Children Designing Robots: A Modified Cooperative Inquiry Approach to Developing Social Robots

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Cooperative inquiry is a set of techniques developed for intergenerational co-design of future technology. We took inspirations from this methodology and used variants of their techniques in an online robot co-design study with 8-12 years old children in quarantine in order to explore their perceptions of social robots in school setting and inform our future research. We used diverse design steps including brainstorming, sketching, crafting, storyboarding, and animation-making. Our methodology accommodates remote collaboration with individual children and compensates for the lack of direct facilitation by researchers. This paper details our approach and contributes insights for future work on designing social robots with and for children.

CCS Concepts: • **Human-centered computing → User centered design**.

Additional Key Words and Phrases: child-robot interaction, co-design, research through design, social robots

1 INTRODUCTION

Bullying in schools among children is a widespread problem with serious and long-term consequences [Bauman et al. 2013]. While researchers have used various ICT tools in developing anti-bullying interventions [Nocentini et al. 2015], the use of social robots is generally underexplored. We are developing *RE-Mind* [1]: a robotic system that aims to empower children against bullying and encourage peer support. As a first step, we conducted a co-design study with children to investigate their perceptions of social robots in school settings, and their understanding of bullying (e.g. whether they think robots, as non-human entities, can be bullied).

Prior research suggests that co-designing with future users in early stages of development can enjoy benefits such as providing access to users' experiences, and thus resulting in a better match with their needs and increasing the project's effectiveness [Steen et al. 2011]. Scholars have discussed methodologies for such co-design practices. For example, cooperative inquiry (CI) consists of methods that facilitate adults and children working together as design partners to create new technologies [Walsh et al. 2013]. The co-design techniques used in this work were inspired by CI, but are modified to address the specific needs of this project and to accommodate the lack of in-person studies imposed by the global COVID-19 pandemic. In this work, we present our intergenerational co-design methodology that is suitable for remote studies. We build on frameworks offered by prior literature to discuss the role of researchers in our proposed approach. We envision that the methodologies detailed in this manuscript can serve as a starting-point for HRI researchers partnering with children in designing future robotic technologies.

[1] **R**obots **E**mpowering **Mind**s

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2 RELATED WORK

Traditionally, user-centered design was approached from an expert perspective. That is, researchers would observe passive users interacting with a technology, and analyze their observations in light of theories gathered from experts in the field in order to gain insights and develop knowledge. However, the co-design approach acknowledges users as *experts of their own experience*, and holds the researchers responsible for supporting the ideation and expression of users and facilitating the research inquiry. Prior work posits that this changes the roles of researchers from *translators* between the users and the designers to *facilitators*. [Sanders and Stappers 2008]

In designing technology for children, it is common for researchers to rely on the opinions of adults as a proxy. While adults such as parents and educators are valuable resources for such projects, their experience of being a child is limited to their own childhood, which has a discrepancy with the richness and technological complexity of a child's world and lived experience today [Guha et al. 2013]. Scholars emphasize that it is important to involve children in the design process, and advise researchers to refrain from undermining children's ideas as *fantastical* or *impractical*, and instead suggest that, as an integral part of partnering with children in design, to involve thoughtful adults that listen to children's elaborations and pull out the big ideas [Guha et al. 2013]. However, despite an abundance of research in the development and use of robots for children, intergenerational co-creation is underexplored in the field of HRI.

That said, several prior HRI studies have used co-creation with children in various capacities. For instance, Sunguitan and Hoffman partnered with children to design accessories for their hand-crafted robot Blossom [Suguitan and Hoffman 2019], and Alves-Oliveira et al. used co-design with children to develop movements and behaviors of their creativity-inducing robot, Yolo [Alves-Oliveira et al. 2017]. We build on this prior work and discuss a set of co-creation techniques applicable to designing social robots with children.

3 COOPERATIVE INQUIRY

Cooperative inquiry (CI) is a subset of participatory design that includes guidelines and techniques for partnering with children to design future technology. This approach emphasizes multidisciplinary partnership with children, understanding contexts, and iterative prototyping [Walsh et al. 2013]. As young children may need more structure in various design steps such as idea-generation, CI techniques can be used to facilitate such co-creation. For example, *Bags of Stuff* is a low-fidelity prototyping technique that uses bags filled with art supplies (e.g. glue, papers, markers, strings, socks, scissors) as a medium for creating low-fidelity prototypes. The authors posit that this technique "can strongly support bringing children into the design process" [Guha et al. 2013].

