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SCIENCE LEARNING IN EVERYDAY LIFE

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Place-based learning processes in a family science workshop: Discussion prompts supporting families sensemaking and rural science connections using a community water model

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Abstract

This study addresses intergenerational learning processes in informal settings by investigating families engaging in science talk and practices during a water quality science workshop led by local science experts. As part of a larger design-based research study, this analysis examines how modified Think–Pair–Share discussion prompts within the water quality workshop curriculum supported the families' (a) sensemaking strategies and (b) place-based scientific reasoning about local water sources as they interacted with a community water model. Using sociocultural theories of learning as our foundational basis, we analyzed parent–child interactions and family sensemaking processes that took place in four workshops with 44 h of video data (12 families). Through our analysis, we identified six distinct types of sensemaking conversations that arose during the workshops: (1) family experience connection, (2) rural connection, (3) model contextualizing, (4) parent revoicing, (5) parent questioning, and (6) prediction. We also found that families spatially distributed physical gestures over three media (air, table, community water model) to support different types of sensemaking conversations. Our findings point towards the importance of family discussion prompts in informal programs as a mediational means that connects abstract science topics to local, rural experiences to support family sensemaking practices. Implications for designing family-focused science workshops in informal settings include designing discussion prompts to spark families' personally relevant connections with science and providing ample physical space for families to gesture during sensemaking conversations.

KEYWORDS

family learning, informal learning, parent–child interactions, place-based learning, science education, Think–Pair–Share

1 | INTRODUCTION

With the goal of providing science learning opportunities to families in informal settings, research (Bell et al., 2009) has focused on pedagogical practices, strategies, and tools that engage families in science talk. Family science talk that leads to learning has been documented in museums (Ash, 2003; Borun et al., 1996; Eberbach & Crowley, 2005), science centers (Zimmerman et al., 2008), nature centers (McClain & Zimmerman, 2014), zoos (Patrick & Tunnicliffe, 2013), and gardens (Eberbach & Crowley, 2017). Families leverage a diverse array of sensemaking strategies, such as engaging with science practices (Gleason & Schauble, 2000), asking questions (Gutwill & Allen, 2010), making connections to prior experiences (Allen, 2002; McClain & Zimmerman, 2014), and creating shared understanding of novel scientific phenomena (Zimmerman et al., 2010). In our work, we leverage this prior research to investigate how families make sense of local science issues when attending a scientist-led workshop in an informal learning setting. To date, only a few studies analyze how families learn and interact together during scheduled science workshops in informal settings (e.g., Linnemann et al., 2013; McClain & Zimmerman, 2019; Tenenbaum et al., 2002), with even less attention given towards family science workshops in rural libraries and museums.

Beyond exploring a novel informal learning setting, our study provides a unique contribution to the informal education field as it investigates how families make sense of local science issues within their own communities, thereby contributing to a broader understanding of how, where, and when the public engages with science topics and practices (Stilgoe et al., 2014; Stocklmayer & Gilbert, 2002). By bringing a local scientist together with families during a hands-on workshop, we posit there is an increased potential for adults and children to build a personal awareness of science (Stocklmayer & Gilbert, 2002), which can ultimately lead to broader conceptual understandings (Gilbert et al., 1999).

1.1 | Purpose of study

As part of a larger design-based research study (Zimmerman et al., 2019), our team examines how to engage families in science and engineering practices during scientist-led workshops at rural libraries and a science center and nature center. This article investigates how modified Think–Pair–Share discussion prompts (Kothiyal et al., 2014; Lyman, 1987) supported (a) the sensemaking strategies families used during a water quality workshop and (b) families' place-based reasoning about water sources as they interacted with a community water model. We answer the following research questions:

(1) How did family discussion prompts in a water quality workshop influence learners' sensemaking and place-based connections with their community?

(2) What sensemaking resources (i.e., talk and gesture) were observed to support the families' conversations and place-based learning processes while using a water model designed to represent their local community?

2 | SOCIOCULTURAL THEORETICAL FRAMEWORK

This study's design is grounded in sociocultural theories of learning (Bell et al., 2009; Lemke, 2001), where learning is conceived of as participation in practices. We adopt the view that family learning is a social enterprise that occurs between and across multiple individuals with a shared history and with the physical tools and conceptual resources that are available within a particular setting (Ellenbogen et al., 2004). To analyze families' participation in science workshops, our theoretical framework draws upon four areas: (1) family sensemaking in informal science learning settings, (2) gestures to support science sensemaking, (3) place-based learning, and (4) scientific reasoning about real-world phenomena using models.

2.1 | Family sensemaking during informal science learning experiences

In everyday and informal science settings, family learning is a social, cultural, and collaborative experience (Bell et al., 2009). Parents often play an essential role in guiding children's participation in science activities that take place in designed spaces, such as museums and science centers (Crowley et al., 2001; Gleason & Schauble, 2000; Tscholl & Lindgren, 2016; Zimmerman et al., 2010). During these informal learning moments, parents have been observed engaging their children in scientific talk, observation, and reasoning through posing questions that encourage children to explore (Ash, 2004; Willard et al., 2019). Some science conversations also encourage children to describe and explain science phenomena (Eberbach & Crowley, 2017; Kisiel et al., 2012; Van Schijndel & Raijmakers, 2016). For example, Tscholl and Lindgren (2016) investigated parents' and children's interactions in an interactive simulation environment for physics learning; they found parents supported children's reasoning by assisting them to make observations and formulate explanations of scientific phenomena.

Family conversations are an integral part of science sensemaking—a critical learning process in informal spaces—where families collectively integrate new information with the old via discussing science content (Allen, 2002; Haden et al., 2014; Palmquist & Crowley, 2007). As such, we view family's prior experiences as epistemic resources that families use during sensemaking (Zimmerman et al., 2010), where prior experiences add meaning to the new phenomenon and make science knowledge personally relevant to the learners (McClain & Zimmerman, 2014). In this way, family conversations around science topics are ultimately shaped and viewed through the lens of prior, shared experiences and memories that families bring with them wherever they go.

2.2 | The use of physical gestures to support science sensemaking

Sensemaking is not just a verbal process. Gesture, together with speech, supports collaborative sensemaking activities by providing another mode for externalizing one's thinking and understanding of a concept (Roth, 2001). Hand gestures are forms of "representational expressivity" (Hegedus & Moreno-Armella, 2009, p. 49) that support one in communicating ideas through highlighting relevant physical features (e.g., shape, action, relative location, etc.) to a peer (Goodwin, 2003). Pointing, a type of gesture, is a situated interactive activity where one person's act of directing a finger towards an object creates a shared focus among individuals in conversation (Goodwin, 2003). Because family learning is a social effort, Goodwin's work on pointing provides a foundation for understanding gestures as tools that create shared focus and express meaning during group sensemaking.

In science learning, gestures support collaborative sensemaking by making invisible objects, phenomena, hypotheses, and processes salient (Azevedo & Mann, 2018; Crowder, 1996; English & King, 2015; Marin & Bang, 2018; Rahm, 2004; Steier et al., 2015)—and thus, available for shared reflection. For example, children have been observed using hand gestures while imagining or simulating science phenomena (Alibali & Nathan, 2018). Gestures are also important communicative actions when learners interact with models. In classroom settings, gestures serve as a mode of representation to support students' scientific reasoning when engaging with physical models (Crowder, 1996; Gilbert, 2004). In work with sixth-grade science students, Crowder (1996) found that gestures aided in the construction and communication of the students' scientific insights about earth sciences. Consequently, our study considers talk *and* gestures as essential for parent and child sensemaking during their engagement with water models during a water quality workshop.

