# Child-Robot Interaction to Integrate Reflective Storytelling Into Creative Play


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**Figure 1: A child creates with interlocking bricks then converses with their stuffed animal to tell a story about their creation.**


## ABSTRACT

When young children create, they are exploring their emerging skills. And when young children reflect, they are transforming their learning experiences. Yet early childhood play environments often lack toys and tools to scaffold reflection. In this work, we design a stuffed animal robot to converse with young children and prompt creative reflection through open-ended storytelling. We also contribute six design goals for child-robot interaction design. In a hybrid Wizard of Oz study, 33 children ages 4-5 years old across 10 U.S. states engaged in creative play then conversed with a stuffed animal robot to tell a story about their creation. By analyzing children's story transcripts, we discover four approaches that young children use when responding to the robot's reflective prompting: Imaginative, Narrative Recall, Process-Oriented, and Descriptive Labeling. Across these approaches, we find that open-ended child-robot interaction can integrate personally meaningful reflective storytelling into diverse creative play practices.



## CCS CONCEPTS

• **Human-centered computing → User centered design**; **User studies**; • **Social and professional topics → Children**.

## KEYWORDS

child-robot interaction, conversational agents, creativity support, storytelling, reflection

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## 1 INTRODUCTION

Reflection is critical to creative invention [18, 30], design mastery [31], and transformations in knowledge [3] — because when we reflect, we re-examine a situation and combine information in new ways to form a more elaborate construal [45]. Reflection is foundational to cognitive control in the brain's prefrontal cortex, and is a metacognitive skill that must be strengthened through practice [45]. In constructionist learning, both creating with artifacts and reflecting on artifact creation are fundamental to the process of making new ideas [18, 30]. Yet while children in the early years may receive abundant support for creative play from caregivers (and can utilize expressive tools such as kids' markers and toy blocks), there are few tools in early childhood that combine creative play with reflective practice. Voice interaction in particular might be leveraged to support reflection because conversation itself is a powerful way for young children to learn [6], and reflective conversation can be transformative [45]. To address this opportunity, we first develop design goals for child-robot interaction in early childhood: Integrate into *Real-World Contexts* and *Diverse Creative Play* experiences, support *Personally Meaningful Reflection*, accommodate diverse verbal and communication skills through *Scaffolded Storytelling*, nurture *Iterative Creating and Storytelling* practices, and focus on *Playful Child-Centeredness* throughout the interaction. We then prototype an embodied conversational agent to systematically integrate reflection into early childhood creative environments.

In this study, we explore the ways that young children communicate their ideas and perspectives when prompted by a robot companion. We recruit 33 children ages 4 to 5 years old across 10 U.S. states for a remote child-robot interaction session. Using a range of materials found in their homes, children freely craft or build, then choose a stuffed animal robot to guide them in telling a story about their creation. The robot asks scaffolded, open-ended questions about the child's creative play, and together they collaborate in a multi-turn sequence to craft a reflective story. From child-robot interaction transcripts with 33 participants, we use affinity diagramming and thematic analysis techniques to categorize young children's reflective approaches in response to the robot's prompting. The data suggests that young children use four distinct approaches to reflective storytelling: *Imaginative*, *Narrative Recall*, *Process-Oriented*, and *Descriptive Labeling*. Finally, we explore the affordances of each approach in relation to our design goals and consider the ways that our design goals can be supported in both the study design and the interaction design. We conclude that across differing approaches to communication, open-ended prompts within child-robot storytelling can foster personally meaningful reflection in varied creative play contexts.

## 2 RELATED WORK & DESIGN GOALS

Our design goals for child-robot interaction are informed by related work as well as by a series of formative studies in preschools and homes [16, 17]. In this formative research, we explored the dynamics of child-robot storytelling with children ages 3 to 7, as well as the real world contexts of young children's creative construction. From these studies and related works, we extract several high-level goals for designing a system to integrate reflective storytelling into creative play:

**Real World Contexts (DG1)**
To support young children wherever they engage in creative play, we aim to design a system for home, school, and child care environments — rather than for laboratories or research settings. Real-world contexts differ in the creative materials available to children, and often have multiple children sharing interactive materials [16, 17]. While in laboratory environments children may have only one task to focus on, in real world contexts children might flexibly switch between a variety of activities. For example, in home and school settings children may need to pause an activity to attend to a caregiver's instructions, or to help a sibling or friend in need. As such, we aim to design a system that can integrate into many different early childhood settings.

