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Equity & Excellence in Education

ISSN: 1066-5684 (Print) 1547-3457 (Online) Journal homepage: https://www.tandfonline.com/loi/ueee20

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To cite this article: Filiberto Barajas-López & Megan Bang (2018) Indigenous Making and Sharing: Claywork in an Indigenous STEAM Program, Equity & Excellence in Education, 51:1, 7-20, DOI: 10.1080/10665684.2018.1437847

To link to this article: https://doi.org/10.1080/10665684.2018.1437847

EQUITY & EXCELLENCE IN EDUCATION
2018, VOL. 51, NO. 1, 7–20
https://doi.org/10.1080/10665684.2018.1437847

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ABSTRACT

In this article we expand on ideas of making and maker spaces to develop Indigenous making and sharing. We draw from an ArtScience participatory design project that involved Indigenous youth, families, community artists, and scientists in a summer Indigenous STEAM program designed to cultivate social and ecologically just nature-culture relations grounded in Indigenous ways of knowing, being, and making. In this article we focus specifically on clay making and the ways in which onto-epistemic heterogeneity can be engaged to create transformative maker spaces. We present findings from an analysis of the pedagogies of walking, observing and talking lands and waters to outline principles of Indigenous making and sharing in youth-based learning environments.

I was able to connect with those that came before me. The manipulating [of clay] and using my hands in some version of the form that had been done generations and generations ago was incredible. I don't know how else to put it. It was amazing to have that space and time … I don't think there has been a time where I was that connected to ancestors.
–Miguel, Indigenous Scientist

Reflecting on doing claywork—making with clay—for the first time, Miguel describes the intertwining of making with the opportunity to learn and enhance his relations to history, culture, and community (ancestors) while feeling and engaging in practice. Miguel narrates making with his hands as a deeply cultural and identity driven activity and, though perhaps implicitly, we argue as a profoundly political one as well. Given the history of colonialism and the intended erasure of Indigeneity throughout the world, we argue Indigenous making and sharing opens possibilities for Indigenous forms of learning and being that cultivate and enact Indigenous presences (Vizenor, 1998) and futurities. Importantly we are not suggesting that Indigenous making is a subset of a broader category of the newest articulated generation of making, rather we are suggesting that making is a human practice and, in this case, a part of human hand work (e.g., Rose, 1999).

Educators and scholars have argued that making and makerspaces have the potential to cultivate new forms of learning and equity, in part because they mobilize youths' everyday interests and practices with new forms of activity (e.g., Barron, 2006; Calabrese Barton, Tan, & Greenberg, 2016; Halverson & Sheridan, 2014; Ito et al., 2010; Sheridan et al., 2014). However, as these and other scholars have argued, the purposes, relationships, and identities afforded by and structuring interaction and meaning-making in makerspaces are vital in realizing such potential (see Vossoughi, Hooper, & Escude, 2016; DiGiacomo & Gutierrez, 2016). Further, how the field conceptualizes, narrates, and positions the current generation of making with historicized, everyday, or currently othered forms of making is critically important if making is to have expansive and consequential impacts, particularly for youth and communities

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historically placed at risk. As Vossoughi et al., 2016 argue, the maker movement tends to privilege the creation of products over people in ways that are representative of normative white culture and activity, and are positioned and motivated by economic growth and nation state development. They argue that developing makerspaces that can support transformative learning for youth from non-dominant communities requires developing pedagogies that include: (1) critical analysis of educational injustice; (2) historicized approaches to making as cross-cultural activity, (3) explicit attention to pedagogical philosophies and practices, and (4) ongoing inquiry into the socio-political values and purposes of making. These dimensions reflect and build on equity-oriented research from the broader field of science education, which has focused on understanding identity and cultural practices in science learning (e.g., Bang & Medin, 2010; Barton & Tan, 2010; Emdin, 2010; Nasir, Rosebery, Warren, & Lee, 2006; Tzou & Bell, 2012; Brown, Cook, & Cross, 2016).

In our own work, we have studied how relational epistemologies (ways of making knowledge) and ontological premises (foundational assumptions about the nature of being) about nature-culture relations that are central to phenomena typically associated with science education shape teaching and learning. More specifically, we have sought to understand how the relations between human worlds and natural worlds are culturally constructed, impacting not only forms of practice and engagement but also forms of knowledge, knowledge organization, and reasoning and sense-making about phenomena (Colleague & Author, 2014; Bang, Warren, Rosebery, & Medin, 2012). From this perspective navigating onto-epistemic heterogeneity is fundamental to science learning (Rosebery, Ogonowski, Di Schino, & Warren, 2010; Author, 2016). Many STEM learning environments simply ignore the existence of other ways of knowing or more actively deny their legitimacy, reifying historically saturated claims to epistemic superiority and deficit models of non-dominant students and communities. Thus, learning environments that take seriously the demands of onto-epistemic navigation are focused on transforming powered relations between knowledge systems to support students to engage in consequential (Gutiérrez & Jurow, 2016) and resurgent forms of learning and doing.

