Building Child-Robot Collaborative Relationships in Creative Interactions

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HRI'21, March 09–11, 2021, Virtual
ACM 978-1-4503-6819-3/20/04.
https://doi.org/10.1145/3334480.XXXXXXX

Abstract
Collaborative relationships occur when multiple actors work together to accomplish common goals. In our work, we develop child-robot interactions that facilitate creative collaborations.

Author Keywords
child-robot interaction, collaboration, creativity

CCS Concepts
•Human-centered computing → **Interaction design; HCI design and evaluation methods; •Computer systems organization** → *Robotics;*

Introduction
Collaborative relationships are key to creative interactions between multiple actors. In our work, we develop child-robot interactions that facilitate creative collaborations using a creativity scaffolding paradigm. Collaborative relationships between teachers and students in classrooms develop through an exchange of ideas, asking and answering questions and providing feedback [5, 6]. In this work, we used a co-designing approach where we use a Wizard of Oz method [4] to use instructors' inputs into the robot's verbal and non-verbal scaffolding behaviors. We *learn* from teachers' interactions to model the robot's creativity scaffolding behaviors to develop a collaborative relationship

Figure 1: WeDo 2.0 Construction kit

Figure 2: Visual programming interface used to program the WeDo controller

Figure 3: Child programming the rover (bottom middle) with Jibo

between children and robots.

Related Work

Social robots have previously been used for fostering collaborative relationships by stimulating positive behaviors in numerous learning tasks, such as teaching children how to use Lego Mindstorms [10], vocabulary acquisition [3], and storytelling through collaborative emergence [2]. Exploratory research suggests using bodily, cognitive, and emotional engagement as indicators for overall engagement in collaborative child-robot interactions [8]. For heightened control over the social robot's interactions, HRI researchers often use the Wizard of Oz method [7] to operate the robot, allowing for instructors or facilitators to provide more delicate scaffolding than autonomous interactions can currently provide [9]. In our work, instructors use the Wizard of Oz method to personalize robot speech and animations to the child's specific problems, ask reflective questions, and provide unique ideas and positive reinforcement, stimulating the child's collaborative response as well as their creativity.

Methods and Materials

In this interaction, children and the Jibo robot collaborate to build models using the LEGO Education WeDo 2.0 Core Set [1]. The set consists of LEGO bricks and electronics that can be programmed using a visual programming interface on an Android tablet application (Fig 1), and aim to introduce children to computational thinking and engineering principles in an engaging way.

The interaction involved children making projects using the WeDo construction kit in the presence of a social robot, which assumed the role of a tutor and provided creativity scaffolding to the child. To get acquainted with the programming interface, children were first guided by the robot to build a rover using LEGO blocks, and to program it to detect obstacles and respond to their commands using the WeDo Android tablet application (Fig 3). Children could utilize WeDo kit items including a controller, LEGO bricks, motors, and motion sensors. This guided activity was conducted through a step-by-step verbal exchange between the child and the robot and lasted for six minutes, with the robot taking the instructor's role. The activity introduced them to sequential commands, condition statements, delays, and loops. Then, children were given time for free play, where they could explore different functions of the WeDo app, add new LEGO blocks, and make their models perform new actions. The idea generation process was guided by both the child and the robot. Throughout the interaction, children could ask the robot questions and receive dynamic troubleshooting guidance. The robot also engaged in active creativity scaffolding which involved asking the child reflective questions, challenging their ideas and assumptions, and suggesting alternate ideas for creations with the rover. The robot also provided feedback and positive affirmation after children generated new ideas.

The robot is controlled by an instructor using a dynamic desktop Graphical User Interface. We model the teachers' interactions to build a semi autonomous robotic interaction. Through user studies with 43 participants, we observe interactions that demonstrate the development of a collaborative relationship: question asking, challenging, help seeking, idea generation, seeking and providing affirmation, and providing feedback.

Conclusion

We contribute a framework for designing collaborative social robots by co-designing with teachers, an approach which can be contextualized to other tasks. More research is needed to develop metrics for assessing the creative collaborative relationships between a child and a social robot.

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