**Diverse Creative Play (DG2)**
To avoid imposing limitations on creative play, we aim to design a system that can integrate reflective storytelling across a range of creative activities occurring in real-world contexts. For example, preschool and daycare settings traditional offer several play stations — from arts and crafts, to dramatic play, to working with manipulatives such as blocks and bricks. In a series of formative studies [16, 17] in preschool settings, we examined creative storytelling in the context of arts and crafts activities. For this study, we aim to explore how storytelling can accompany other forms of creative play too.

**Personally Meaningful Reflection (DG3)**
Social robots have been used with young children to support cognitive activities such as creativity [2], curiosity [14, 34], and growth mindset [28]; in this work, we aim to support metacognitive reflection. For young children, storytelling can be a developmentally appropriate way of engaging reflection [25], and even labeling one's perspective can facilitate reflection [45]. Although we ground our reflective storytelling interaction in creative play, we aim to support young children in using this platform to reflect on a range of personally meaningful experiences — whether it be the act of creating, the creation itself, their interests, their ideas, their challenges, or their life experiences. Here, meaningful reflection is "relevant, connected to something familiar, and able to be transferred to new situations or problems" [46].

**Scaffolded Storytelling (DG4)**
Interaction design researchers have examined the developmental, language, social, and cultural benefits of interactive storytelling with children [4, 13, 20, 37, 38]. In addition to the role of listening partners (such as robots) in encouraging narrative expression [27, 33, 39], open-ended questioning in particular can support children's expressive ability [5] and narrative skills [5, 29]. Open-ended questions can support young children's verbal participation in child-parent interactions [19, 22, 26] as well as in child-agent interactions [41–44]. To support the highly variable speech and language patterns of early childhood (such as incomplete grammars, incoherent pronunciation, and made-up words), we aim to design a system that uses open-ended scaffolding to accommodate diverse communication needs [15, 36].

**Iterative Creating & Storytelling (DG5)**
Based on formative studies [16, 17], we aim to support iterative creating and storytelling in order to (a) deepen and extend creative play practices [46], and (b) provide opportunities for children to develop their skills in reflecting and

storytelling. Because reflection is a metacognitive skill that requires practice [45], creating opportunities for iteration [46] will guide children in developing their skills.

**Playful Child-Centeredness (DG6)**
Through all aspects of the interaction, we aim to support playful child-centeredness. While learning goals such as vocabulary, character development, and narrative coherence are important in many storytelling domains, in this work we primarily seek to build a tool that prioritizes children's own interests in the interaction. We look to the five elements of play — joyful, active, engaged, meaningful, and iterative [46] — to inform our understanding of child-centeredness.

# 3 INTERACTION DESIGN

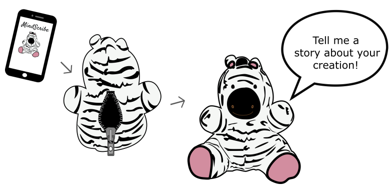


**Figure 2: A graphic of our initial child-robot interaction. A mobile application running the voice interaction is inserted into a stuffed animal (stuffie) embodiment. We say to the children, "We put the phone in the stuffie, to make the stuffie talk."**

Our child-robot interaction design is informed by a series of formative studies [16, 17]. Here, we visited preschool classrooms and explored the ways in which caregivers ask questions to guide children in telling stories about their creative artifacts. This method of asking questions to develop stories about creative play is based on the Storybook Journey curriculum [25]. We analyzed transcript data to categorize patterns of inquiry and abstracted an open-ended 'serve and return' model to describe the caregivers' story scaffolding methods. In the 'serve and return' early childhood model of contingent reciprocity, cooperation occurs as partners appropriately respond to each other's input [35].

We then diagrammed this conversational model into an abstract state machine and iteratively developed its implementation into an interactive robotic object (IRO). The result is a conversational agent that asks scaffolded questions (DG4); in return, the child constructs responses to tell a story. After asking a question, the conversational agent waits for the child's response. After the child responds, the agent asks a new question with the aim of scaffolding the development of a story. A mobile application runs the voice interaction, and the smartphone or speaker is inserted into a stuffed animal embodiment (Figure 2). Through this screenless design, we aim to support children's attentiveness in real world contexts (DG1). And by using everyday materials to construct our interactive robotic object — such as smartphones, speakers, and stuffed animals — we aim to develop a tool that can be used in a variety of settings (DG1, DG2).