The work we present in this article makes contributions to broader equity efforts in the making and tinkering movement by deepening understandings of how culture, identity, and power are central to making, and details possible forms of making practices as well as pedagogical practices. More specifically, we propose that onto-epistemic constructions of nature-culture relations are central to making because they shape culturally and sociopolitically consequential constructions, orientations to, and practices with materiality. What is defined as "material" and how relations to particular materialities are narrated and enacted are reflective of knowledge systems. Given the challenges of the 21st century are largely reflections of problematic constructions of materiality seeped in human entitled nature-culture relations leading to unsustainability, we suggest that if makerspaces are serious about transformative and equitable learning, they must take seriously the kinds of material relations (i.e., capitalist markets and resource extraction) undergirding maker activity. Given these broader perspectives, our main aim is to explore and articulate how making practices and pedagogies emerge in activity systems based in Indigenous knowledge systems.

A key aspect of our work has been to desettle the sociopolitical values embedded in making, especially constructions and relations with materiality which are a key site of settler-colonialism, in order to begin to articulate Indigenous making on its own terms. King (2013) argues settler-colonialism manifests both materially (primarily through conquering, owning, and commodifying land) but is also a concept that organizes the conceptual ecologies of settlers that allows and enables ideas to become desired and developed into commodities. Further King and other scholars (e.g., Escobar, 2007) argue that relations to materiality, more specifically ones central to settler-colonial societies, structure epistemological activity, aesthetics, and imaginative processes of creation—all of which are central to making. Importantly, Indigenous art scholars, echoing Fanon (1963), have increasingly called for Indigenous arts and aesthetics to be a critical site of fugitive Indigenieties, in which the material struggle for decolonization is engaged and resisted. Further they have worked to make visible the ways in which Indigenous arts and aesthetics are subject to enclosure within capitalist markets (Martineau & Ritskes, 2014). Often constructs of materiality are reflective of and linked to the origins of settler-colonialism—land/water and the Cartesian cut from life to constructions of property and/or the powered transformations of life to material resource or

good for human entitled use (e.g., Barad, 2010; Deloria, 1979; Wolfe, 2006). While recognition is important, we aimed to refuse decolonization as a metaphor (Tuck & Yang, 2012) and create spaces in which resurgent forms of Indigenous relations to land/waters are central. We posit that a central challenge to creating equitable and transformative learning in makerspaces in the 21st century rests on the extent to which cultural variation in meanings of and relations to materiality are engaged and how dominant forms of material use are disrupted and transformed.

In this article we aim to explore Indigenous perspectives on making and learning that unfolded in the context of the summer program that aimed to cultivate living Indigenous ontologies, epistemologies, axiologies, and cosmologies in learning, practice, and being. This learning environment supported youth living in currently named urban territory in imagining socially and ecologically just nature-culture relations in the present and in sovereign futures. One of us is from the territories of central Mexico and one of us is from the Great Lakes, and our own positionalities as Indigenous scholars and educators, who challenge western frames and are working to develop Indigenous-based solutions, are important. In addition to living and raising families in Indigenous communities, each of us has spent important time and effort working in both school and community-based contexts with families and communities to develop learning environments that are transformative for our communities. It is from this perspective that we narrate the work undertaken in the Indigenous Science, Technology, Engineering, Arts, and Mathematics (ISTEAM) summer program and consider the ways in which such work can offer expansive forms of making and intervene in Indigenous erasure by focusing on Indigenous resurgence. We ask:

- What forms of making and pedagogical practices are enacted during Indigenous making and sharing?
- How do facilitators narrate and cultivate Indigenous forms of making and sharing?

We examine an interview with an adult program facilitator that was conducted after the program, as well as three episodes from the art studio activities that focus on the making and pedagogical practices from the summer camp. In our analysis we focus on understanding the ways in which multidimensional dynamics of Indigenous knowledge systems manifested in facilitators' practices and narratives and propose a beginning set of principles for Indigenous making and sharing.

Design and context of learning environment

Historically, Indigenous communities, like all cultural communities, have developed their own technologies and practices of making to engage the world. Towards honoring this truth, this participatory design research project (Author & colleague, 2016) involved Indigenous youth, families, community artists, and scientists from the Seattle intertribal community in co-designing a summer program aimed at cultivating Indigenous nature-culture relations through a focus on pedagogies of walking, reading, and storying lands and waters as the foundations in making activities (Cajete, 2000; Marin & Bang, accepted; Kawagley, 1995). In the camp, we designed across three primary forms of daily activity to cultivate Indigenous making and sharing, including: storytelling (communicating meanings, feelings, ways of being—including elder storytelling), walking (noticing and being present with stories in places with more than human others), and making (clay making—among others mediums). Over the past four years the two-week summer program served over 100 1st–12th grade Indigenous youth with the goal of helping to prepare them to take on the 21st century challenges of changing complex socio-ecological systems that define both Indigenous and non-Indigenous peoples futures. We deliberately engaged Indigenous artists and scientists to share perspectives and practices both in the design of the camp and in implementation. These forms of engagement reflect an ethic of imagining possible futures for Indigenous youth through embedded professional development for facilitators and explicit design towards a practice that enabled multiple identity pathways and role models for Indigenous youth during the camp.