2.3 | Place-based science learning processes for families

Place-based learning is an educational approach that utilizes the place in which learners inhabit as a resource to support locally relevant, culturally salient knowledge building during authentic learning experiences (Sobel, 2005). Place-based learning acknowledges multiple knowledge sources, meanings, and human–place–animal–plant relationships as valid sensemaking tools (Gruenewald, 2003; Marin & Bang, 2018; Semken et al., 2017). While science-related phenomena are often presented using abstract terms or examples in traditional learning settings, place-based learning processes ground those same science phenomena in experiences that are familiar to create a meaningful context for learning (Coker, 2017). In this way, place-based learning provides important educational opportunities through the explorations of one's community, which serves as a sensemaking foundation for later understanding abstract phenomena (Smith, 2002). While place-based learning processes typically involve authentic activities situated in the place (e.g., learning about plant species while hiking in the environment in which they grow), according to Semken et al. (2017), place-based learning can occur “in an environment that strongly evokes the place” (p. 545), such as an indoor space where learning is experiential and hands-on.

Our study is situated in a rural region of the northeast United States. An off-shoot of place-based learning, rural science education acknowledges people's everyday lived experiences in their small town and rural communities as being useful sensemaking resources (Zimmerman & Weible, 2017). Local knowledge resources are leveraged by rural learners to generate locally relevant understandings of science. In work with high school students, Zimmerman and Weible (2017) found that a place-based education inquiry at a local stream allowed the learners to “leverage their rural knowledge in contextualizing the investigation within their community” (p. 26). Furthermore, the place-based stream investigation was a successful pedagogical approach for engaging the students in science practices as they gained scientific knowledge. We adopt the view that creating opportunities for rural children and families to apply their “local rural knowledge” in science learning can make science more accessible to rural families (Avery, 2013).

2.4 | Scientific reasoning with models in informal settings

Scientific reasoning is the practice of making and testing predictions as well as seeking, developing, and interpreting evidence (Allen, 2002; Kisiel et al., 2012). As previously described, parent-guided talk in museums has been shown to assist children's scientific reasoning (Ash, 2003; Mercer et al., 2004). Learning with models also supports reasoning through providing simplified representations that facilitate observation, prediction, and interpretation of science phenomena (Louca & Zacharia, 2012; Manz, 2012). While the science education literature refers to many different types of models (e.g., mental models, conceptual models, mathematical models, etc.), for our purposes, we focus on *physical (material) models* (Ornek, 2008; Penner et al., 1997). Material models, as characterized by Penner et al. (1997), are “defined by their representational links to the world” (p. 127). As such, different objects can be used to represent the properties of real-world phenomena. In our workshops, for example, families engaged with a surface and underground water model that represented their community.

Modeling and using models to demonstrate scientific understandings are considered important practices in formal and informal science education (Gilbert & Boulter, 2000). Research supports engaging learners in manipulating models (e.g., generating representations, experimenting measures, interpreting data), rather than only passively engaging learners through reading or viewing models (Gouvea & Passmore, 2017; Manz, 2012). Models that support children's scientific reasoning have been largely explored in classrooms (e.g., Coll et al., 2005; Manz, 2012), while few studies focus on modeling practices in informal settings, or with families as the unit of analysis, as we do in this body of work.

3 | BACKGROUND OF STUDY: SUPPORTING FAMILIES' SENSEMAKING AND RURAL SCIENCE CONNECTIONS DURING A WATER QUALITY SCIENCE WORKSHOP

Our overarching research study employs an iterative design-based research (DBR) methodology (Sandoval & Bell, 2004) where we develop pedagogical practices to better connect families to science in their rural communities while making theoretical contributions to the family science sensemaking literature (see Zimmerman et al., 2019). In this larger study, STEM professionals led science workshops (e.g., engineering, water quality, astronomy, meteorology, pollinations) for families at rural libraries, a museum, and a nature center. Given the small size and limited resources of our partnering community groups, the informal institutions we worked with asked that we rely on STEM professionals to lead the workshops, rather than their own staff members. In this article, we focus on one portion of the larger DBR study—the water quality workshop—to understand how discussion prompts supported families' science sensemaking and reasoning related to community water quality during this third (and final) DBR iteration.

3.1 | STEM professionals as workshop educators

Each water quality workshop lasted 60–75 min and was led by one of three STEM professionals: Ed, Cassandra, or Chelsea (pseudonyms). These STEM professionals had backgrounds in water quality and had previous experience conducting outreach programs to the general public related to water and environmental issues. Ed, a program director at a local environmental center, led one workshop. Chelsea, a district manager of a Rural County Conservation District, led two workshops. Cassandra, a watershed educator at a not-for-profit riparian conservancy center, led one workshop. The research team met with each expert to give an overview of the workshop structure and activities. Each professional was provided with a workshop lesson plan with the embedded family discussion prompts. A research team member met with each facilitator in-person or virtually to informally train the STEM professionals before their leading of the workshop; an educative curriculum was provided. All the facilitators in this iteration of research had taught a prior version of the water quality workshop (i.e., using the curriculum without the full set of family discussion prompts) to a similar rural audience. While the STEM Professionals sometimes deviated from the provided curriculum, their facilitation of the workshop deliverables and implementation of the family discussion prompts ultimately satisfied the aims and objectives of the research team's iteratively designed workshop.

3.2 | Design of the water quality workshops

The water quality workshops originated from curriculum created by the Penn State Extension (2017) and were adapted by our team to be used with families with younger children. Workshops began with the STEM

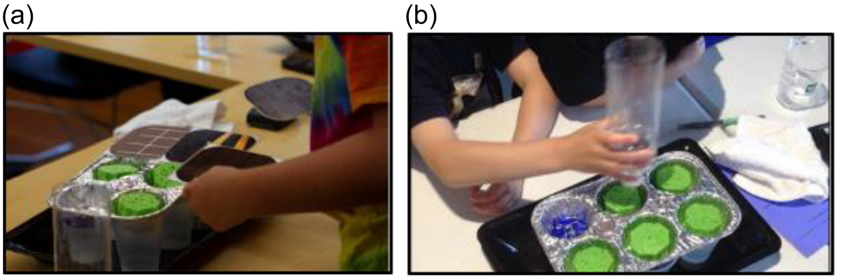


FIGURE 1 Left and Right: Two families' water models where the green sponges represent normal ground and the blue tin represents a lake. Beneath the model is a container to capture the water from the experiment, which represents groundwater

professionals introducing how they became interested in science (related to water quality) and a driving question for families to consider throughout the program: 'How can we build a better world around water in our community?' Next, families conducted three experiments where they built a series of surface and underground water models to represent their local community. Using these models, families engaged with the science practices of observation, prediction, and explanation as it related to precipitation and the influence of different landforms on groundwater and aboveground water flow. Each experiment was on a different type of community (see Figure 1, left and right):

- an undeveloped community (basic water model structure),
- a developed community (using laminated cards representing roofs, parking lots, roads, sidewalks),
- or a green construction-built community (using laminated cards or objects representing green infrastructure concepts such as green roofs, rain gardens, and permeable asphalt).

For each experiment, families showered 250 ml of water (representing rain) over the model to observe the process of water flow and to see where the water collected—above or underground. After each experiment, families measured the amount of water collected in cups that represented groundwater and surface water. Throughout the modeling experience, families engaged in observing water flow, collected data in a workbook, and compared and interpreted experiment results both within their family and between families sitting at the same table.

3.3 | Family discussion prompts

In earlier iterations of the water quality workshop, we found that if the STEM professional did not deliver the discussion prompts in a manner encouraging families to discuss together at their table (i.e., the prompt was either delivered at the workshop level or STEM professionals did not explicitly give families time to converse), little to no personally relevant or rural connections were made between the participants and the science topic of water quality (McClain & Zimmerman, 2019). Given these previous findings, we redesigned the workshop curriculum to more intentionally emphasize the discussion prompts as family conversational supports so that the STEM professional could create a space for family sensemaking talk in their workshop. As such, this third version of the water quality workshop (the focus of this paper) used the refined curriculum.

