increasingly significant in various

aspects of life. There is a quote by Meireles when she says, "materiality makes more than one language possible" (1995, p. 161). It is a generative way to end our article because the core argument is that making in learning contexts forges a spirit of democracy across modes. In brief, matter and making allow for multiple languages.

The reason why we used maker literacies and posthumanist frame in this article is because the act of making is far more co-constructed between the maker and the physical world than a purely cognitivist lens (i.e., language as the ultimate representation of learning in making practices) can accommodate. The primacy of language suggests a direct relationship between an external artifact and a maker's organizing and structuring of their thoughts, concepts, and experiences. In actuality, the vignettes included in this article show that making involves far more emergent meaning-making, where makers tinker with various solutions and adapt their projects based on feedback from early drafts of their projects, not entirely conscious of what makes them gravitate toward one solution over another. In this way, we argue that posthumanist explorations of the impact of emerging technologies on human identity, agency, and embodiment are better suited to capture the broader socio-cultural implications of technology and its influence on human cognition, agency, and identity.

Furthermore, this investigation also examines the ways in which language, as an *a priori* measurement of learning, can play a role in maintaining or reinforcing unequal power relationships between genders. The language that is used to describe spaces and learning activities can contain stereotypes and biased expressions that reinforce gender roles and expectations. For instance, certain words or phrases may be associated with specific gendered behaviors, occupations, or characteristics, reinforcing traditional gender norms. Biased language can limit opportunities and shape perceptions of what is appropriate or expected for boys and girls, potentially reinforcing unequal power dynamics. This article ruptures normative framings of what subject domains like literacy, math, and STEM should be and how they should be done, instead suggesting that material-affect-modal intra-actions make it possible to become part of the product-oriented processes that give shape to their underlying explanations. This way of framing, researching, and theorizing learning moves beyond a transmission view of teaching, but most of all, it moves beyond a reliance on words and language to learn, solve problems, and be together in contexts.

Our objective in this framing is to foster more equitable spaces for learning that empower individuals from all backgrounds to engage in creative expression, develop skills, and contribute to the broader maker community. Maker culture encourages individuals to explore their own ideas, passions, and creative expression. It provides a platform for individuals to develop their unique voice, interests, and personal agency through making. This form of literacy enables individuals to communicate their perspectives and values through the artifacts they create. Considering diverse modes of assessment provides students with multiple ways to demonstrate their learning. This recognizes that different individuals have varying strengths and preferences for expressing their knowledge and skills beyond the traditional use of language. By offering a range of options, educators can support the diverse needs and talents of youth and create a more inclusive and engaging learning environment.

What happens when literacy, math, and STEM teaching moves into wordlessness? Words and language are as much material actors as images, movements, and sounds, and in many ways, other modes beyond language collapse the boundaries that language constructs. In other words, there is more of a propositional and speculative feel to making, crafting, and matter more broadly, and we hope that our bird's eye view into three contexts invites more ways to expand, redefine, and disrupt.

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