Integrating Narrative Into the Design of Preschool Science Programs

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Abstract: We investigated how narratives from science storybooks can become tools to structure and problematize science phenomena for preschool-age children during museum programs. Analysis of video from four programs with preschool-aged audiences suggests the story-driven investigations provided opportunities for preschool-children to co-construct evidence-based explanations with educators through the mediation of elements which arose from the narrative-infused design. We present the relative affordances of salient mediating processes influenced by the storybooks' narratives, including the structure of the investigations, discourse, gesture use, and generation of representations.

Stories can engage children with science by making concepts more meaningful and relatable (Avraamidou & Osborne, 2009). Stories can also help children find the motivation to learn science by helping them identify the importance of a problem or concept (Murmann & Avraamidou, 2014). Stories have the potential to generate the *narrative effect* by helping children remember, generate interest, and improve understanding (Norris et al., 2005). However, more research is needed on the use of stories as tools to support children's science learning, particularly as a way to facilitate their engagement in science practices. Story-based activities require scaffolds to facilitate educators and children's use of stories towards engaging in science practices about science phenomena (Murmann & Avraamidou, 2014). Plummer and Ricketts (2018) found that preschool-age children were able to identify patterns in observations and provide support for explanations when educators used questions drawn from science storybooks. This suggests that there are elements of a storybook which might be used in the design of learning environments that prompt children to engage in science practices, leading to our research question: *What elements in museum programs that integrate children's science storybooks in their design mediate young children's opportunities to construct evidence-based explanations?*

Conceptual and theoretical frameworks

Norris et al. (2005) developed a framework defining the role of narrative explanations in science. A narrative explanation is one which "[e]xplains an event by narrating the events leading up to its occurrence, cites unique events as explanatory of other unique events, [and] posits some events as causes of others" (p. 550). The power of narrative explanations comes through meaning making that happens as a sequence of events unfold which, through their unique and unrepeatable nature, develop into the particular explanation. We use Norris et al.'s language of *narrative elements* to identify characteristics of science storybooks that are taken-up by children or educators or that embody elements of the investigation in our program design: *event-tokens* (educator or child references a particular occurrence from the storybook narrative), *structure* (children engage in the same structure of events as occurred in the storybook), *agency* (children act like the main character(s) from the storybook while engaging in the same event(s) from the storybook), and *purpose* (children engage in understanding the same science phenomenon as the storybook as a way to help them better understand the natural world).

In designing the programs for this study, we also drew on a sociocultural perspective in which children develop scientific ways of thinking as an emergent process when engaged in social activities with other children, parents, or educators (Rogoff, Dahl, & Callanan, 2018). For young children, science is a way of knowing that is "enacted and embodied" (Siry & Gorges, 2019, p. 2) as children interact with others and their environment. This embodied enactment of science is revealed as children use multiple modalities, including words, drawings and gestures, as they make sense of their own ideas, others ideas, and new observations of science phenomenon (e.g., Siry & Gorges, 2019; Siry & Max, 2013). This perspective guided our design choices as we developed a museum environment which we conjecture would provide young children with opportunities to use their own observations of science phenomenon as evidence to co-construct explanations (McNeill, Berland, & Pelletier, 2017).

Methodology

The study was guided by a design-based research methodology using conjecture mapping (Sandoval, 2014). Conjecture mapping is a systematic approach to design research which specifies how the most relevant theoretical features of a learning environment design are predicted to produce the desired outcomes. Conjecture mapping is organized around a set of design conjectures (how design elements generate mediating processes) and theoretical conjectures (how theory-based mediating processes produce desired outcomes). We proposed design conjectures which relate the narrative explanation from a children's science storybook to specific mediating processes (discourse, gestures, investigation of the phenomenon, and generating representations). We conjectured that each of these mediating processes could produce evidence-based explanations with young children based on our theoretical framework of science as "enacted and embodied" (e.g., Siry & Gorges, 2019).

We designed museum programs around four children's science storybooks:

- *Moonbear's Shadow*: Moonbear tries to get rid of his shadow so that it won't scare fish while fishing.
- *Breakfast Moon*: A brother and sister observe the Moon each day and, while comparing the Moon to breakfast foods, also uncover its pattern.
- *Creating Craters*: A brother and sister go to the Moon, compare the size and depth of craters, wonder why the craters are different are different sizes and decide to return to the Earth to do an experiment.
- *Magnet Max*: Max and friend investigate which objects around Max's house are attracted to magnets.