To adapt the child-robot interaction for a remote study, we employ a hybrid Wizard of Oz method. We ask children to first choose a stuffed animal from their home (DG1), and we explain that we will use a computer, a smartphone, and a robot voice to make their stuffed animal talk. When they are ready to tell their story, we ask them to place their stuffed animal atop their parent's smartphone. We then operate the robot's text-to-speech voice through the smartphone by listening for the children's response then cueing the software to verbalize the next robot prompt. In this way, the children have control in co-locating the robot's voice with any of their stuffed animal embodiments (DG6).

To start the child-robot interaction, the stuffed animal introduces itself to the child, *"Hi, I'm the story helper. I will help you tell a story about what you made. I will ask you lots of questions to help you tell a story."* We designed the robot's questions with the goal of being sufficiently open-ended to integrate within a wide variety of children's creative play activities (DG2, DG3, DG4). From the children's perspective, their conversation experiences with the robot consists of four stages: (1) The robot initiating conversation, (2) the robot asking story beginning questions, (3) the robot asking story follow-up questions, and (4) the robot asking story ending questions. Throughout, the robot uses open-ended 'wh-' questions to elicit children's verbal expression. For example, the robot initiates storytelling by asking *"What did you make?"* and *"Tell me a story about what you made."* The robot proceeds by asking scaffolded questions to guide the child in telling a story about their creation (DG4).

By saying *"The end"* or *"I'm all done,"* the child signals to the robot to end their storytelling session. The robot then asks the child to name their story to guide the child in synthesizing their story's theme (DG3, DG6). Finally, the robot transitions the interaction by asking a series of reflective questions to foster iteration (DG5), including *"Next time you make something, what are you going to make?"* and *"Next time you tell a story, what is it going to be about?"* Through the robot's scaffolded, open-ended questioning and stuffed animal embodiment we aim to support our design goals of: (1) **Real World Contexts** (DG1), (2) **Diverse Creative Play** (DG2), (3) **Personally Meaningful Reflection** (DG3), (4) **Scaffolded Storytelling** (DG4), (5) **Iterative Creating & Storytelling** (DG5), and (6) **Playful Child-Centeredness** (DG6).

# 4 METHODS

Due to the ongoing COVID-19 pandemic in the United States, we conducted a remote study in participants' homes to prioritize the safety of all involved. We limited our study sessions to 30-minutes with the goal accommodating the differing needs and backgrounds of parents — who may have competing caregiving, work, and household demands (DG1). Our goal in recruitment was to represent families from diverse regions, backgrounds, family structures, income levels, and educational experiences.

## 4.1 Participants

We recruited 33 children ages 4–5 (M = 4.95 years, SD = 0.58 years, 17 females and 16 males) and their parents. Of the 33 families in our study, one family had two children ages 4 and 5 years old. To support their family dynamic, we included both siblings in our study (Figure 3). We recruited participants through child care centers, family services email lists, community advocacy groups, and social media announcements shared broadly in neighborhood parent-social groups.

Participants resided in 22 cities from 10 states across the U.S. (Arizona, California, Colorado, Idaho, Illinois, Michigan, Montana, New York, Oregon, and Texas). In Michigan, for example, the participants' cities were as rural as Mikado (population 899 in 2018), as suburban as Highland (pop. 20,179) or Waterford (pop. 72,948), and as urban as Detroit (pop. 672,662) [9].

Children varied in the type of educational programs they attended, with 42.42% (14) attending preschool or pre-kindergarten, 45.45% (15) attending kindergarten, 3% (1) child attending a home-based preschool program, 3% (1) child attending a home-based kindergarten program, and 6.1% (2) without an educational program.

Parents identified their children's racial and ethnic backgrounds: 18.75% (6) identified as being of Hispanic or Latino descent, 68.3% (28) as White/Caucasian, 14.6% (6) as Black or African American, 7.3% (3) as Asian; 7.3% (3) as American Indian/Alaska Native, and 7.3% as Other (mixed race). Six children (18.75%) spoke a language in addition to English (Shona, Mandarin Chinese, and Spanish).

