MindScribe: Toward Intelligently Augmented Interactions in Highly Variable Early Childhood Environments

Layne Jackson Hubbard[1] **Boskin Erkocevic**[2] **Dylan Cassady**[3]
Chen Hao Cheng[1] **Andrea Chamorro**[1] **Tom Yeh**[1]
[1]**Dept. of Computer Science** [2]**Dept. of Electrical Engineering** [3]**Dept. of Mechanical Engineering**
University of Colorado Boulder
Boulder, Colorado, United States
{lahu1329, chch6597, boer8364, dyca8010, anch9699, peye9704}@colorado.edu

ABSTRACT

Early childhood is a period of critical development, with impacts that can last a lifetime. And inequities in the quality of care for this vulnerable population—especially for those at-risk due to disability, family income, or trauma—can perpetuate further downstream health and school-readiness effects. Technology-enabled solutions have the ability to bridge quality-of-care gaps by intelligently augmenting daily activities. However, many traditional computational approaches to natural language interactions are not yet feasible nor affordable in highly variable and dynamic early childhood environments. Yet for rapidly developing preliterate young children, solutions are needed now. We present MindScribe, an interactive robotic object that leverages open-ended 'serve and return' natural language interactions to intelligently support reflective inquiry and school-readiness in highly variable and imaginative early childhood environments.

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; Interactive robotic objects; Voice interaction; Natural language; Early childhood development; Constructionism; Accessibility; User-centered design.

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1 INTRODUCTION

In the constructionism theory of learning, learners create new ideas when they make some sort of external artifact which they can reflect upon and share with others [2]. While making and sharing are prevalent activities in early childhood environments, reflection is often undersupported as valuable one-on-one creative inquiry with young children requires both time and expert resources [1]. And in low-income communities, these are especially constrained assets. To scalably support this constructionist learning cycle, we sought to build an inquisitive assistant that engages reflective inquiry through the medium of imaginative storytelling—a developmentally-appropriate practice in early childhood environments.

Specifically, we sought to approximate an intelligent user interface that met the following human-centered requirements: (1) Utilize the 'serve and return' early childhood model of contingent reciprocity wherein cooperation occurs as partners appropriately respond to each other's input [3], (2) interact using natural language to orally scaffold the children's construction of reflective stories about their creative artifacts; (3) support natural language interaction given the highly variable range of young children's speaking patterns, including pronunciation, grammar, and speech-language pathologies; (4) support the children's development of their original, imaginative ideas; and (5) support cost-effective deployment in low-income communities. In sum, these specifications represent a highly variable, wide domain with a focus on affordable accessibility.

2 METHODS

To develop MindScribe's natural language model, we engaged in iterative cycles of user centered design with early childhood communities, including low-income and multilingual environments. We initiated this work by first engaging storytelling sessions through human-human interaction between caregivers and preschool children. We analyzed the transcripts to categorize patterns of inquiry and abstracted an open-ended 'serve and return' model to describe the caregivers' scaffolding methods. Next, we diagrammed this model into an abstract state machine and iteratively developed its programmatic implementation into an interactive robotic object (IRO) using Wizard of Oz methods.

Figure 1: The MindScribe zebra—a stuffed animal with a zippered pocket to insert a mobile device, wherein a custom hybrid application (native + web) powers its voice interactions.

3 IMPLEMENTATION

To scalably and affordably integrate MindScribe's natural language model into an IRO, we utilized two everyday objects—a smartphone and a stuffed animal (Figure 1). In our implementation of the IRO (Figure 1), 19 children engaged in 28 storytelling sessions in a variety of creative contexts across home and school environments (Figure 2). They communicated with MindScribe in either English, Spanish, or Vietnamese. In the sessions, children of differing ages responded orally to the IRO's questions; they engaged in storytelling for variable lengths of time (Table 1). Most of the session lengths were constrained by turn-taking, as a number of children were interested in telling (or retelling) their stories.

Table 1: Children's Storytelling Session Data

	Ages	Word Count	Minutes
Mean	5	100.1	3.1
Median	4.5	97	2.65
Max	7	232	6
Min	3	27	1.28

Figure 2: Clockwise from top left: At home, a child constructs with play dough while telling MindScribe a story (about a turtle who lost a circle); a child converses with MindScribe (about a rescue boat) in Vietnamese while acting out a drama with his props; at home, a child sets up her story environment (about a rainy day) using costumes and props; at preschool, a child uses puppets to talk with MindScribe (about an ostrich who rescues beached animals).

The results of our exploratory implementation showed that MindScribe's open-ended 'serve and return' model for reflective inquiry is capable of supporting highly variable young children in imaginative storytelling—in a variety of contexts (Figure 2). It supported children in producing connected narratives that demonstrate a range of social, emotional, cognitive, and language development. In future work, we will explore (1) the contents of the children's narratives, (2) the children's questions for MindScribe, and (3) the caregivers' interactions with MindScribe sessions.

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