We began with a series of design principles. First, we developed learning environments in which the practices of making and sharing enacted refusals of settler colonialism and Indigenous erasure (e.g., Calderon, 2014; Tuck & Gaztambide-Fernández, 2013), which had denied Indigenous peoples' the right to assert our own culturally-based ways of being and doing. Making is a millenarian practice that Indigenous communities have developed as a technology in the past and in the present. Frequently, technologies

are rhetorically synonymous with the West with newness and innovation as desired qualities. Technologies whose life courses are much older are often erased completely or positioned as antiquated heritage practices within settler-colonial paradigms (Bang, Marin, Faber, & Suzukovich, 2013). Indigenous technologies, like clay making and weaving, when not made completely invisible, are often reduced to artistic expressions only or deemed irrelevant to contemporary problems and solutions. In our programs, we disrupt these narrative trajectories to locate technologies as persistent and growing within Indigenous time—past, present, and future—and made visible their foundational principles of sustainability and dynamic relationality. Further, we worked to embed and guide these ontological stances about technology within our pedagogical practices. More specifically, we took up and reclaimed clay making as an original technology that continues to nurture the way Indigenous people manifest their relationship with the land.

Second, we aimed to cultivate practices that supported onto-epistemic heterogeneity (Rosebery et al., 2010) and transformative forms of onto-epistemic navigation between Indigenous ways of knowing and western ways of knowing in sense-making and embodied practice. While we privileged Indigeneity, we also engaged young people in western ways of knowing and with western forms of making. We aimed, however, to do this in ways that supported Indigenous children to critically utilize dominant knowledge (western ways of knowing) as (and when) useful tools but not be dominated by them. We aimed to create a learning environment that refused the epistemic and ontological violence (Marker, 2006; Bang, Curley, Kessel, Marin, & Suzokovich, 2014) and erasure that normative STEM educative spaces deliberately or heedlessly inflict on Indigenous peoples to cultivate and enact resurgent land-based pedagogies, Indigenous arts, and critical cultural revitalization (Simpson, 2014).

Third, we focused on key forms of Indigenous pedagogies, including storytelling and walking, in community relations. We designed for young people to engaged in story work (Archibald, 2008) through relations with storytellers and to practice storytelling. Further, we designed for mobile activities of walking and observing in lands/waters. This design principle is central to the analysis and will be further elaborated below.

Fourth, we aimed to cultivate youths' observational practices in order to support sense-making and to engage in making as a resurgent and humanizing way of contributing to their own communities. Thus, we worked to engage youth in practices of making as continual cultural practices and enactment of nature-culture relations to fulfill family and communal responsibilities or toward what Whyte (2013, 2014) has called collective continuance.

In our program, youth learned in and about multiple ecosystems (forest, wetland, and ocean/beach) and, as part of these inquiries, youth selected among multiple modalities (e.g., claywork, weaving, mobile digital stories, e-textiles, theater, or mural making) to engage in making that expressed and extended their learning and relations. We focus this article on claywork for two primary reasons: 1) claywork emerged based on youth exploring clay deposits on the beach and wanting to know more about them, and 2) both youth and participating adults became engrossed in the work in ways that enabled the most robust intergenerational interactions. The focus on clay emerged from youths' own discoveries while exploring tidal pools and the beach as part of the study of "beach relatives" (animals that live in the tide pools) and changing waters (ocean acidification). During the beach exploration, youth found a large clay deposit exposed on the beach that prompted questions about the geology of the beach and its relations with the tide pools and the beach relatives we were learning about. In Year 2, we further delved into these ideas but also took more intentional explorations of the multiplicities of relations that clay has— including with humans through claywork. Clay became a preferred medium for youth and participating adults because it allowed participants to engage with it in the same way that previous generations have for millennia: mixing clay from its dry unmixed state to molding and working clay into ceremonial pieces that renewed relationships with and responsibilities to lands, waters, and community.

Data collection and analysis

In this study, we examined the making activities that took place in the Indigenous STEAM camp during the summer of 2016 and in the summer of 2017. Throughout the camp, Indigenous youth engaged in activities intended to cultivate Indigenous ways of knowing, being, and making through the pedagogies

of walking, reading (observing), and storying lands and waters (Cajete, 1999) as the foundation for the making activities. To note, making was not the lead or driving activity of the camp. Rather it was part of a constellation of practices within the designed activity system.

Video, audio recordings, and field notes of the making activities as well as interviews with youth and adults form the basis of the data for this study. In total there was approximately 120 hours of video collected from these camps. In addition to implementation video, we also conducted post-interviews with the adult facilitators and participants in the claywork activity. The data were logged in five-minute intervals across each summer and tagged with key markers of making, Indigenous knowledge systems, and practice configurations. These tagged data became the central data corpus for this analysis. We approached our analysis by further organizing the data into four key sequences: beginnings or launchings, unfolding processes of making, sharing making, and reflecting on making.

As part of the analysis, we looked for instances when stories and storytelling were shared or retold, especially stories where science and mathematics were explicitly embedded and emerged in the activities. In addition, we identified moments when youth or artists referenced ideas or concepts from the walking activities in the making activities. Across the data, we identified significant relationships among the storytelling, walking, and making activities; however, in this study we highlight the relationships that emerged from the clay making. We aim to show how clay making (direct engagement with natural materials) presents multiple opportunities to form relationships with animate materials as a process of knowing, being, and doing. Our analysis in this article is centered on an interview with the focal partnering scientist for this project, Miguel; a discourse analysis of the implemented learning environments, which center around Hector, the lead clay artist; an interaction with a young girl named Sarah; and the sharing of the making that profiles an Indigenous boy (Henry) and girl (Jen). The highlighted data are intended to show key conceptions and interactional dynamics that emerged from our analysis.