Parents were predominantly female (93.9% (31), 6.1% (2) male). Ten (30.3%) parents were the sole caregivers in their household, whereas 69.7% (23) of parents had an additional caregiver in the household. The total number of people in participants' households ranged from 2 to 7 people (M = 4.18, SD = 0.98).

Families reported household incomes as low as $4,000 USD per year, and as high as $400,000 USD per year. The national median household income in the United States was $63,703 in 2019 [10] — of our participants, 61.29% (19) families had a household income above the national median, while 38.71%, (12) families had a household income below the national median.

Parents' educational levels varied as well. Eleven parents (33.3%) reported having a Bachelor's degree. Eleven parents reported having less than a Bachelor's degree (6.1% (2) with a GED, 6.1% (2) with a high school diploma, and 21.1% (7) with an Associate's degree). And eleven parents reported having greater than a Bachelor's degree (27.3% (9) with a Master's degree, 3% (1) with an M.D./Ph.D., and 3% (1) with a J.D.)

**Figure 3: (Left) This child worked independently to make their creation using play dough, paper, and drawing materials — then chose a stuffed animal for storytelling. (Right) These siblings shared play dough materials, then took turns telling their stories.**

## 4.2 Protocol

*4.2.1 Setup.* Parents were given instructions prior to their session: (1) Gather a variety of materials to support their children's creative play (DG2). Include, for example: paper, crayons, markers, paint, stickers, glue, paper scraps, paper shapes, dried leaves, interlocking bricks, magnet tiles, and bristled blocks. (2) Setup a table or desk with the creative supplies. (3) Have their child choose a stuffed animal to use in the reflective storytelling activity (DG6). We then used the mobile application for Zoom conferencing to host the study session. We asked families to connect via audio without using video in order to (1) respect participants' privacy in their home environments (DG1), and (2) maintain focus on the child, parent, and child-robot interactions (DG6) — rather than on the researcher's visual persona.

*4.2.2 Creative Activity.* First, the researcher asked the child to describe their creative materials (*"What things do you have to create with today?"*), and then invited the child to create something using the materials provided. Children were given options for their activity: *"You can make your family, your school, a forest, a garden, or your own idea."* Children were given options as a way to support initial ideation if needed, but were also reminded that, *"You can make it however you want."* Children were given 5 minutes to make their creation, and could ask their parents for help or work together.

*4.2.3 Reflective Storytelling Interaction.* Next, the researcher instructed the child: *"Now, your stuffed animal is going to ask you questions to help you tell a story about what you made. We're going to use a computer, a phone, and a robot voice to make your stuffed animal (stuffie) talk. When you're ready, pick up your stuffie and sit it down on top of the phone to make your stuffie talk."* The researcher then used our story scaffolding software and text-to-speech (TTS) synthesized voices to guide the child in a spoken question-and-answer (Q&A) dialogue. Here, the researcher acted as a hybrid Wizard-of-Oz by listening until the child is finishing responding before cueing the software to verbalize the next robot prompt. During the Q&A, the stuffed animal robot asks open-ended 'wh-' questions and the child improvises responses to the prompts (DG3, DG4).

## 4.3 Data Analysis

To explore the diversity of the children's creative and storytelling experiences and to explore our design goals, we transcribed the audio recordings and used qualitative techniques including affinity diagramming and thematic analysis. Among other uses, affinity diagramming [11, 32] is used in human computer interaction (HCI) and design research to analyze qualitative data from observational and user interviews [21, 24]. In this study, we used affinity diagramming techniques to spatially cluster narrative approaches from the children's story transcript data. Next, we used thematic analysis [7, 12] — a qualitative analysis technique used in both psychology and interaction design [8, 40] — to generate themes from the clustered data and use those themes to code the story transcripts.

# 5 FINDINGS

## 5.1 Robot Embodiment

Children selected a variety of stuffed animals (stuffies) from their homes in order to engage the child-robot interaction. Some children

**Figure 4: (Left) This child selected two stuffed animals for the activity, a Harry Potter doll and a koala bear. After creating (right), the child incorporated their Harry Potter doll into the storyline: *"The water spilled. Rain came. [...] There was water, too much in the soil. A car came. Harry Potter came. There was a huge storm."***

brought one stuffed animal to the activity, while other children gathered several stuffed animals. Across all children, these include a penguin, a bunny, a bear, a unicorn, a pig, a tiger, a panda, frogs, dogs, cats, monkeys, and sharks — as well as character stuffed animals including Harry Potter, Buzz Lightyear, Barbies, and two Pikachus.