As a set, the family discussion prompts aimed to spark conversations that would bring prior experiences to the fore, making connections to place, and unpack the results of the experimentation with the water model. Informed by our prior work (McClain & Zimmerman, 2019), we adopted a modified Think–Pair–Share pedagogy, where families were given purposeful time during the workshop to think and talk together and then share ideas in their

TABLE 1 The eight family discussion prompts delivered by the STEM professionals during the Water Quality Workshop

Rural connection discussion prompts	#1: What types of bodies of water do you have in the community where you live? (How) do you use this water? #2: Before we had a lot of people, what did the land look like? What was the natural environment like in the community *where you live* before people moved in and altered it? #4: What are things people build in their communities to live? #6: Discuss with your family and compare the different results. What might be some ways to increase groundwater in your developed community? #8: Discuss with your family: Are there any of these designs that are currently in your neighborhood? Are there any of these designs you could potentially implement inside your community?
Prediction discussion prompts related to the water quality experiment with the community model	#3: Where do you think the water will go? Which one will get more water: the white cups and sponges (groundwater) or the blue cup (local body of water)? (1st experiment) #5: Make your prediction: where do you think the water will go this time? (2nd experiment) #7: Discuss your predictions: will there be more runoff, or more infiltration (i.e., more water in the blue cup, or more water in the sponges and cups for groundwater)? (3rd experiment)

intergenerational group, before sharing out in a large group discussion. This contrasts with an instructor-led conversational pedagogy where a facilitator calls on only a few people during a large group discussion.

Specifically, the eight family discussion prompts in the water quality workshop were designed to facilitate families' connections to their rural communities and to engage them with the science practice of making predictions before each experiment. We thus organized the prompts into two categories (Table 1):

- Five rural connection discussion prompts (e.g., What types of bodies of water do you have in the community where you live?) and
- Three prediction discussion prompts (e.g., Where do you think the water will go?).

4 | METHODOLOGY

Within our DBR study design, we utilized interactional, video-based qualitative techniques (Derry et al., 2010; Jordan & Henderson, 1995) to closely analyze specific instances of family sensemaking across the water quality workshops.

4.1 | Study setting

The water workshops analyzed for this paper were offered four times; the workshop was held at two libraries, one museum, and one nature center. The two libraries serve communities in two rural counties. Each library is open to the public and has multiple designed spaces such as reading spaces, a computer area, and play zones for children. The libraries also have conference rooms where they hold regular library programs. The museum includes various science and technology-themed interactive exhibits and programs for children ages 14 and under and their families. The nature center, affiliated with a research university in the region, features indoor and outdoor animal exhibits, several walkable forest trails around the center, environmentally themed programs and displays, and two indoor classrooms. All water quality workshops took place in indoor spaces outfitted with tables and materials as workspaces for each family.

4.2 | Participants

Families, consisting of a parent or guardian (called parent for purposes of this study) with at least one child aged 6–10 years old, were recruited on-site. Our library and museum partners helped disseminate the workshop information to families and provided spaces for the workshops. In total, 12 families consented to participate in this iteration of our larger study:

- 28 individuals
  - o 14 adults (11 mothers and three fathers);
  - o 14 children (four daughters and 10 sons; ages ranged from 6 to 10 years old, with an average age of 8 years old).

The participants consented and assented to have their conversations and interactions video-recorded for research analysis. Only those family members that also consented to have their image shown in research products are included in this manuscript. In keeping with ethical standards for video-based research, (a) we blurred their faces for an extra level of privacy and (b) used pseudonyms for the experts', families', and informal settings' names.

4.3 | Data collection and analysis

We analyzed 44 h of video with 5 h of supplemental audio from four workshops. In each workshop, three to four cameras were set up to record families' interactions at each table. Additional audio recorders were placed on the tables to capture family talk.

4.3.1 | Analytical process

Our analysis considered the conversational and physical (gestural) sensemaking strategies employed by the families after they heard the eight family discussion prompts. To capture the dialogic exchanges and gestures, we employed a microethnographic approach (Spradley, 1980) to create narrative accounts and analyze the family conversational episodes. Microethnography allowed us to pinpoint specific moments of family sensemaking to analyze, thereby creating an analytical account of how the learning processes unfolded in real-time.

We first created a family prompt account for every family that included full transcripts of family talk, screenshots of families' actions, and detailed descriptions of families' interactions following each prompt. Video records were professionally transcribed. Transcripts were checked by a research team member to ensure accuracy. Next, we adopted an interactional, video-based qualitative analysis (Jordan & Henderson, 1995) technique to cowatch videos to identify emerging themes within the families' science talk. Collaborative review sessions with other research team members were carried out to discuss common patterns and confirm analyses. We referred to relevant literature to identify and label emerging themes related to family sensemaking. Next, the researchers read through the detailed, interactional accounts again to confirm or disconfirm the prevalence of identified themes across families. Finally, to enhance the trustworthiness of the analysis, these accounts were shared with the other researchers and at a conference; we took feedback from team members, conference reviewers, and others to update our thinking and communication about this analysis.

Coding frameworks

Our coding frameworks sought to describe families' engagement with the eight prompts, which were designed to involve families in science conversations related to their rural communities. The codes were bolstered by prior literature related to family science learning, family science sensemaking, and physical gestures to support learning. Given that family science sensemaking is shaped through verbal conversations (Allen, 2002; Ash, 2004; McClain & Zimmerman, 2014; Zimmerman et al., 2010) and physical gesturing (Azevedo & Mann, 2018; Crowder, 1996; English & King, 2015; Goodwin, 2003), we created two coding frameworks to elucidate the different sensemaking resources families used:

(1) types of family science sensemaking conversations (Table 2),
(2) types of physical gestures that supported family science sensemaking conversations (Table 3).

In Table 2, we created two overarching categories within our framework to identify: (a) *personally relevant sensemaking conversations* that supported family science learning processes through experience and rural connections to their local community during the water quality workshops and (b) *scientific reasoning sensemaking conversations* that supported family science learning processes through participation with science practices, parent facilitation of children's scientific reasoning, and reasoning with a physical water quality model.

Even though gestures occurred predominantly alongside dialogue, we coded gestures in their own framework to fine-tune an analysis of the spatial occurrence of the families' gestures during the workshop. In Table 3, we have delineated different coding categories for the gestures based on the physical space where they occurred: (a) in the air space between family members, (b) on the tabletop where families were seated, or (c) directly on or around the community water model.

5 | FINDINGS

Our data analysis revealed that, overall, the family discussion prompts engaged parents and children in rich sensemaking conversations during science practices throughout the hour-long water quality workshop. Our findings are focused on the utility of the family discussion prompts to support sensemaking and place-based learning for families as they reasoned with a community water model. We have two main findings, which are discussed in detail below:

(1) The family discussion prompts in the water quality workshop resulted in six distinct types of family sensemaking conversations.
(2) Three types of physical gestures aided families' sensemaking conversations and place-based learning processes while using a community water model.

5.1 | Six types of family sensemaking conversations during the water quality workshop

Examining the families' talk in response to the eight family discussion prompts showed that the 12 families engaged in multiple forms of sensemaking conversation throughout the water quality workshop. After applying the analytical framework in Table 2, the tabulation of the coded transcripts resulted in 330 distinct family science sensemaking conversations. Figure 2 breaks down the frequency for each of the six sensemaking conversation types occur across

TABLE 2 Coding framework used to identify moments of family scientific sensemaking during a Water Quality Workshop

Type of family science sensemaking conversation	Code	Definition	Example from data set
Personally relevant sensemaking conversation	Family experience connection	Families make a connection between the water quality content from the workshop to a family shared prior experience, such as a family trip or everyday activity (McClain & Zimmerman, 2014)	*Roxanne*: That's why when we are driving and it's raining like this, we have a lot of time avoiding the water on the road because there's just so much water.
	Rural connection	Families make a connection between the water quality content from the workshop to a landmark or physical setting in their rural community (Zimmerman & Weible, 2017)	*Britain*: In [Nature Center's] Creek. Um...what was in there? I think there was a lake.
Scientific reasoning sensemaking conversation	Model contextualizing	Families contextualize (Rivet & Krajcik, 2008) the community water model by referring to the components of the model as real-world landmarks or physical attributes (e.g., grass, lake, river) during the workshop experiments.	Arthur: So, I think these are plants that will absorb the water ((*picks up one of the sponges*)).
	Parent revoicing	Parents revoice (Author et al., 2010) the workshop-designed prompt to their child(ren) that was originally delivered by the STEM professional	*Corinna*: (revoicing prompt #1) What are some of the bodies of water that are near where we live? What are places that have water?
	Parent questioning	Parent seeks clarification from child or asks child to explain their reasoning (Ash, 2004)	*Bradford*: Probably a lot more animals, right? Do you think there was a lot of deer?
	Prediction	Families engage with the scientific practice of making a prediction (Szechter & Carey, 2009) as it pertains to the water quality experiments during the workshop	*Karl*: The water will go from here to here.

the participating families. Figure 3 illustrates how each family engaged with the six different types of sensemaking conversations.

