MindScribe: Reflective Inquiry through Scaffolded Storytelling for Low-Income and Multilingual Early Childhood Communities

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ABSTRACT

When young children create, they are exploring their emerging skills by engaging with the world. When young children reflect, they are deepening their learning experiences by extracting insights. And when young children share, they are strengthening their community by creating opportunities for collaboration. To support such constructionist learning, we present MindScribe, an affordable interactive robotic object that engages preliterate children in reflective inquiry. As children create artifacts, MindScribe invites them to "tell a story" about their creation—in any language. And through scaffolded questioning, MindScribe elicits children's insights into their creative discoveries. Together, they spark child-led communication and innovation in early learning communities.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Natural language interfaces**; **User centered design**; **Accessibility technologies**; • **Computer systems organization** → **Robotics**;

KEYWORDS

Human-agent collaboration; Human-robot interaction; Child-robot interaction; Interactive robotic objects; Early childhood development; Constructionism; Accessibility.

1 INTRODUCTION

Early childhood environments—such as preschools, homes, and libraries—are rich with creative activity as young children use their emerging skills to understand and influence the world around them.

As children draw, build, and craft, they are exploring not only their developing motor skills but also their cognitive, social, and emotional relationships. Children's creative works can be an evocative window into their developmental needs, and can serve as a medium for conversation and further collaboration [2].

By telling improvisational stories about their creative works, young children are empowered as ideators and innovators within their communities. But preliterate young children lack access to the reflection and storytelling tools that are available to older, literate learners, such as writing in a diary or posting to a blog. Furthermore, children who speak a language different from their caregivers and peers experience isolation from verbal communication.

To scalably meet these needs, we sought to build a technologically-augmented storytelling tool. We aimed to create a user-centered engagement distinct from other talking toys by: (1) utilizing everyday objects to build an affordable solution for low-income communities, (2) designing developmentally appropriate interactions by prioritizing children's sensory and social experiences, and (3) putting the child's mind at the center of the interaction by building a solution that acts as an assistant to the child's ideas rather than as an entertainer, educator, or ideator itself.

Through an iterative user centered design process, we created MindScribe (Figure 1), an interactive robotic object (IRO) that engages young, preliterate children in reflective storytelling in any of the child's spoken languages.

Figure 1: The MindScribe zebra (left), a technologically-augmented stuffed animal, helped a child tell a story about her drawing. We then transcribed her words into text, and printed her story into a book (right) for her to share with her family, school, and friends. She named her story, "The Girl Who Wanted to Change the Day."

2 USER CENTERED DESIGN

MindScribe's design context was informed by our first author's past role as a preschool teacher with children ages 2.5 to 5 years old. There, she utilized the Storybook Journey curriculum [3] to playfully support learning, and Developmentally Appropriate Practices [1] to guide effective interactions. MindScribe is grounded in these principles, and is motivated by the impact of her students' stories.

To further develop our design requirements, we visited homes, schools, and library events to gain insight on environmental and interpersonal dynamics. Through collaborations with children, parents, teachers, and speech-language therapists, we iteratively constructed and tested design probes to support reflective storytelling.

These probes taught us the following: (1) the IRO's interaction must be scaffolded to support children with differing storytelling and communication experiences, (2) the IRO's interaction must complement children's fine motor crafting activities to encourage sensory exploration, and (3) the IRO's body must be screenless to allow for children's ocular awareness to their surroundings.

Through human-human interaction, human-puppet interaction, and human-robot interaction, we conducted 64 storytelling sessions in English, Spanish, or Vietnamese using Wizard of Oz methods. These interactions informed our storytelling scenario.

3 STORYTELLING SCENARIO

In the MindScribe workflow, a child first creates an artifact—such as a drawing, a building, a painting, or a 3-dimensional model. When the child is finished creating, a teacher, parent, or caregiver invites the child to tell a story about her creation, thus extending the initial activity. The child finds a quiet area of the room and sits with MindScribe, a soft stuffed animal imbued with the power of dialogue; she may even continue to create as she converses (Figure 2). MindScribe asks the child questions about her work using scaffolded questioning. For instance, MindScribe might ask "And then what happened?" to support sequencing, or "How does your story end?" to support cohesion.

Through this scaffold, the child constructs a story that represents her thoughts, ideas, perceptions, and learnings. While she tells her story, her classmates or siblings might sit with her and listen in, or even contribute (Figure 2). Afterward, she might build on her story by constructing a new artifact that iterates on the design of the first. If she is engaged in a multilingual community, her caregivers might use a translated transcription to share her story across language groups. She may also choose to tell stories in each of her spoken languages (Figure 2), depending on the context, and turn her oral stories into books for sharing (Figure 1). Finally, she shares her constructed thoughts with her caregivers, who themselves reflect on how they might iterate on their curriculum to meet her needs.

4 PROTOTYPE ARCHITECTURE

MindScribe's voice interaction is delivered via an application running on a mobile device, which is inserted into a zippered pocket in the belly of a stuffed animal. By building our interactive robotic object out of everyday objects–a stuffed animal and a smart phone– we created an IRO that can be affordably implemented and updated. We have built two, working applications using both (1) the mobile

web, to access without download or installation, and (2) hybrid application development (native + web), to access offline. The stuffed animal shell can be interchanged for character variety, while maintaining a screenless interaction. In future iterations, tactile inputs can be added (such as squeezing the paw to advance the questioning) to increase children's agency.

Figure 2: (Top) Two siblings take turns telling a story to the MindScribe zebra while constructing with play dough. (Middle) A child constructs with Legos while telling a story in Vietnamese with the MindScribe zebra. (Bottom) At school, a child uses puppets to converse with the MindScribe zebra.

ACKNOWLEDGMENTS

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