Several children chose a stuffie for their first story (e.g. a penguin), then requested to tell another story with a new stuffie as the robot's voice (e.g. a bunny). And some children incorporated their stuffed animals into their storylines (Figure 4). The wide variety of stuffies, the turn-taking with stuffies, and the incorporation of stuffies into storylines all suggest potential for children's agency and control in deciding on their robot embodiments. Child-robot or child-agent system design that allows children to both choose and switch their robot characters might allow for increased child-centeredness in the interaction (DG6).

## 5.2 Creative Contexts

Using our initial prompt to gather a range of supplies from their home (DG1), parents provided children with diverse materials for creative play (Figure 5). While paper and drawing tools such as markers and crayons were the most common offering, many parents added other materials to the mix. These included glue, paint, dried leaves, yarn, fabric scraps, cut paper pieces, play dough, and building materials such as interlocking bricks, bristled blocks, and magnet tiles (DG2).

**Figure 5: From left to right: (A) The parent provided paper, colored pencils, leaves, cut paper shapes, interlocking bricks, and magnet tiles for the creative offering. (B) The child chose a stuffed animal shark to embody the robot's voice. (C) The child glues paper shapes and leaves to the paper. (D) The child's resulting creation.**

## 5.3 Creative Constructions

Children used the materials provided by their parents to make diverse creations. Given an initial prompt that included options as well as open-ended choice — *"Do you want to make your family, your school, a forest, a garden, a lake, or do you want to make your own idea?"* — children constructed a range of creations from abstract to concrete. Many children selected from the options given, while many others chose to create their own idea. Similarly, many children worked independently while creating, while many others requested input from their parents in order to generate ideas for their creative play. These differences in children's needs and preferences suggest that child-robot interaction design for effectively scaffolding storytelling *about* creative play may also require scaffolds to support creative construction as well (DG2, DG4). Just as children fluctuated in how much input they desired from their parents while creating (responding or not to parent prompts), creative play scaffolding could also be activated (or not) by the child. System design that allows children to flexibly decide when and how they engage in creative play scaffolds may support the overall child-centeredness of the interaction (DG2, DG6).

The children's resulting creations serve as the foundation for their next activity: reflective storytelling with a stuffed animal robot, wherein the robot asks questions to guide the child in telling a story about their creation. Because all children interact with the same robot system, the robot's story prompting will need to flexibly handle this range of creative activities (DG2).

## 5.4 Story Approaches

We used affinity diagramming and thematic analysis in order to understand the types of stories that children told in response to the robot's prompting. We extracted four main types of approaches to the storytelling prompts: Imaginative, Narrative Recall, Process-Oriented, and Descriptive Labeling.

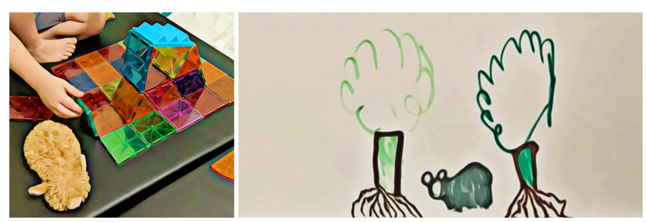

**Figure 6: (Left) This child built a creation with shape tiles then talked with their stuffie to tell a story about it. (Right) After telling a story called *"The Lost Pika,"* the child decided to draw a picture of their story too.**

*5.4.1 Imaginative.* Here, children constructed characters, settings, and/or events in response to the robot's prompting. A few imaginative stories were decidedly concise: *"There was a little boy. There was a big puppy. And then the big puppy went and got the little boy. The end."* But many other imaginative stories tended to stretch across multiple events. This next child's story began in a home, traveled outside, underground, into the ocean, onto cliffs, across countries, and finally *"they fringed out in space. On Mars. Then he hopped to Jupiter. And then Saturn. And then Uranus. And then she* *hopped on Earth. Then she went all the way to Neptune. Because she wanted to go through Neptune."* Whether short or long, imaginative storytelling became a platform for children to express a diverse range of characters and contexts (DG3, DG4).