In the following sections, we examine each of the sensemaking conversations by providing an example from our data. Each vignette includes "bolded text" to signify where our analytical codes were applied.

5.1.1 | Personally relevant sensemaking conversations

In our analysis, we marked talk as *personally relevant sensemaking conversations* to encapsulate conversations that supported family science talk through making connections to new content by bringing in either shared family

TABLE 3 Coding framework used to identify moments of physical interaction that supported family science sensemaking during a Water Quality Workshop

Code	Definition	Example from data set
Air gesture	Hand gestures take place in the air space between family members (Azevedo & Mann, 2018; English & King, 2015)	*Leslie:* [Town Name's] Mills ((*using her hands to mimic the movement of water*))
Tabletop gesture	Families superimpose hand gestures (Goodwin, 2003) on the physical tabletop where they are seated during the workshop	*Shawn*: Um ... some sort of park. Then there's playground here. ((*points on the table*)), Barbecue place here ((*points on the table*)), and creek ((*points at another spot on the table*))
Community water model gesture	Hand gestures center around the physical model (Crowder, 1996) families used during the water quality workshop	*Sade*: ((*points at a piece of green material placed on a taller spot*)) What does this sponge do for the pollution?

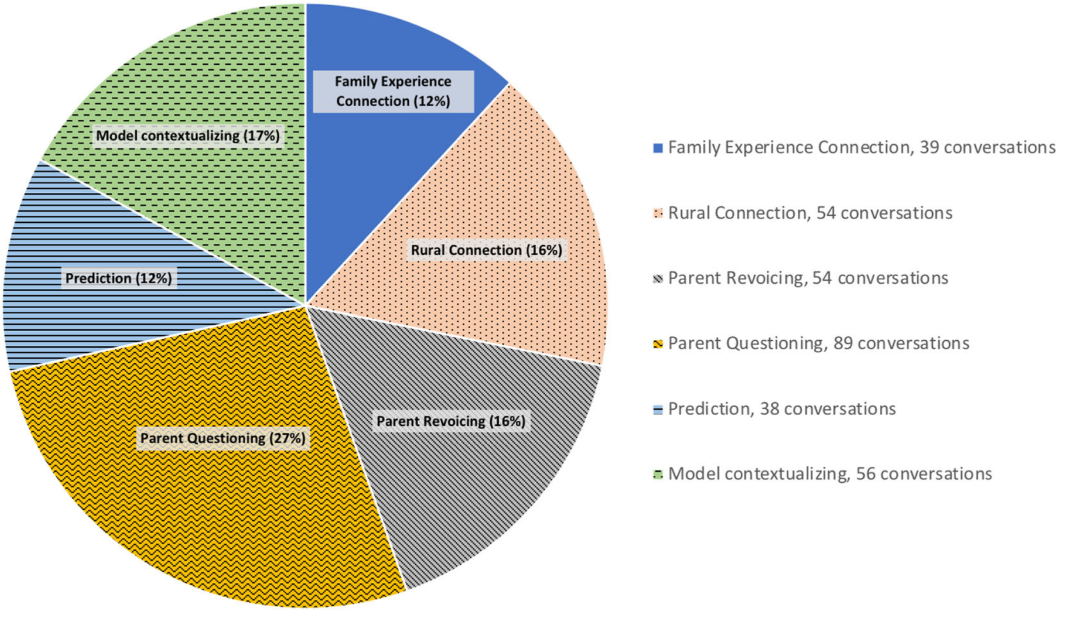


FIGURE 2 Categories of 330 Distinct Sensemaking Conversations Observed Across 12 Participating Families During a Water Quality Workshop

experiences or the local rural community during the water quality workshop. As such, personally relevant sensemaking conversations were either coded as family experience or rural connections.

Family experience connection

Across the 12 families, *family experience connections* occurred in 39 distinct conversations. The family experience connections most often occurred because of discussion prompt #1 ("What types of bodies of water do you have in the community where you live? How do you use this water?"), where 11 out of the 12 families referred to a family experience. In conversations coded as family experience connection, families often recalled shared experiences, thereby drawing on knowledge about different local water bodies and water uses. For one family, referring to

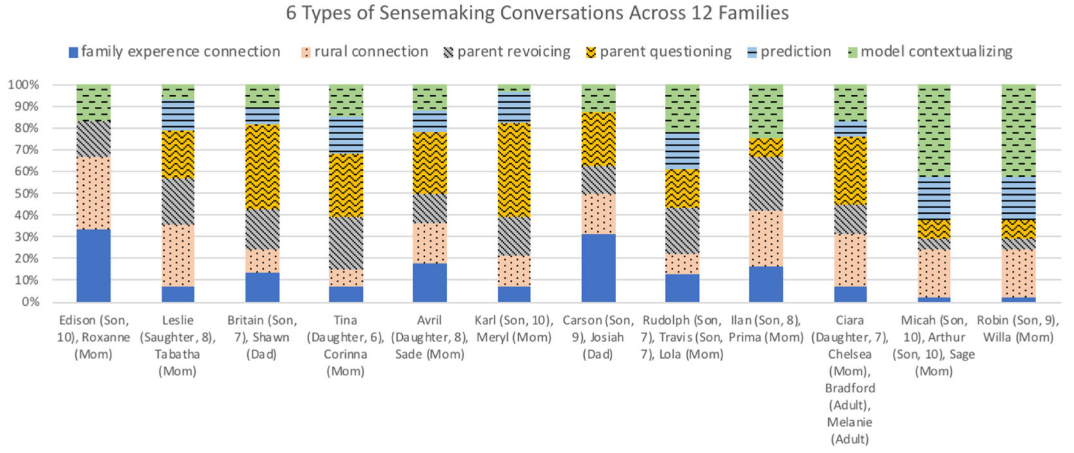


FIGURE 3 Six types of sensemaking conversations observed within each of 12 participant families

specific car trips and routines allowed a mother (Sade) and daughter (Avril, age 8) to remember and then reflect on bodies of water in their community:

> *Sade*: What about some other streams you can think of that's around here? What about in Bluefield? **When we were driving, remember when we were driving?**
>
> *Avril*: **On the way to Dad's house there?** There's a swamp.
>
> *Sade*: There is. You're right. You're right. There's a big swamp right there, isn't there?
>
> *Avril*: ((nods))
>
> *Sade*: Right up by um, you know the Christmas tree farm. What about um, that pond that **we see when we go on the way to [our relative's] place?**
>
> *Avril*: ((nods))

In this example, Sade prompted Avril to remember a stream they saw when they drove through a nearby town; Avril clarified her mother's reference by asking if it was "on the way to Dad's house there?" and that she remembered seeing a swamp. Sade also referenced a local pond that they drove by "on the way" to a family's property. Referring to specific memories from this family experience, such as "remember when we were driving" and "when we go on the way to [our relative's] place," supported the mother in reminding her daughter about local streams and ponds. In this case, like others in our data set, family prior experiences were used as sensemaking resources to connect families' prior experiences in their community to their water quality workshop experience.

Rural connection

Rural connection conversations occurred in 54 distinct conversations across the 12 families. In these conversations, families identified different types of water (e.g., ponds, lakes, and streams) and formally named or gave a specific location for a water source. In one example, a mother, Willa, and 9-year old son, Robin, made rural connections to water after being prompted to think about water sources in their community (discussion prompt #1):

Willa: I wish we had paper, we've listed five or so.