Findings: Charting the principles of indigenous making and sharing

In this section we present the findings from the ArtScience activities from the ISTEAM Camp through analysis of an interview and implementation events. The transcript from the interviews and the episodes we highlight exemplify and provide insights into the principles of Indigenous making and sharing. The three implementation episodes we selected are representative of the ways in which making takes shape as a (1) form of storytelling, (2) historical and contemporary Indigenous practice and technology, (3) space to integrate observations from walking (pattern and design in nature) into storytelling, and (4) way of establishing sharing as an integral part of solidifying family and community relations in the making space and in family/community settings. The first episode, "Clay making is storytelling," details some of the grounding of storytelling as part of clay making. The second episode, "What does it mean to do claywork?", articulates the detailed dimensions of doing claywork as a practice of making that is oriented to an act of community making and Indigenous thriving. The third episode, "Reading lands and waters through walking: Pattern and design in nature," articulates the sense-making that occurs in walking and addresses the ways in which making and design come together in storytelling through Indigenous making. In the fourth episode, "In relation with lands: 'What's chocolate got to do with this that I don't know about?'", we highlight the meanings that youth narrate from their engagement in clay making. Finally, we use the episodes to chart the principles of Indigenous making in youth-based learning environments.

We start with Miguel's interview in part because he was the expert scientist on the project with the deepest knowledge of the materiality taken up in making activities, especially the claywork, which is our focus. Also, we focus on him because he was the only adult to participate fully with the youth in claywork (besides the lead clay artist). Further, as we will show, he verbally manifested our design goals in navigating Indigenous and western knowledge systems most obviously.

Making and materiality: Identity and relations to land, water, and ancestors

A central aspect of making and sharing in this context was enacting Indigenous relations and knowledge systems. These forms of knowing and being opened potential relations and forms of materiality that were animated and agentic in ways that are elsewhere to western paradigms—or, what we

might call fugitive Indigenous makings. McDougall (2014) argues that fugitive Indigenous aesthetics makes the past present in ways that challenge colonial temporalities and reconstitute other parameters of sensing time and space that subvert dominant ways of knowing and being. In the quote below, it is important to notice how Miguel wove together both Indigenous ontologies and cultural paradigms to explain clay as well as western scientific narratives and functions of clay in ecosystems. He said:

> *When I think about clay, I think of elders, like old, old water … Clay holds a lot of history. Clay's seen a lot of things and the traumas, in particular, are found within its properties, so when you think of trauma and how trauma holds, clay's usually negatively ionically charged, so a lot of the positive charged ions, such as metals, are attracted to them. Not only that, but the negative ones are released, and they're pushed forward. If you think about clay, and anything passing through clay, it's like a filter, these positive-charged ions will stick around, whereas these negative ones like chlorine will pass through … The thing is clay is really impermeable, so it takes a long time to get through a layer of clay, which makes it a good aquitard. It holds water … it can hold water above it, which what that does is change its chemical properties around. It changes, it influences the chemistry around it. … It's a storyteller in the sense that you can look at clay and you can get told a story of history—what has been through it, it's still there, you can see it. … I identified it as elders—elders that tell stories, elders that filter information in a way that it gives us what we need to know, and we can interpret it. It's just sort of like a story is meant to be.*

Miguel describes clay as a living elder that keeps stories about lands and waters and persists through the many transformations that the earth has undergone over millions of years. Elder clay also shares important knowledge/teachings about the world to those who come in relation with it. From an Indigenous perspective, knowledge about the world derives from relationships with place and therefore lands and waters represent both a source of knowledge and are viewed as sacred and give and sustain life. Miguel recognizes clay as animate and agentic, influencing land and water, and that by positioning oneself in deferent ways to understand and perceive clay's agency "you can get told a story." Miguel connected clay to trauma and, in this case, he means trauma to land and water and the way it moves through clay. He narrated this trauma through chemical processes and influences in water, soil, and clay interactions. However, in the interview he connected trauma, storytelling, and the use of clay to manifest human-nature relations in specific ways.

> *I want to just highlight and to reiterate the trauma of clay, the storytelling of clay, and our own interaction with clays come in the form of pottery. And pottery's nothing new around the world … but there are some different properties to it in different scenarios and viewpoints, perspectives of it. I think what's common in all cultures are that the clay we use, we use it for a purpose. You use it as a tool, but not everyone thinks about—and this is where the intersect between engineering and cultural bridge gets blurred, or for me anyways, where I feel like it's in the same sense of being in a good spirit and having good intention and positive mentality when working with food. The same is working with clay; you put your good intentions in this clay and your spirit into it, and that impacts your physical, outward transformation of clay. It was very, very healing and meditative, with self-reflection, and then a goal to where I want to be in the future, not just for the artwork, but just the personal well-being of those that I interact with around me.*

Here, Miguel extended his understanding of how clayworks in ecosystems to how the practice of making with clay (he names pottery here) in an ongoing cultural practice that is shared across cultural communities. He importantly emphasizes that the purpose of pottery matters. Miguel asserts that the relationship with clay and the intention behind the work "impacts your physical, outward transformation of clay." That is, the intention and the purpose behind the claywork manifests in how the clay piece will look or the purpose it will serve to the individual and the community. In this, we hear Miguel suggesting that making is infused with political intent and consequence and is resonate with emergent "cradle-to-cradle" principles in professional western engineering in which the longer term impacts and consequences are central to design (McDonough & Braungart, 2010).