Similarly, imaginative approaches to storytelling provided an avenue for children to explore their special interests. One Colorado child self-reported an interest in pikas — a small, mountain-dwelling mammal who also lives Colorado. This child built *"a forest and a pika"* with shape tiles then responded to the robot's prompting with this story extract: *"The first thing that happened to my story is it rained. The pica saw two trees and it ran under. And then it had a shady spot to rest. Because there was no place, there was no place to hide except that place."* After their story, the child iterated on their ideas in response to the robot's prompting, *"Next time you make something, what are you going to make?"* The child responded, *"I'm going to make a forest but with a different creature. The trees will be bigger and more animals will come."* The child then drew a picture of their story (Figure 6). In this way, the robot's prompting both during and after the storytelling can serve to support children in exploring a special interest, as well as generating new ideas from their original focus (DG3, DG4).

*5.4.2 Narrative Recall.* Here, children shared something that occurred in their own lives — be it an interaction with their teacher at school, helping their parent with a remodeling project, a family member going to jail, or attending the funeral of a relative. Children share personal, social, and emotional memories in this approach to storytelling (DG3). As such, engaging in crafting and storytelling about personal experiences could provide caregivers with new opportunities to learn about their children's inner worlds (DG3, DG4).

Two different children responded to the robot's prompting with narrative recall about a death in the family. As one child shared, *"After I was in kindergarten, the other day yesterday, it was my birthday. And then it started to rain. Because, because, heaven. Cousin [Name] was trying, um crying. So cousin [Name] passed away and then, and then he died, and then he didn't feel good and then he was in heaven. And I saw him with his eyes closed and then didn't scare us at the church. They came and then they had to show us cousin [Name] and then I prayed."* In both of these children's stories, they shared events and memories from school, home, their neighborhood, and/or family outings. Through open-ended prompting from a stuffed animal robot, they each chose to communicate memories and stories about loss (DG1, DG3, DG4).

Several children shared stories from their school day, *"I go inside. And then I walk into my classroom. Um. Then I, then I sit at my desk. Because have to do school."* Some children shared about conflicts at school too, *"Something happened for school. Because. Um, school. Um, my teacher told me I'm not listening."* Interactions with teachers appeared in two different children's stories, *"I goed to school and my friends were not listening and Mr. [Name] said he didn't love me."* In addition to themes of families and home life, this suggests that future activities with both crafting and storytelling about the school day or school environment could provide a rich source for social-emotional support from caregivers (DG1, DG3).

*5.4.3 Process-Oriented.* Here, children sequenced the steps that they executed in order to make their creation: *"I make me. Then I made my papa. And then I made my mommy."* (Figure 7). Yet as the robot continued prompting with questions, this child's approach became increasingly reflective: *" Um, cause I want my family to be here with me. Then I drew my baby cousin. Cause I wanted him to be in here, because he was born a month ago. Okay, so she really likes drinking milk. Um, he likes to sleep."* In this way, the robot's scaffolding of questions served to elicit reflection and narrative recall in addition to the child's initial process-oriented approach (DG3, DG4).

**Figure 7: (Left) A child's initial *"family"* creation. After using a process-oriented approach in their child-robot storytelling interaction, this child then iterated and decided to explore *"shapes"* (right).**

After this initial story, the child responded to the prompt, *"What are you going to do next?"* by replying, *"I wanna make some shapes."* Then, they executed on this creative iteration (Figure 7). This was a familiar pattern across many of the stories, and especially common to process-oriented stories. This approach might serve to foster ideas for creative iteration (DG5).

Another child — who created with LEGO® bricks — included the researcher's role into their process-oriented storytelling: *"Well, then I was building and then person set a timer and she was talking about what I wanted to build. Then I and she set a timer. And then after that when timer went up it was right now. And then the story was right now."* Throughout their process-oriented approach in response to the robot's prompts, this child reflected several times on the novelty of the storytelling situation: *"I don't know, well, stories are always gonna be short because this is not really like usual. So it's kind of weird what I'm doing."*

During their story, this child began to re-engage with crafting, and responded to the robot's continued prompts by sharing and reflecting on their real-time crafting process. In this way, a process-oriented approach can foster creative iteration (DG5) while also sharing similarity with the think-aloud protocol [23] — a method for supporting users in thinking aloud while navigating a user interface in order to gain insight into users' cognitive processes and expectations. Here, a real-time process-oriented approach might also provide an opportunity for children to communicate their needs, challenges, and insights while crafting (DG3).