Each ~30-minute program began with the educator reading the storybook. The educator then prompted children to investigate the storybook's phenomenon using hands-on materials. Finally, the educator guided children to generate representations (drawings or physical models) to reflect on what they learned about the phenomena. Programs were delivered three to four times with different groups of ~10-15 children, age 3-to-5 years; each session was video recorded with two cameras. We used conjecture map elements (embodiments, mediating processes, outcomes) as codes to analyze our video data. After the second author coded each video, the first author reviewed the coded instances and the authors discussed coding to improve validity and reliability. Finally, we looked for connections between mediating processes and evidence-based explanations as well as narrative elements that may have helped generate mediating processes.

Findings

Across all four programs, children co-constructed evidence-based explanations for phenomena in collaboration with the educator. We present here an example from Moonbear's shadow; children made sense of the relationships between light source, object (a plastic bear figurine), and shadows as they co-constructed evidence-based claims with the educator (Nora):

Nora:	Put your Bear back down by the side of the pond again. And see if you can make him have a shadow that does not scare the fish so he can catch a fish.
Mark (4 yrs):	Hey, I made the shadow not scare the fish and I made the Sun go this way [points to flashlight] and the shadow went this way [traces along shadow pointing away from pond].
Nora:	So, you put the Sun over this way and the shadow that way [both Nora and Mark trace the shadow] and it is not scare - Can you make it scare the fish again? How would you do that?

Mark moved his flashlight to the other side of his Bear model so that the shadow fell on the pond. Nora encouraged children to test their ideas about how shadows are formed. In response, Mark made a claim about how he made a shadow that doesn't scare the fish and indicated his evidence by gesturing to the shadow in his model. He also provides reasoning for how he made a shadow point in that direction as he indicates where he placed his flashlight. Across the programs, children co-constructed evidence-based explanations by manipulating materials, gesturing, and received the guidance of the educator's prompts and questions. After analysis confirmed that our design supported children in co-construction evidence-based explanations, we considered how the storybooks' narrative influenced embodiments of our design produced the mediating processes that led to those outcomes.

Relationship between narrative, investigation, and evidence-based explanations

Our analysis indicates three pathways from the storybook's narrative to investigation design. 1) <u>Investigation mimics elements of the narrative *structure*</u>. This pattern was observed for both Moonbear's Shadow and Magnet Max. In Magnet Max*,* the investigation structure reproduced the same investigation as was carried out by Max and his friend in the storybook. Children used magnetic wands to test materials around the classroom and were then guided by the educator to use these observations to make claims about what is magnetic. The investigation questions were drawn from the *structure* of the storybook's narrative. As a result, children's evidence-based explanations were constructed within the context of the *narrative* and for the same *purpose* as the story's narrative. 2) <u>Investigation explores the same *purpose* but not the same *structure* as the storybook's narrative.</u> The

Breakfast Moon investigation engaged children in uncovering the pattern of the lunar phases - the same *purpose* as the storybook - but does not follow the same *structure* as in the story. In the narrative, the characters observe lunar phases over several days to discover the pattern; in the program, the educator guided children to reproduce the pattern of lunar phases by matching individual lunar phases to a banner and then to summarize the full pattern as increasing and decreasing. As a result, children's evidence-based explanations responded to the same *purpose* as the storybook's narrative but did not follow similar *event-tokens*. 3) Investigation extends the *purpose* of the storybook narrative by taking up narrative *agency*. The Creating Craters investigation begins with engaging children in describing the same phenomenon as was explored in the storybook - the diverse sizes of craters on the Moon. Children construct explanations for the characters' final question: why are there craters of different sizes? As a result, children's evidence-based explanations expand on the *purpose* and extend the narrative *structure* by taking up the characters' wondering (*agency*). Summary: The programs' investigation design embodied the storybooks' narrative structure, purpose, and/or agency to varying degrees as a method of mediating children's opportunities to co-constructing evidence-based explanations.