According to Miguel, engaging deeply with the purposes of making and sharing also can have transformative well-being effects (both emotional and physical) for himself and others. Miguel narrated the layers of the practice of making and sharing with clay across time and place in a way we suggest refuses colonial enclosures. He further explained how his own human intentionality interacted with the clay in a way that demonstrated a kind of deference to clay—a positioning we suggest is antithetical to western positionings of humans with respect to the natural world. He said:

It was definitely collaborative. I had an idea of what I wanted; the clay told me, "Nope." Just like, "This is what you have to work with," so I was restricted, in a sense—self-restricted, because I had an idea what I want, but what I needed the clay was guiding me towards.

Miguel's notion that the clay was guiding him resonates with how he described clay as an elder telling a story and filtering information. Miguel located this process of sharing and learning as intertwined with the physical act of making. He recognized that making is an emergent process that unfolded in unexpected ways guided by the clay. Miguel connects the physicality of shaping the clay across generations solidifying relations for him to his ancestors. He said:

I was able to connect with those that came before me. The manipulating [of clay] and using my hands in some version of the form that had been done generations and generations ago was incredible. I don't know how else to put it. It was amazing to have that space and time to … I don't think there has been a time where I was that connected to ancestors.

We find this particularly poignant in considering how the practices of making are not devoid of sociohistorical context. The making activity strengthened and animated ancestral relations and made present Indigenous forms of making that defied time and coloniality. These forms of making opened possibilities for Indigenous identities and futures that directly refuse Indigenous erasure across temporalities. Indeed, Miguel went on to say that while he was engaged in claywork:

Time was open to big picture and then zoom right back into a micro lens of where I was, and it was zooming in and out, in and out, so time wasn't relevant in the sense that I would zoom to the past and zoom to present and the future in matters of seconds …

According to Miguel, his deep engagement with clay allowed him to be present in the act of making (e.g., "the micro lens of where I was") and "zoom to the past" and be in relation with the traditional forms and ways of doing claywork hundreds or thousands of years ago and to "connect with those that came before me." Miguel's narrative on the role of clay across cultural communities, we suggest, reflects a manifestation of what Martineau and Ritskes (2014) name as the decolonialized struggle with materiality and the destruction of colonial parameters of creative expression that seek to position some materiality as old or heritage and some materiality as modern and innovative (e.g., digital).

Further, in Miguel's narrative of claywork we see important aspects of onto-epistemic navigation between Indigenous and western knowledge systems that do not reproduce normative powered dynamics, that is, dynamics in which western forms are dominant. From an Indigenous perspective, clay is described as an elder that holds and tells stories of "what has been through it." He is able to weave this perspective with language reflective of western science as he describes both chemical processes as well as clay's role in ecosystems (e.g., aquitard). Miguel is making sense of clay and the processes of making through multiple knowledge systems. Drawing from this data, we suggest that achieving equity in makerspaces must not simply be about inclusion, but instead cultivate heterogeneous forms of making and sharing that take seriously the ways in which processes and relations with materiality are positioned and nurtured. In our case, at minimum, this means cultivating Indigenous conceptions, relations to land/water, and manifestations of materiality in making and sharing in ways that support listening to and responding to materials from places that are not instantiations of human domination.

Episode 1: Beginnings: Clay making is storytelling

The first example from the implementation data comes from a launch into the artstudio activities on day one of the camp. In the artstudio launch, each of the five adult artists introduced one type of making that youth could choose to be engaged in throughout the week. Each artist described the medium (e.g., tools, materials) and possible "products," provided a historical grounding of the making activity, and discussed the activity as part of a contemporary Indigenous practice. Youth then selected their preferred choice for the week. Below is the introduction from Hector, the clay maker. Hector framed clay making as another form of storytelling which invited youth to build on the practice of storytelling through claywork.

Hector: *You will be thinking about ways to tell stories. We've heard stories today … What kinds of stories did we hear from Larry? What kinds of stories did we hear? … So we have been hearing*

> *a lot of stories. Larry is one person. And then other groups today, when we were learning about plant relatives, we were also telling other kinds of stories. But what we are going to be doing throughout the week is working and telling stories through art. Ok. So one of the things that we want to do today is to begin to show the different ways that you can tell stories through art … .I want to share with you a story. This story. Before I get started with telling the story. I want you to look at what I've done here [shows a clay sculpture] and I want you to think about what kind of story do you think I can tell. Just from looking at this, without even hearing my story, what do you think the story is going to be about?*

Storytelling through oral means is recognized as an essential form of Indigenous oral tradition to communicate knowledge about the world (e.g., Archibald, 2008). In this instance, Hector is establishing that youth will be storytelling through clay making and connecting it to the stories told earlier by an elder storyteller named Larry. He is both establishing clay making in an identity nurturing way and positioning youth to become storytellers. Hector's pedagogical prompt to have youth anticipate the story that is represented in the clay piece he shares orients youth to think of the types of stories that can be told via non-oral methods. We see Hector working to cultivate youth disposition to the clay—similar to Miguel's narrative—as foundational to learning and making. We approached claywork by drawing from ceremonial practices originating from Indigenous communities in central Mexico. The ceremonial practices are the accumulation of thousands of years of making that are based on storytelling and apprenticeship relationships. While not represented in the episode above, Hector went on to narrate the multiple stories that were represented in a clay sculpture of a dog that is used on altars throughout central Mexico during the days of remembrance for those who have died. Importantly this launch infuses clay making, a form of material storytelling, with historical and culturally important purposes, creating a context for youth to learn and strengthen their own identities.