While CI has been extensively used for intergenerational co-creation in various domains, many of its techniques are designed to facilitate collaboration with groups of children, rather than individuals. For example, *stickies* uses sticky notes and frequency analysis to critique prototypes, or *big paper* uses large-sheets of paper to facilitate collaborative brainstorming between different children in the group [Walsh et al. 2013]. This approach also relies on the presence of researchers to monitor and facilitate the various design steps. However, even though we had initially planned to conduct our co-design study in local elementary schools and have researchers facilitate the sessions, it was not feasible to do so at the midst of a global pandemic. As such, we utilized modified versions of several of the commonly used techniques and conducted the study with individual children remotely, and with minimal involvement from researchers [2]. We detail this approach in the next section.

4 METHODOLOGY

Prior work on child development suggests that young children can have a difficult time verbalizing their thoughts about abstract concepts and actions [Druin 2002]. As abilities in expressing ideas vary between children, it is recommended that methods for generating ideas and collecting information should be sensitive to their skills [Vaajakallio et al. 2009]. Therefore, we included diverse methods in our co-design approach to accommodate for children with different sets of abilities. Our methodology consisted of 6 steps that we detail below: brainstorming, sketching, collecting art supplies and crafting, story-writing, animation-making and brief interviews.

Brainstorming. As children need more structure in brainstorming, we encouraged idea generation in smaller steps. That is, we asked children to brainstorm their design ideas for the robot by breaking it into three steps of robot appearance, personality, and names. We took inspiration from CI's *stickies* technique that asks children to write down one idea per note, and encouraged children to briefly think about each concept, and then use one-minute timers to write down one idea on one sticky note. Children repeated this procedure four times for each of the sub-concepts of design (see Fig. 1).

Sketching. We used a variant of CI's *paper prototyping* technique and asked children to sketch their favorite brainstorming ideas on a piece of paper. This helped children narrow down their ideas, and provided participants that were more comfortable with expressing themselves through sketching with another medium for idea-generation (see Fig. 1).

Crafting. We used a variant of CI's *bags of stuff* to facilitate low-fidelity prototyping. As we were not able to provide children with art supplies ourselves, we instructed them to collect clean and safe recycling material (e.g. egg cartons, plastic bottles) and some basic crafting supplies with the help of an adult. Once they gathered their own bag of stuff, we encouraged them to make low-fidelity prototypes of their robots based on their sketches and brainstormed ideas (see Fig. 2 for examples).

Story-writing. Inspired by CI's *storyboarding* and *comicboarding* techniques, we encouraged children to write stories about various positive and negative interactions of their robot at school by using

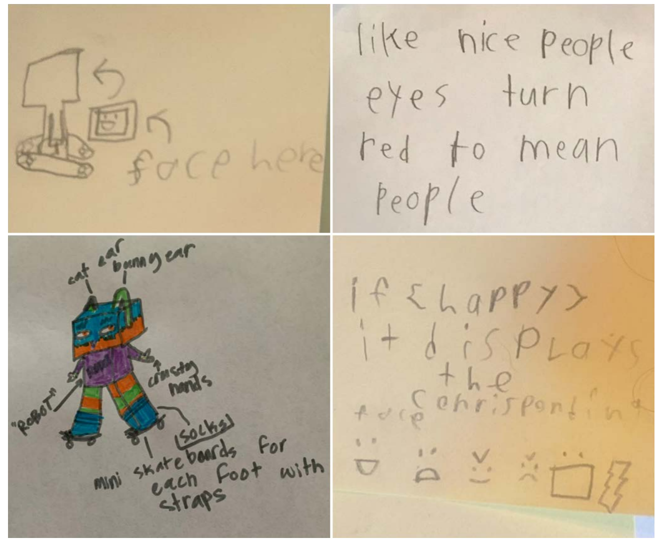

Fig. 1. Examples of brainstorming ideas and sketches made by children.