Robin: **Or the [Neighbor's] pond-**that's a body of water.

Willa: Yeah, **that drainage pond at the [Neighbor's] pond**; with the big dip.

Robin: No, **I meant their pond in their backyard** because that's a body of water.

Willa: Oh, **they have a little fish pond back there, too.** Yeah.

Robin: Um…

Willa: ((listing and counting off on fingers)) **Color Lake, Ray Lake, Raptor Lake, Fall Creek, Middle Marsh…**

Here, Willa said that they have thought of at least five types of water, yet Robin continued to think aloud about other bodies of water, including a pond in a neighbor's backyard. Willa suggested a drainage pond, but Robin clarified that he meant the backyard pond. Similar to this family, the other 11 families also made at least one named rural connection to a local water source. This suggests that the families participating in the water quality workshops were aware of surface water landmarks in their rural communities.

5.1.2 | Scientific reasoning sensemaking conversations

Our analysis organized the remaining family sensemaking conversations as *scientific reasoning sensemaking conversations*. These conversations supported family science learning processes through their participation with science practices (i.e., making predictions, asking questions, reasoning with a physical model) and parent facilitation of children's scientific reasoning. In this category, scientific reasoning sensemaking conversations were coded as either parent revoicing, parent questioning, prediction, or model contextualizing.

Parent revoicing

Parent revoicing occurred in 54 different conversations across the 12 families. We found that parents would often summarize, rephrase, or repeat, a discussion prompt shortly after it was delivered by the STEM professional. The parents restated the prompt verbatim, reframed the prompt using different words, or refocused attention to the prompt by saying, *"Okay, so what do you think about that?"* The following examples were taken from parents revoicing the prediction prompts to their children (discussion prompts #3, #5, and #7):

Chelsea (STEM Professional) delivers discussion prompt #3 during a workshop in a small science museum: Think about and talk with your families, where is this rain going to end up? Make some predictions and then we'll see what happens.

Lola (mother) attending workshop with twin sons (7 years old): **Where do you think the rain's gonna go?**

Cassandra (STEM Professional) delivers discussion prompt #5 during a workshop in a rural library: Let's again put back on your scientist's hat and come up with–I want you make a hypothesis about where you think the water's gonna go this time, and how it compares to our first natural environment.

Shawn (father) in a rural library with 7 year old son: **What's your hypothesis?**

Ed (STEM Professional) delivers discussion prompt #7 during a workshop in a rural library: Alright let's make a prediction [to see] if it will help at all; if we will get more groundwater…

Tabatha (mother) attending workshop with 8-year-old daughter: What did you think about more water? **Which one do you think will have more water?** *((gestures to community water model))*. The blue or the white cups?

In each of the examples above, the parent revoiced one of the prediction prompts to focus their child on the science practice of making a prediction with regard to how the water would flow on their community water model during the workshop. We posit that in these ways, parents assumed the role of facilitator to encourage their child's participation in the activity task.

Parent questioning

Parent questioning occurred the most frequently across the 12 families—accumulating into 89 conversations. We coded family sensemaking conversations as parent questioning when parents sought additional information from their children. These coded segments differ from parent revoicing because the questions went beyond restating the STEM professional's discussion prompt and instead, elicited further explanations or clarification *after* a child had made a prediction or shared an idea related to water. Lola (mother) and her twin sons, Travis and Rudolph (7 years old), were about to participate in the first experiment, Lola first revoiced discussion prompt #5 and urged her sons to expand on their brief predictions about where the water will end up in their community water model:

Lola: Which one do you think is gonna have the most water?

Travis: That one. *((looks at the cups))*

((Rudolph points at blue cup))

Lola: **Why?**

Rudolph: Cuz it has no sponge on it. It's gonna hold the water up and it has holes.

Lola: Okay.

In this example, Travis and Rudolph's mother first revoiced discussion prompt #5 by asking them to make a prediction about which cup will "have the most water?" Travis said "That one" while Rudolph pointed at the blue cup in their model. While both boys responded to the discussion prompt to make predictions, Lola encouraged them to think further about their predictions by asking them why the water would end up in the blue cup. Rudolph articulated his understanding, "Cuz it has no sponge on it. It's gonna hold the water up and it has holes." The blue cup represented above-ground water with no soil (i.e., no sponge) that went directly into the water source (i.e., holes). This scenario, like others in our data set, portrays how parents supported their children's engagement in science practices of making and explaining their predictions. Our results indicate that parents also asked their children to articulate their thoughts as they made personally-relevant (i.e., nonscientific) connections to the workshop topic.

Prediction

We designed the water quality workshop to engage families with the science practice of making predictions through the incorporation of family discussion prompts. When we coded the data, this objective was actualized because sensemaking episodes focused on *prediction* arose 38 times in the transcripts. These occurred after discussion prompts #3 (*1st experiment: Where do you think the water will go? Which one will get more water: the white cups and sponges (groundwater) or the blue cup (local body of water)?*), #5 (*2nd experiment: where do you think the water will go this time?)* and #7 *(3rd experiment: will there be more runoff, or more infiltration (i.e., more water in the blue cup, or more water in the sponges and cups for groundwater)?)*. Children overwhelmingly made the predictions; 37 out of the 38 prediction conversations were led by children and one by a parent. Although we intended for parents to also make predictions so that the family as a whole participated, our data suggests that parents believed their children should make the predictions about the water flow in each experiment. In the following example, Tabatha (mother) facilitated her 8-year old daughter, Leslie, to make a prediction after hearing discussion prompt #7:

> Tabatha: What did you think about more water? Which one do you think will have more water? *((gestures to community water model))*. The blue or the white cups?
>
> *Leslie*: **I think—I feel like three of them will have more.**
>
> Tabatha: So which one? Do you think the lake will have more water?
>
> *Leslie*: **This***((points to blue/lake cup))*
>
> *Tabatha*: So you think the lake … I don't know … okay

In this instance, Tabatha first revoiced discussion prompt #7 so that Leslie predicted what will happen during the third experiment. When Leslie responded that "three of them will have more [water]", Tabatha asked Leslie to clarify her thinking about her prediction: "So which one? Do you think the lake will have more water?" When Leslie answered by pointing to the blue cup (representing above-ground lake water), Tabatha's response ("I don't know") suggested that she was not sure about Leslie's prediction, yet did not put forth her own prediction.

Model contextualizing

During our data analysis, we noted *model contextualizing* when families referred to components of their community water models by using names of real-world, physical objects or landmarks. For example, the five green sponges in the model (that represented the soil covered areas that filter water as it goes below ground) were often called grass or land. The blue cup in the model (that represented above-ground water such as lakes or ponds) were frequently given specific lake names from the local community by the families. This practice of model contextualizing was coded in 56 distinct conversations across the 12 participant families. Interestingly, the families not only made references to the real-world representational components of the model when they made predictions, but they also contextualized the model when they engaged with rural connection discussion prompts. The five excerpts below illustrate how different families enacted model contextualization talk in their sensemaking conversations:

> *Bradford (father attending with 7-year old daughter) in response to discussion prompt #2*: Do you think there was more green stuff? *((points at the green sponges))* **More trees?** [Understands green sponges represent plant-covered soil within model]
>
> *Robin (9-year old boy) in response to discussion prompt #3*: It goes **underground** *((points downward with water bottle))*. [Understands groundwater within model]

Tina (6-year old girl) in response to discussion prompt #6: This may be the **grass**. *((holds up the lawn patch card from the build a green community experiment))* The idea is so great; **having roads and grass** at the same time! [Understands groundwater with model]

Roxanne (Mother attending with 10-year old son) in response to discussion prompt #7: I'm pretty sure *((picks up one green building material piece))* we want this, because we want to get more **groundwater**. [Understands groundwater within model]

Sade (Mother attending with 8-year old daughter) in response to discussion prompt #7: So you don't have any sponges between this *((points at the cup next to the blue cup))* and this *((points at the blue cup))* **where the fish live**. [Understands surface water within model]

In these examples above, parents and children are observed making real-world connections to the community water model during the water quality workshop. We view these types of sensemaking conversations as evidence that the family discussion prompts supported the families' scientific reasoning as they conducted experiments with a community water quality model. These examples are also suggestive that the place-based elements of our projects were realized; families made connections from the abstract model to actual places in their community—the general scientific principles could be realized in local places such as Sade referring to surface water as "where the fish live" and Roxanne referring to the building material covering the green sponge as related to groundwater. In other words, when families engaged in the scientific practice of modeling during a 1-hour workshop, they (a) understood the representational features of the physical model (i.e., blue cup = above-ground water and green sponges referred to water filtered before going underground), (b) could identify an example of that representational element in their community, and (c) understood the phenomena in the model represented scientific phenomena in the real world (i.e., the water flowing through the green sponges into the clear cups represented water being filtered through the plant-covered soil into the groundwater).