Following the launch, youth explored the stories they wanted to tell and considered the physical ways to do that. For example, they questioned how they would be able to make a 3-dimensional piece when few had ever worked with clay. The most challenging element for youth, however, was developing the story they would tell through the piece and the purpose they would assign to the piece. Throughout the clay making activities, youth and adults made sense of the relationships that they were developing with plants and with sea life through the activities at the beach and in the forest. This in turn helped youth think about the possible stories they might narrate through their claywork. Some youth integrated plant designs into clay pots to retell stories about plants they learned about (e.g., stinging nettle, big Maple) while others took on the challenge of creating clay replicas of animals (e.g., otter, wolves, starfish) that could be used as incense burners.

One example that stands out is the clay incense burner a young girl named Rachel made. The incense burner was molded in the body and shape of a floating otter with a concave belly. The hollowed belly served as a receptacle to burn sage, tobacco, cedar, and other plant medicines. In the original conception of the otter piece, Rachel focused on retelling a story of an otter she observed during one of the beach activities. While we were at the beach exploring the impacts of climate change, youth learned about how people have had deep negative impacts on lands and waters but also have made efforts towards restoration. More specifically, how sea otters were wiped out of the Puget Sound by settlers, but have since been reintroduced and flourished. This, however, required scientists to learn more about otters and their relationships and interactions in ecosystems after some failed attempts. Rachel's claywork focused on narrating the presence of otters in waters where otters had not been seen for many years. The first iteration of the otter was conceived as a storyboard on a 2-dimensional flat piece of clay representing a linear story progression, but by the third day the concept of the otter story had evolved into a 3-dimensional piece (e.g., an otter incense burner). This piece would be the material story of otters (e.g., elimination and return of otters in the region) and for the purpose of family and community prayer for living things including animals, plants, and water. Importantly, the material otter manifested the story of the return of otters—making them again physically present—in powerful ways that an oral version alone may not have done. For youth, material storytelling presented a new and different mode of conceptualizing stories about the various activities and experiences during the camp.

Episode 2: Processes of making

The second episode draws from an introductory interaction that took place with only the youth who decided to work with clay on day two of the camp. Before having an opportunity to work with clay, Hector provided some framing for how claywork should be approached. According to Hector, claywork has a purpose and history that is elaborated on throughout.

Hector: We are not just doing art just to do art. We are actually doing a type of work that has been done for thousands of years. I learned from people who have been doing this work [in this way] for thousands of years. This is actually a science. This is actually a technology that is very old and traditional. … Where do you think this clay comes from?

Youth: The earth.

Hector: The earth.

Hector: Well, today we only have these two … There's a gray and one of these days on the beach you'll get to see more clay and you'll get to learn where it comes from. This one here comes from Vashon Island … One of the things we are going to do as you're working with your clay is put some prayers down here … We took this clay from somewhere. Somewhere the earth is offering us this … this soil … Think about who you want to make these offerings for. I always … when I do these things … you know who I always think about. I always think about my family. … And the other people that I want to give thanks to. I'm going to offer some cedar. I want to thank you all. I think that this work of doing clay, I think it gives more meaning to what I do. I know that you all will learn something and take it to your families and back to your homes.

Hector grounds claywork in a genealogy that has been practiced and passed down for thousands of years. He honors the practice of making and positions it as a privilege to engage in and one that must be acknowledged. Hector also intervenes in western dominant paradigm about what counts as science and technology by describing the traditional practice of claywork, an Indigenous practice, as a science and technology that spans thousands of years and is relevant to the present and possible future. Hector's assertion that clay making is a science is key because it grounds clay making as a process to understand the use and properties of the earth (e.g., both the chemistry and biology) as part of the human experience and of interactions with the natural world but it also names clay making as science, something that many Indigenous learners do not have honored and reinforced in learning environments. Hector also makes sure to acknowledge the life courses of clay and the multiple places in which it is in relations. He positions clay making as a practice to contribute to family and community. Finally, the exchange ends with Hector acknowledging the importance of youth engaging in claywork by thanking them for pursuing such work. This gesture indicates the beginning of apprenticeship relationships and welcomes youth into the practice. The welcoming of young people into practice shows intergenerational exchange as a consequential element of Indigenous making. Together, in this episode, the practice of making is oriented toward an act of community making and Indigenous thriving.

Episode 3: Walking and observing lands and waters

The third episode highlights pedagogical practices intertwined with clay making and sharing that privilege epistemic activity exploring patterns and design in nature during the times of walking land and water. The focus on clay emerged in the ISTEAM camp from youths' own discovery while exploring tidal pools as part of the study of beach relatives and changing waters (ocean acidification). Students encountered clay deposits that prompted a series of questions and deep interest. We redesigned to focus on claywork in Year 2 of the camp and worked to intertwine youth experiences with making relations in the natural world with processes of clay making. For example, the beach was about a half mile walk from the community center that served as the base of the ISTEAM camp. We designed inquiries into the mathematics of the natural world for youth to explore during these walks through observations of patterns in plants from various scales and perspectives. They explored symmetry, shapes, angles, tessellations, lines, and curves in plant relatives native to the Pacific Northwest. The episode below, occurring during

a walk, exemplifies how youth, in this case Sarah a 9-year-old, made connections among the activities of storytelling, walking, and making.