*"I'm just gonna like make another creation of my own but I don't really know how to make a paper cube. So I'm going to ask my dad or mom if they can help me. And that, and those are called crafts. So now I'm doing it again. Because it didn't really work out how I wanted. So I tried again. That's what you're supposed to do. And sometimes it's good to make mistakes, you know. Did you know that?"* Here, the child shares a lesson with the robot, after struggling to execute

their vision. This suggests the potential for supporting personally meaningful play from open-ended questioning in a process-oriented approach. (DG3, DG5)

*5.4.4 Descriptive Labeling.* Here, children described the elements of their resulting creation. One child explored numerical representation in their craft, then described those representations in their story (Figure 8). While most children who used this approach blended it with other approaches, another child simply labeled the elements of their *"forest"* creation: *"There was trees. There was animals. There was ground. There was the sky. There was a cement."* Yet when the robot later asked, *"Next time you make something, what are you going to make?"* the child responded, *"A city."* Here, the element of *"cement"* in the child's forest is now connected with their iterative creative play — building a *"city"*. This suggests the potential of descriptive labeling approaches for informing the next stage of the children's creative play. (DG4, DG5)

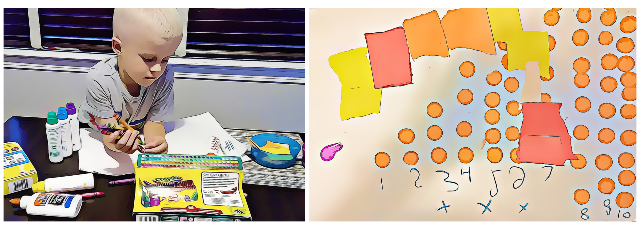

**Figure 8: A child (left) uses a descriptive labeling approach when interacting with the robot to tell a story about their creation (right): *"So I have a one under one dot. And a two under two dots. And a three under three dots. And a four under four dots. And a five under five dots. And a six under six dots. And a seven under seven dots. Eight under a eight dots. Nine under nine dots. And ten under ten dots."***

## 6 DISCUSSION AND FUTURE WORK

In this work, we demonstrated how child-robot interaction can integrate reflective storytelling into creative play practices. By scaffolding storytelling through open-ended prompts, a conversational agent can elicit personally meaningful reflection from young children across a range of topics. In this way, social robots can support storytelling within varied creative experiences. Young children engaged with the robot's open-ended, scaffolded prompts in four ways: *Imaginative*, *Narrative Recall*, *Process-Oriented*, or *Descriptive Labeling* (Section 5.4). Across these approaches to reflective storytelling, we discovered ways that children can communicate their ideas using differing verbalization patterns. Finally, we explored ways that child-robot interaction design can foster our goals in supporting the diverse needs of young children: Integrate into *Real-World Contexts* and *Diverse Creative Play* experiences, support *Personally Meaningful Reflection*, accommodate differing verbal and communication skills through *Scaffolded Storytelling*, nurture *Iterative Creating and Storytelling* practices, and focus on *Playful Child-Centeredness* throughout the interaction. When designing for child-robot interaction in the early years, we encourage interaction designers to consider how each of the six design goals might support the needs of young children in their own communities. We also encourage designers of conversational agents to use the four reflective storytelling approaches when considering how their designs elicit young children's expression and verbalization. While we aimed to support ecologically valid contexts inside children's homes, a limitation of this study is that children participated in the creative and storytelling activities at a scheduled time for a limited duration and in a set sequence. The playful child-centeredness of the interaction was similarly impacted by this setup and timing. To better understand the role of child-robot interaction in playful, real-world contexts, future work could benefit from observing children's natural interactions with the robot over a period of time. In future work, we also aim to explore ways to provide children with more agency and control when interacting with the robot. In addition to voice interaction, we wonder how multimodal input such as tactile interaction might support young children with differing verbal skills in controlling the robot's prompts according to their own interests and needs. As Edith Ackermann reminds us, "Learning, especially today, is much less about acquiring information or submitting to other people's ideas or values, than it is about putting one's own words to the world, or finding one's own voice, and exchanging our ideas with others" [1].

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