5.2 | Hand gestures take place across three spatial elements to augment families' sensemaking conversations

The above analyses demonstrated that different sensemaking conversation strategies were used across families to facilitate their connections to the science of water quality. We conducted a second analysis to illuminate the importance of hand gestures for aiding sensemaking conversations and real-world connections with their community water model. We observed that the families' hand gestures occurred on or around one of three spatial elements: (a) the air space between family members, (b) the physical tabletop where families were sitting, or (c) the community water model used for the workshop experiments. For instance, when discussing the bodies of water, some families used gestures to visualize the shape, relative location, and size of the lake, stream, or pond mentioned. In the instances in our data set, gestures were used to represent the physical appearance of objects and the characteristics of phenomena. In addition, when asked to make predictions, all 12 families pointed or used gestures to describe where and how the water flowed on the community water model. For example, children pointed at specific cups or sponges on the model to indicate which areas collected the most water and used hands to draw lines and form shapes to show the water flow, amount of water collected, and rain and infiltration (Figure 4a–c).

To demonstrate how gesture-mediated sensemaking occurred across the families during the workshop, we present three fine-grained analytical accounts (Tables 4–6). Each vignette represents how families leveraged the three types of gestures to scientifically reason and create personally relevant connections with their community water model and the science workshop topic of water quality.

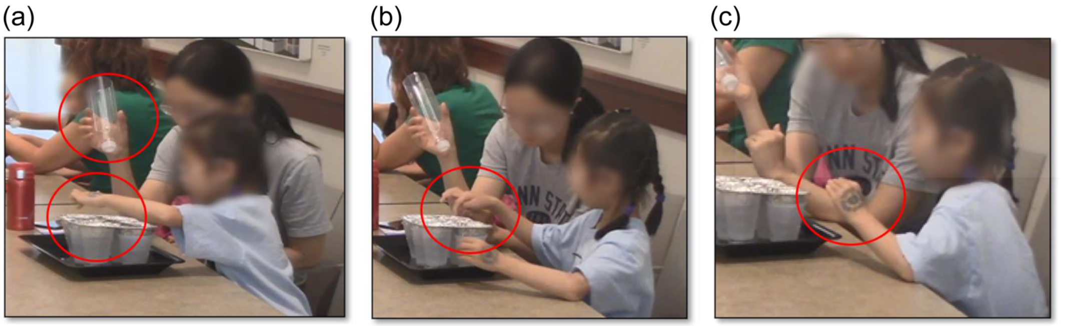


FIGURE 4 Left and Center: A daughter and her mother pointing at muffin tin cups to predict where the water would flow. Right: A daughter gesturing to show the little amount of water that the highest cup would collect

5.2.1 | Example of air gesture to support explanation of water movement

We categorized families' embodied sensemaking interactions as *air gestures* when family members used their hands to emphasize or reinforce their verbal explanations in the air space at the water workshop. In the first account (Table 4), Prima (mother) and her son (Ilan, age 8) have been prompted by Chelsea to talk with each other about bodies of water in their community and how they use this water (discussion prompt #1):

> *Chelsea*: "Before we start it, I want you to take a couple minutes with whoever brought you here, whoever you're with, and talk about —what are some of the bodies of water, you know, lakes, rivers in the ground? What are some of those near where you live and how are you using that water? So, take a minute and talk about that."

After first discussing local bodies of water, Ilan and Prima talked about the water they use in their home and where that water comes from.

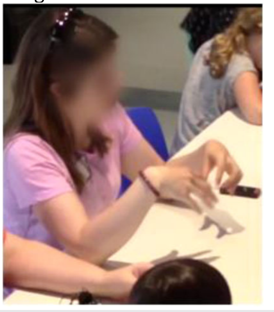
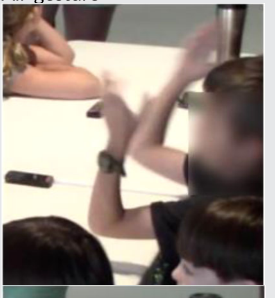
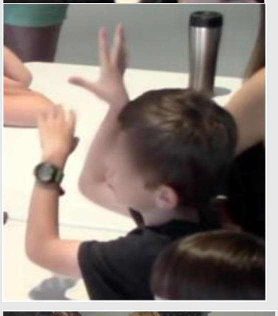
In this example, Ilan and Prima used their hands to gesture. Prima moved her hands downward when talking about the sewer system where their water goes as waste. When Ilan shared his understanding of how the sewer system works, he mimicked the movement of water through the sewer system by moving his hands upwards to indicate the water going up the pipes so that it can be "fixed" (i.e., cleaned) by the sanitation engineers. Both family members leveraged air gestures to emphasize and augment their explanations to each other.

5.2.2 | Example of tabletop gesture to create maps

Throughout the workshop, the participating families utilized the top of the table where they were sitting as a drawing board. Sometimes the tabletops were used as an imaginary map or to outline the shape of a creek, river, lake, or pond. In Table 5, we provide an example where a father, Shawn, who attended the water quality workshop at a library with his son (Britain, age 7), gestured on the tabletop to remind Britain about a park with a stream.

Britain's father utilized the table where they sat as a physical map to remind Britain about a community park where there is a stream. Shawn used his hands and fingers to touch the tabletop to pinpoint certain locations in the park. By using the tabletop gesture to orient Britain to the park's layout, Britain made rural and family connections with his father. Britain also made an air gesture to demonstrate to his father his understanding of the same map. We interpret this to show that sensemaking gestures that represent mapping can be done either on a physical surface (such as the tabletop) or an imagined one (such as the air).

TABLE 4 Example of air gesture in action from the data set

Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Prima: Ilan, we have the county water. So, we get our water from the sewer system ((gestures hands in a downward motion)).	Ilan's mother explains to him that they "have the county water," so they get their water from the sewer system.	Rural connection	Air gesture 
Ilan: Isn't that... isn't that where the toilet water goes through the sewers ((uses hands to mimic the flow of the water in the sewer systems)), and then it comes up and the people fix it... and they take out the poop and they take out the germs...	Ilan responds to his mother's statement by explaining what he knows about sewers and the people that "fix" the water to remove toxins.	Family experience connection	Air gesture   

5.2.3 | Example of community water model gesture to support scientific reasoning

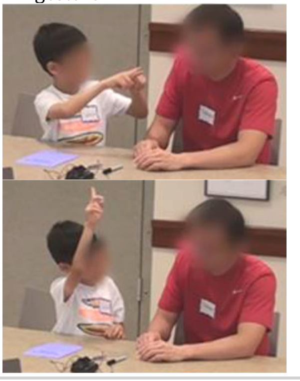
In our final gesture example, we provide a representative example of how families used gestures with the community water model to focus their scientific reasoning. During a workshop held at a nature center, two families interacted together during their experiments with their community water models—Sage with sons Arthur and Micah (twins, aged 10 years old), and Willa with her son, Robin (Age 9). In the analytical account portrayed in Table 6, Micah, Arthur, and Robin share ideas with each other using elements of their models to represent where they predict the water will go during their first experiment.