Relationship between narrative, discourse, and evidence-based explanations

We identified two ways discourse embodied storybook narrative in ways that mediated children's evidence-based explanations: narrative-driven discourse and phenomenon-driven discourse. 1) Educators and children engaged in narrative-driven discourse related to narrative *event-tokens* as they made sense of the investigation's phenomenon. Narrative-driven discourse was most frequently observed during Moonbear's Shadow programs as the educator and children used flashlights to represent the Sun and a plastic figure to represent Moonbear. As children's explored shadows, the educator encouraged children to recreate particular *event-tokens* or *structures* as a way to help them investigate different ways to form shadows, such as having children try to create a shadow with their bear figure that would "scare the fish away" in their model. 2) Educators and children engaged in phenomenon-driven discourse related to the storybook's science phenomenon but without reference to narrative *event-tokens.* Each program engaged children and educators in discourse around the storybook's science phenomenon without making use of particular narrative's *event-tokens*. For example, during *Creating Craters,* the educator asked children whether they predicted their craters would be deep or shallow, spatial concepts introduced in the storybook to describe craters, but without reference to the storybook's characters or their experiences. Summary: While all programs led to explanations using phenomenon-driven discourse, only Moonbear's Shadow frequently engaged children in discourse around narrative *structures* and *event-tokens*.

Relationship between narrative, gestures, and evidence-based explanations

Children used gestures to mediate their construction of evidence-based explanations during Moonbear's Shadow, Creating Craters, and Breakfast Moon. Children's gestures helped them indicate evidence for their claims, such as a child tracing the length of a shadow during Moonbear's Shadow, or to support their construction of a claim, such as how a child described the depth of a crater with her hands during Creating Craters. Children use these gestures to help them make sense of and to communicate their understanding of phenomena during investigations. The programs where children used gestures to construct explanations were for phenomena that are spatial in nature (shadows, craters, and lunar phases). Only Magnet Max, which focuses on magnetism and does not require spatial reasoning, had no instances of gesture use during explanations. Summary: Gestures arose as a mediating factor for evidence-based explanations in programs developed around storybooks which construct narrative explanations for spatial phenomena.

Relationship between narrative, representations, and evidence-based explanations

Children drew or used clay to represent the phenomena as a final reflection. These representations mediated children's discourse as they co-generated explanations with an educator. We designed the programs to use the storybook's narrative by including prompts for educators to encourage children to respond to a question framed around storybook *characters* and *event-tokens*. For example, "Can you make new craters on the Moon for Arthur and Mae to explore with your clay?" However, these prompts were not entirely successful for the purpose of connecting the *narrative structure* to the children's representation. While the educators occasionally used the prompts when introducing the representational activity, they frequently switched to only asking questions that referred to the phenomenon (e.g., "What kind of craters did you make?). Only during Moonbear's Shadow was the *character* (Moonbear) frequently referenced; this was because the children's task was to draw the Sun and Moonbear's shadow. Summary: Though narrative elements were designed into the representational task for the children, educators and children rarely used these elements for all but Moonbear's Shadow program.

Discussion

Identifying narrative element as children constructed explanations required us to consider how children communicate science ideas through a variety of modalities, including verbal, gesture, and material manipulations in the museum (Siry & Gorges, 2019). The story-driven programs provided opportunities for children to co-construct evidence-based explanations as mediated by material-rich opportunities to investigate phenomena, discourse between children and educator, gesture-use, and generation of representations. The storybooks' narrative most directly influenced investigation structures and, though more limited, use of narrative-driven discourse. The storybooks' narratives indirectly influenced gestures and representations through the phenomenon around which each storybook constructed a narrative explanation (Norris et al., 2005).

We conjectured that our program design would elicit more frequent uptake between educator and children from *event-token* and *narrative structures* within the discourse that guided children's sense-making during the investigation and reflection portions of the programs. Built in opportunities for educators to explicitly call-back to the narrative structure through questions and prompts rarely produced traction with children's discourse across all programs but Moonbear's Shadow. Moonbear's Shadow may have produced more *narrative-driven discourse* around *evidence-based explanations* because, not only did the structure of the investigation mimic the storybook's narrative structure but, the children used a bear figure in their model and representation which provided an *agent* in their investigation (Norris et al, 2005). Magnet Max's investigation also mimicked the *narrative structure* of the storybook but children were not using a model with a character to investigate so had limited need to draw on the same narrative feature of the *agent* in their discourse.

Direct up-take of storybook narrative within the investigation took place when children modeled both the situation and the character from the storybook. The next round of design-based research where our designs embodies scenarios where children can use characters and storybook narrative elements to facilitate investigation of phenomena can help us better understand the role of narratives as a tool for children's sense-making opportunities in science. Uptake of the narrative during the investigation along with the tight conceptual focus within that narrative has the potential to enhance children's science learning (Fisch, 2000). To further test how this more extended engagement with a storybook's narrative might support children's conceptual learning and use of science practices, our next research cycle may require comparative studies between how children take-up opportunities to construct explanations in relatively narrative-rich versus narrative-poor environments.

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