Sarah: I saw many patterns and shapes.
Hector: You were telling me you saw many patterns and shapes. Your question was how would I include it in clay. What are some—can you give me an example of a pattern you saw?
Sarah: This is one pattern where the leaves were kind of forward, kind of like a clover and then it would do that for like every branch.
Hector: Why might it all be growing out like that?
Sarah: Like sunlight. It spreads out and gets more nutrition.
Hector: Is that the only one you saw or were there others?
Sarah: There was. I remember when we were telling my team and and nettle goes like that and that and that [gestures growth of stem in perpendicular form].
Hector: So the nettle—how it was going in one direction. Cool. That's another good example.
Sarah: Oh, also I noticed that on the horsetail there would always be like a bunch around the stem and then wait and then do it again. So it's kind of over and over.

In the episode above, the interaction demonstrates how youths' observations of patterns in nature are conceived as part of the process of clay making. Sarah drew from patterns in nature to design her clay piece. This was a practice that paralleled one of the stories that an elder storyteller told on another day. In that story, a young native girl persists to overcome feelings of incompetence by learning to make baskets from a cedar tree. The cedar tree guides the girl to learn patterns and designs by observing nature (e.g., rivers, mountains). This reflects an epistemological framework—it teaches a process for making knowledge—and one that Sarah is now engaging in her claywork. In deciding the type of design to incorporate into her clay piece, Sarah compared her observations of horsetail and nettle and she recalled the types of growth patterns she observed. In addition, she began to conceptualize why particular plants grow the way they do (e.g., exposure to sunlight) and specific relationships to other plants.

This episode demonstrates the role of story as an integrative part of making practices where multiple relations (e.g., connecting to ancestors, engagement in a millenary practice, and noticings of pattern in nature among others) can be enacted. Further, the episode demonstrates how Indigenous youth can engage in meaningful nature-culture relationships where scientific and mathematical knowledge can be constructed as a deferential part of an Indigenous knowledge system. During the walking activities, Sarah engaged with mathematical concepts (e.g., patterns, symmetry) as part of her observations. Although making more broadly may afford this kind of interdisciplinarity, this is particularly important for Indigenous ways of knowing.

Episode 4: In relation with lands

Finally, we highlight the fourth episode to show how youth narrate stories that reveal insights about renewing and instantiating family and community relations as part of making and sharing processes. To exemplify this we focus on Henry, a 12-year-old, and Jen, a 10-year-old as they share their pieces with families and other campers on the last day of camp.

Jen: The medicine that I put in the cup is corn, sage, and chocolate, and cedar, and—

Adult audience member 1: Chocolate is a medicine?

Jen: Yes.
Henry: Yes, cocoa is.

Audience member 2: I was wondering, 'What's chocolate got to do with this that I don't know about?'

Henry: So this is mine. I wanted to make something that was personal, something that's still important to people around here, so I made a salmon. It's supposed to be a salmon. I used designs from people around here [Indigenous people from the Pacific Northwest]. The stuff inside of the clay was … I put in cedar for my family that I have here, cedar for Washington, like

> my mother, my father, and two sisters. My two sisters were really important to me, so I put chocolate inside there, make it a little sweet. I put yellow cedar inside there to represent my family that's in Chicago right now.

Hector had asked youth to share aspects of their clay making that are not apparent from only looking at the completed pieces. Jen's explanation of the medicines in her piece open up questions about chocolate. Henry explains that cocoa is medicine and the audience recognizes that they must not know something important. To share and perhaps teach, Henry tells the story of his clay piece—a container used for burning medicinal plants in the shape of a salmon. We see Henry doing this, in part, to help the audience understand that putting something into their piece always carries meaning and simultaneously demonstrates a kind of solidarity with Jen by sharing why he offered cocoa in his piece. Importantly, this moment of sharing also nurtures and evolves Henry and Jen's relations to each other as Indigenous youth.

Henry shares multiple storylines revealing the layered nature of Indigenous making and sharing for the audience. Henry wanted to honor the peoples whose homelands he was on. During camp we learned about the role of salmon in the Pacific Northwest and Tribal nations' leadership and efforts in salmon restoration and health. Further, campers learned about why it was important to recognize and honor Indigenous peoples and homelands wherever one is. Henry, whose homelands are in the Midwest, took this teaching deeply seriously and is enacting an important political stance and relation to the lands and waters that he dwells in here. The physical shape demonstrates deference to the place he lives and then he infuses it with medicines, prayers, and his own family genealogy both here and in his own homelands (Chicago is part of his tribal nations' original homelands).

We see Henry enacting forms of Indigeneity personally, culturally, and politically, beyond settler-colonial enclosures and space-time. Although he has done this in his own way, it is reflective of what we saw in both Hector and Miguel's words, suggesting that the pedagogical innovations of these adults were taken up by youth, and there were important intergenerational continuities generated in this space. Further we see Henry developing resilient relations to place and family that are counter to dominant narratives of urban Indigenous people. Further, this interaction illuminates how family and community relations are critical in Indigenous making and sharing. The pieces made are more fully understood when the makers' meanings, intentions, and prayers are engaged. Thus, it is not only important to support individual makers in onto-epistemic navigation, but also to cultivate an environment in which communities of makers work together toward onto-epistemic navigation in meaning making and strengthening relations together.

Principles of indigenous making and sharing in youth-based learning environments

Across the episodes, Indigenous making is rooted in storytelling about human-nature relationships and through making practices emergent from Indigenous knowledge systems, multiple relations come to fruition. Building from the four episodes, we offer some refined principles.