TABLE 5 Example of tabletop gesture that creates a map from the dataset

Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Cassandra: Before we start it, I want you to take a couple minutes with whoever brought you here, whoever you're with, and talk about– what are some of the bodies of water, you know, lakes, rivers in the ground, What are some of those near where you live and how are you using that water? So take a minute and talk about that.	The STEM professional (Cassandra) leading this workshop delivers family discussion prompt #1 to the families attending the workshop.		
Shawn: The place where there is a creek or stream.	In response to discussion prompt #1, Shawn suggests a local area "where there is a creek or stream" to Britain.	Rural connection	
Britain: The one that was like the beach?	Britain asks his father if he is referring to a local place that is "like the beach"	Rural connection	
Shawn: No … there were stones, *((points to spot on the table))*. there was a playground *((moves his hands on the table to demonstrate the spatial information))* and there was a fire grill, *((points at a spot on the table))*, and there was a place where you could be in case it rained *((places his hand to another spot on table))* and we had ramen, and over here, there were lots of water so you could play inside with [your friend]. Remember that pretty big stream of water?	Shawn describes a local park and the different features found at that park by drawing a "map" of the park on the top of the table where he and Britain are seated.	Rural connection, family experience connection	Tabletop gesture 

(Continues)

TABLE 5 (Continued)

Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Britain: Like this and this? *((makes gestures with hands in the air))* There was sand, playground, and we had something to eat under the pavilion there?	Britain asks if his father is referring to the place that has "sand, playground" and a "pavilion" while using his hands to make a map in the air	Rural connection, family experience connection	Air gesture 

Note: This tabletop gesture was followed in conversation with an air gesture, also representing a map.

In Table 6, the three boys gestured towards the community water model and in the air while making predictions and contextualizing their water model. These gestures externalized their thinking about where the water would go in the first experiment, which allowed for others to contribute their own ideas or add to and refine someone else's idea.

In each of the above examples, we provide evidence that families' verbal scientific reasoning and observations during the water quality workshops were highlighted in a physical manner. Family members organized talk, hand gestures, and pointing when interacting with the surface and underground water model during water quality experiments to test the predictions they made and when describing shared experiences with areas in their community.

6 | DISCUSSION

Our analysis investigated the wide-spread adoption of the modified Think–Pair–Share prompts across four water quality workshops. The findings suggest these prompts supported child–parent conversations and sensemaking during a science workshop focused on water. As previously described, the earlier iterations of our water quality workshop curriculum (McClain & Zimmerman, 2019)—which did not explicitly call out the family discussion prompts—often resulted in the STEM Professional delivering the prompt to all workshop attendees (with participants raising their hand so that one person could answer) or in a rhetorical manner (i.e., the STEM professional answered their own question). As such, the earlier water quality workshop iterations fostered few personally relevant or rural connections between the participants and the topic of water quality (McClain & Zimmerman, 2019). When we redesigned the workshop curriculum (as described in this analysis) to intentionally focus on the family discussion prompts, we observed families talking and reasoning as a social learning group. We thus viewed the STEM professionals as successful facilitators of these family-focused science workshops. In sum, our analysis suggests that family discussion prompts sparked families' place-based, sensemaking conversations during the water quality science workshop.

TABLE 6 Example of community water model gesture in action from the data set

Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Chelsea: And then while we're doing this, let's make some predictions. So talk about with your family, where does the rain go? After it falls down from the sky."	The STEM professional leading this workshop delivers family discussion prompt #3.		
Robin: It goes underground *((points downward with water bottle))*	After hearing discussion prompt #3, Robin makes a prediction that the water will go "underground" (i.e., into the cups) and uses the workshop-provided water bottle to gesture in a downwards motion over the community water model	Prediction and model contextualization	Community water model gesture 
Micah: It's going to go downhill	After hearing discussion prompt #3, Micah makes his prediction that the water will go "downhill"	Prediction and model contextualization	
Arthur: It's gonna first land here *((points at sponge on Robin's tray))*	After hearing discussion prompt #3, Arthur begins to share his prediction by pointing to one of the sponges in Robin's community water model and suggesting that the water will "first land here"	Prediction	Community water model gesture 
Robin: It's gonna go next to the land and then under here *((points at cups))* is underground//	Robin further articulates his original prediction by adding to Arthur's statement and says the water will next go to "the land"; Robin contextualizes the model by pointing at the cups (underneath the community water model) and identifying them as being representative of the "underground."	Prediction and model contextualization	Community water model gesture 

(Continues)

TABLE 6 (Continued)

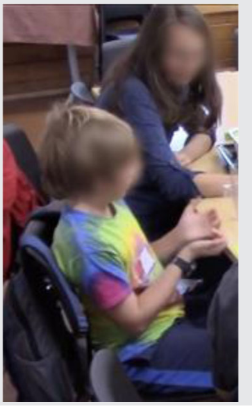
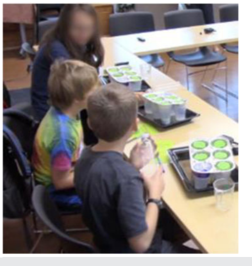
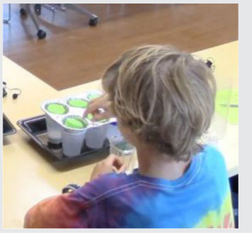
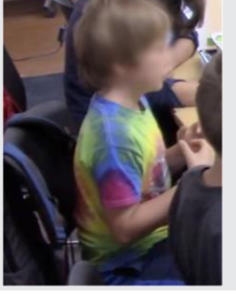
Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Micah: Yeah. It goes onto this … ditch … *((uses cupped hands to represent a ditch))*	Micah agrees with Robin's prediction and suggests that the water may go into a "ditch" on their community water model.	Prediction and model contextualization	Air gesture 
Sage: You think most of it will go in there? *((points at blue cup on Micah's tray))*	Sage redirects the boys' thinking back to the original prompt by asking them if they think "most of [the water] will go in there?"; she asks her question while pointing at the blue cup on Micah's tray to signal which cup she is referring to.	Parent question	Community water model gesture 
Arthur: I think some of it will go into these sponges *((points at sponges on his tray))*	Arthur responds to his mother's question by explaining that he thinks some of the water will "go into these sponges."	Prediction	Community water model gesture 
Sage: Mm hmm	Sage affirms that she has heard Arthur's response.		
Micah: Because they will absorb it *((pushes hands together to show the process of absorbance))* just like the plants and the trees	Micah adds to his brother's prediction by contextualizing the sponges as being able to absorb water "just like the plants and trees"	Prediction and model contextualization	Air gesture 

TABLE 6 (Continued)

Transcribed video record	Analysis of family interaction	Sensemaking conversation code (see Table 2)	Physical interaction code (see Table 3)
Arthur: it will collect it, so I think these are plants that will absorb the water *((picks up one of the sponges))*		Prediction and model contextualization	Community water model gesture 

6.1 | Family discussion prompts facilitate families' place-based and sensemaking conversations during science workshops

Family discussion prompts, which were delivered by the STEM professional, supported parents and children to mutually engage in sensemaking conversations throughout the water quality workshop. More specifically, the discussion prompts provided families with time to share their prior knowledge and experiences with community bodies of water, which supported the "localization" of the science content within the workshop. In this way, families were able to make sense of a local science issue in both a place-based and personally relevant way. We found that both family experience connections and rural connections to their community were utilized as conversational sensemaking tools for families attending the water quality workshop. This finding aligns with literature that supports the importance of prior family experiences during the science sensemaking process in both museums (Allen, 2002; Ellenbogen et al., 2004; Zimmerman et al., 2010) and outdoor-based nature trails (McClain & Zimmerman, 2014), but brings it to the new context of rural libraries. Additionally, family connections to their rural community provided a means for families to overlay their "local rural knowledge" (Avery, 2013) onto the more complex topic of water quality, which we posit made this science topic more locally relevant for both parents and children.

Our discussion prompts also influenced families' science practices, such as making predictions, asking questions, and explaining. In particular, parents specifically revoiced (or reprompted) their children to support engagement with the workshop experiments. Parents also asked follow-up questions so that children were facilitated to clarify or further explain their thinking with the community water model. Our discussion prompts focused on supporting families' predictions about the water experiments, but they were primarily used to support children's reasoning—rather than whole family reasoning. Future iterations of this workshop will consider articulation of the three prediction prompts to welcome both parents *and* children to contribute and discuss their predictions before each experiment.