Fig. 2. Examples of low-fidelity prototypes of robots crafted by children.[3]

our story-planner and storyboarding templates. Children first used the planners to provide short answers to key questions about a story they had in mind (i.e. who, where, what, why, what next). This helped by introduced some structure into the procedure, and helped shape up the stories. Following this, children used the storyboard templates to sketch their story in up to six frames, and added a line or two to explain each frame. For example, Fig. 3 shows a storyboard made by a participant describing a robot's negative interaction with a classmate, followed by the robot reaching a resolution, and confronting the classmate.

Animation-making. We included an optional step for children to make animations in order to support idea expression using bodystorming and role-playing [Segura et al. 2016]. We introduced children to *stop-motion*: a simple animation-making technique in which one can move inanimate objects in small increments and take photos at each step such that when the photos are viewed sequentially, they create an illusion that the objects are moving. We instructed participants to use a free application[4] on a smartphone, and craft DIY simple tripods out of recycling material.

Interview. At the end of the design process, we conducted brief semi-structured interviews with children to go over their designs together and make sure we understood their ideas (e.g. could read

[2] The findings of this study and lessons learned will be discussed in a future manuscript.
[3] Photos are used with permission.

[4] Stop Motion Studio, see cateater.com

Fig. 3. A storyboard made by one of the participants.

their hand-writing). This is similar to the group discussion phase that usually takes place at the end of CI sessions when adults and children ask critical questions about the designs to understand the underlying big ideas.

Finally, to accommodate for the lack of facilitation and direct supervision from researchers, we provided detailed instructions for children on our project website[5] in both written and audio format and in simple language that children could follow. We also asked parents to help us with conducting the study, for example, by obtaining assent and assisting their children with certain steps (e.g. to set up the interviews).

5 PROCEDURE

We advertised this study to parents on social media platforms (e.g. Facebook groups). Interested families contacted researchers and received information letters about the study, and assent letters explaining the protocol in simple language for children. Parents that provided digital consent form and confirmed that they have obtained assent from their child received a link to the project website. Children followed the step-by-step instructions on the website. Once they completed the design steps, their parents uploaded their designs on a webform and scheduled the brief interviews. We thanked children with participation certificates and gave their parents a $15 honorarium for their help. Our research team analyzed data from all the design steps following thematic-analysis guidelines, in relation to children's robot designs and narrative designs. The findings will inform the robot behavioral design, child-robot interaction paradigm, and the narrative models in RE-Mind. We discuss the findings and implications for future work in another manuscript.

6 DISCUSSION

This paper presents our approach to co-designing social robots with children in a remote-setting. This approach is inspired by CI, and is modified to accommodate for remote collaboration, lack of direct facilitation, and working with individual children instead of a group. In this approach, we emphasize providing children with diverse means of idea-generation and elaboration, in order to enable expression in children with varying skill-sets.

Literature on co-creation identifies four levels of creativity: *doing* (getting things done), *adapting* (making things your own), *making* (making things with your own hands), and *creating* (expressing creativity) [Sanders and Stappers 2008]. Based on this, they describe the role of researchers in co-creation to *leading* people at the doing level, *guiding* the ones at the adapting level, *providing scaffolds* to support those on the at the making level, and *offering a clean slate* to the ones at the creating level. Our diverse design steps aimed to support children at all creativity levels. In order to lead children that were looking for inspiration, we provided them with clear step-by-step instructions and many examples, such as specifying which recycling materials would likely be useful for them to collect. To guide those at the adapting level, we explained to children that they can go beyond the recommended material and methods with the supervision of their parents. We provided scaffolds by giving children templates for brainstorming, story-planners with guiding questions about their stories, and story-boards. Finally, we offered them a clean state by introducing them to an animation-making technique and giving them freedom in choosing what to animate, and asking them open-ended probing questions in the interview.

We argue that HRI research can benefit from paying more attention to research through design in general and co-creating robot design and behavior models with children in particular. We envision that the methodology shared in this manuscript can be easily modified and adopted by future work to facilitate tapping into children's perceptions and imagination, and contribute to design of future robotic technology.

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