Indigenous making and sharing:

1. Enacts and communicates stories in a multiplicity of forms in and across temporalities. Knowing, being, and doing are simultaneously unfolding and are essential/defining elements in the practice of material storytelling;
2. Reflects the patterns and processes that cultivate life and draw on deeply interrelated socioecological phenomena requiring interdisciplinary forms of sense-making.
3. Enacts relationships with animate materials that have life courses toward the fulfillment of communal responsibilities.
4. Enables continual renewal of family and community to assert contemporary presences and living Indigenous nature-culture relations.

The principles we outline above derive from the exemplar episodes we highlight in the findings and collectively assert generative and specific forms of Indigenous presences that extend previous scholarship (e.g., Vizenor, 2008) in pedagogical specific ways. Youth in these learning environments got to engage in imaginative processes of creation that renewed and strengthened their relational responsibilities and

manifest Indigenous relations to materiality (King, 2013; Richardson, 2011). We argue making spaces for these forms of activity to thrive are lived ways of resisting settler-colonial enclosures and capitalist markets (Martineau & Ritskes, 2014). More specifically, the first principle attends to the role of storytelling in Indigenous knowledge systems and pedagogies. Historically, storytelling in Indigenous communities has been viewed as an essential component of oral tradition, however, episodes 1, 2, and 4 illuminate how clay making can be conceived as a form of material storytelling as well. In episode 4, youth enacted forms of storytelling that renewed Indigenous knowledge systems in the current moment and enabled young Indigenous people to develop agentic identity storylines (Nasir, 2011). Material storytelling presents an authentic and consequential (Gutiérrez & Jurow, 2016) way for youth to develop knowledge about themselves and assert their connection to cultural practice through direct engagement with natural materials.

Building on scholarship focused on land-based education and Indigenous resurgence of nature-culture relations (e.g., Simpson, 2014), principle two reflects the dynamic nature of learning from lands and waters. In episode 3, Sarah integrates her beginning understanding of patterns in nature into her piece. The episode highlights the deep engagement with plant relatives and shows that observation and making are part of an integrated process of scientific and mathematical inquiry. From an Indigenous perspective, different forms of knowledge emerge in relation to each other and necessitate relationships with lands and waters as well as relationships among families and communities. In this way onto-epistemic navigation is demanded in Indigenous making and maker spaces. Principle three further refines these issues and makes Indigenous materialities explicit. It is derived from episodes 1, 2, and 4 where Hector and Henry established the sacred relationship of living and learning from the land in the process of making as well as recognizing the multiple genealogies in the meshwork of making. Indigenous making ontologically infuses materiality with agency and life courses quite differently from western orientations to materiality that is typical of maker spaces.

Finally, principle four reflects the continuity of living nature-culture relations by centering Indigenous knowledge systems as a viable and sustainable way to engage the world and to connect with materiality. Across the episodes Indigenous making is asserted through a range of robust cultural practices that live and thrive when individuals come in relation with the environment. Lands and waters serve as sites of knowledge production and such knowledge can be honored and regenerated in making and the range of practices that are woven in. We highlight Miguel who explicitly said working with clay created a space for him to connect to his ancestors and to take up the lessons the clay could offer him and Henry who demonstrates this principle by honoring his relations to lands, waters, Indigenous peoples, and family as he supports other Indigenous youth.

Taken together, these principles advance the field's understanding of equity in making by deepening analysis of the roles of culture, power, and knowledge systems as foundational in making activity. Maker spaces aiming to support non-dominant students in consequential forms of learning must engage onto-epistemic multiplicities or they may replicate forms of western epistemic supremacy. As communities continue to reach for more than representational equity within neoliberal paradigms, learning environments must make the "towards what ends" explicit (Politics of Learning Writing Collective, 2017).

Implications of indigenous making and sharing

In closing, we return to the words of Miguel, the Indigenous scientist, who stated "I don't think there has been a time where I was that connected to ancestors." From our perspective, this is the heart of Indigenous making and sharing because it demonstrates that Indigenous people can exert agency to restore futurities by, among other things, reclaiming traditional forms of making as a living legacy of Indigenous scientific and technological activity. Reclaiming traditional forms of making in maker spaces also serves to counter Indigenous erasure and settler-colonial constructions of materiality by centering Indigenous knowledge systems as continual, thriving, and self-generating. More specifically, Indigenous making and sharing can chart new possibilities and perspectives toward equity in making and for self-determination if onto-epistemic heterogeneity and the cultural and political purposes are explicitly part of making. In the case of Indigenous people, making and sharing can be places of learning that

nurture human-nature relations, continual renewal of original instructions, community relationships, and engagement with Indigenous knowledge systems.

Acknowledgements

We thank and acknowledge the following people whose contributions to ISTEAM camp were invaluable and their love for and commitment to Native youth, world changing: Jeanette Bushnell, Roger Fernandes, Fern Renville, Nicole Tiltson, Matt Ecohawk-Hiyashi, Alice Tsoodle, Brett Ramey, Megan McGinty, Priya Pugh, Gabe de los Angeles, Charlene Nolan, Joh Howard, Mario Guerra, Meixi Ng, Ceni Myles, Emma Elliot, Rose O'leary, and La'akea Yoshida.

Funding

Division of Research on Learning in Formal and Informal Settings [1348462].

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