6.1.1 | Revoicing

Prior research on parents' roles in scaffolding children's learning in informal settings has shown that parents can overestimate children's abilities in solving science problems, as well as lack strategies to support their children's learning (Gleason & Schauble, 1999). Yet, in our work, we found providing a facilitator who used discussion prompts led to an emergent learning strategy. Parents supported their children' through the revoicing of a discussion prompt that had previously been delivered by the STEM professional leading the workshop. We examined the role of parent revoicing in a library workshop on astroengineering (Zimmerman et al., 2019) which supported youths' prior experiences with astronomy and engagement in the engineering design process. This analysis of the families attending the water workshop reifies the importance of revoicing with the addition of revoicing to support rural connections and engagement in experimentation with models and in the science domain of earth sciences (water). In these workshops, parents revoiced, or fine-tuned, the scientist's questions to provide a family experience where children could easily and comfortably engage with science. Scholars (Luce et al., 2017) conducting outdoor education research found that it was important for parents to customize learning supports for their children, and our analysis of an indoor science learning program also found that parents customized the learning supports for children by summarizing, rephrasing, or reminding.

6.2 | Hand gestures aid families' sensemaking and scientific reasoning conversations

During the water quality workshops, gestures were used by parents and children in tandem with their verbal conversations. We found that parent–child verbal and gestural interactions with each other allowed for meaningful talk to proceed when the STEM Professional leading the workshop provided the time and space for families to work together. This trend reinforces previous research with families where gesturing is a core component of parent-child learning experiences in both “mundane settings” (Goodwin, 2007) and during forest walks (Marin & Bang, 2018) without disciplinary experts.

In designing the scientist-led water quality workshop, the family discussion prompts aimed to facilitate a place-based learning experience for families through sparking conversation and guiding families to consider the water model as their local community. Based on our three examples outlined in Tables 4–6, we found a linkage between verbal dialogue and gestures to be representative of the sensemaking tools that families used to build their place-based understandings and scientific reasoning throughout the water quality workshop.

6.2.1 | Families spatially distributed hand gestures to support different types of sensemaking conversations

While gestures frequently augmented the families' conversations during the workshop, the physical space where the gestures occurred was utilized for different types of sensemaking conversations. Two prominent trends were that gestures occurring within the air or on the tabletops most often supported personally relevant sensemaking conversations, while gestures occurring around the community water model tended to emerge during scientific reasoning sensemaking conversations.

Air gestures

Hand gestures in the air were most often linked to family experience connections and rural connections. We considered these moments to be representative of the ways in which people verbally and physically constructed their scientific insights as they related to their community's water. Families' gestures externalized the ways that the participants explained science processes (i.e., the way water moves through sewer pipes to be cleaned) to one another. For children grappling with science explanations, Crowder and Newman (1993) argued that the interplay between gestures and language represents real-time explanations of scientific phenomena. Importantly, they propose that researchers and educators should recognize the enactment of gestures with dialogue as evidence for students' doing real scientific work and actively constructing knowledge. Therefore, we interpret the appearance of families' air gestures during the workshop to suggest that both adults and children were working through their science understandings and explanations.

Tabletop gestures

When verbal descriptions and air gestures were not adequate explanation tools, the tabletop provided a shared, physical platform that family members could view and manipulate by drawing on top of the table using their fingers. In work on how gestures unfold during teaching and learning, Roth (2001) identified iconic gestures as hand gestures that move for the purpose of representing a physical place or object. The families in our study often used the tabletops as representatives of the landscape so that individuals could enact iconic gestures to draw maps of local areas to augment their verbal descriptions. In this way, tabletops became "sharable territories and resources [to] facilitate negotiation and meaning making" (Steier et al., 2015, p. 3) between family members. This reinforces the study of people's uses of space in informal learning settings.

Community water model gestures

When gestures occurred around the community water model, it often accompanied scientific reasoning sense-making conversations—particularly children's predictions for the experiments or parent-led questions related to a child's prediction. We view these actions as a means for the families to externalize their sensemaking and reasoning to build shared understandings of the water model and overall topic of water quality. Crowder (1996) found that sixth-grade science students who were actively explaining the seasonal patterns using a sun–moon model tended to "step within the gesture space" (p. 205) of the model. Similarly, we noted that when families were actively making predictions (usually children) or asking clarifying questions related to one's ideas (usually parents), they also stepped into the gesture space by focusing their hand movements around the community water model. For example, in Table 6, we provided an example of a conversation with three boys and one mother that spanned approximately one minute and centered around their predictions for the first experiment with their community water model. In this short time frame, there were multiple gestures at play, including six different gestures to the community water model and two air gestures. We suggest that these gestures amplified the boys' predictions and model contextualizing so that their ideas and reasoning were enhanced and made available for others to acknowledge. In particular, we argue that the frequent presence gestures in concert with model contextualization conversations indicates that the families actively viewed their water model as a representation of their community.

7 | IMPLICATIONS

The findings of this study have implications for educators and designers who are interested in connecting families to science. Our work suggests that discussion prompts are critical to design for and include in family-focused science workshops. Teaching resources (e.g., lesson plans, handouts) that include the prompts could be provided to the scientists (or other facilitators) leading the workshop to ensure that families are given more opportunities to engage in science talk. While this study did not focus on pedagogical techniques per se, we suggest that providing training to scientists leading family science workshops may increase the effectiveness of the discussion prompts designed for family sensemaking. A future line of research could inquire on how to most effectively train scientists to lead family science workshops and explore different modes for delivering the family discussion prompts appropriately.

The ways in which families interacted with the community water model to make place-based science predictions and explanations also has implications for the design of family science workshops, in a physical sense. As demonstrated in our study, families gestured around different surfaces (i.e., tabletop, in the air) and the community water model while engaging in science practice and talk. Applying such findings to family science settings, educators can provide families with physical models and different hands-on tools (e.g., tabletops, instruments used by scientists) for them to physically manipulate and gesture around as they verbalize their reasoning. We posit that by giving families enough physical space to gesture and physically work with science tools during a science workshop, families are more apt to engage in scientific reasoning, practices of science, and sensemaking with each other. When informal learning institutions host programs for families, there arises a common problem of practice with regard to room capacity and participant numbers. We have found that when families have ample physical space during a science workshop, they have more room to gesture over multiple surfaces, which may contribute to their sensemaking process. Given this, we make the recommendation that informal institutions consider the physical layout of the setting where science programs are situated so that participants (especially groups) have the room to gesture without being inhibited. Relatedly, when blended with family discussion prompts, physical tools can support families to better contextualize science representations and domain-specific science content so that the learning experience is not only locally and personally relevant for families, but also allows for physical interactions that support the parent–child sensemaking process. Future work to understand how families interact with rural and family connection prompts in learning settings or with different science topics would be a valuable line of work.

8 | CONCLUSION

This study provides empirical evidence of how families can develop a sense of shared ownership over their science experience and personal meaning-making by engaging in science practices and conversations, and drawing upon personally and locally-relevant prior experiences during a scientist-led workshop. We suggest that these types of science workshops held at rural libraries provide an accessible means for families in underserved areas to engage with local science issues, thereby building public awareness of science (Stilgoe et al., 2014; Stocklmayer & Gilbert, 2002). Within these workshops, our work regards family discussion prompts as significant components of the curriculum. Our data has shown the impact of the discussion prompts on the families' resulting place-based science talk in the water quality workshops. In particular, the embedded discussion prompts facilitated families' connections with the locally and personally relevant science topic of water quality. These prompts also elicited parents' revoicing of prompts and families' gesturing around the water model, which supported children's science practices. To support rural families' place-based science learning processes during scientist-led workshops, we recommend that educators and scientists incorporate family discussion prompts so that families can intentionally engage with place-based scientific reasoning and sensemaking processes through conversational dialogue and gestural interactions together.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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