CozmoNAOts: A Computational Thinking Learning Task

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Rebecca Stower
Department of Psychology and Methods
Jacobs University
Bremen, Germany
r.stower@jacobs-university.de

Arvid Kappas
Department of Psychology and Methods
Jacobs University
Bremen, Germany
a.kappas@jacobs-university.de

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Abstract

We developed a semi-autonomous computational thinking task using the NAO and Cozmo robots. In this task, the NAO robot plays the role of a tutor to aid children in programming Cozmo around a map. We implemented this task at sports camps with children aged 6-10 years of age. In addition to building computational thinking skills, the task was intended as a context in which we can also introduce robot errors through the instructions given by NAO. We measured both children's learning from the robot (via task performance) and the children's perceptions of the robot (via a combination of self-report and behavioural measures). For the self report questionnaire, we targeted social trust, competency trust, liking, and perceived agency. Through combining robot errors, social attitudes towards the robot, and learning performance, an understanding of how robot errors can interact with children's learning from social robots could begin to be investigated.

***K*eywords** child robot interaction · trust · social cognition · social learning · robot errors · faulty robots · learning · education

1 Background and Research Questions

Given current technological limitations with (autonomous) human-robot interactions, and in particular child-robot interactions (cHRI), understanding how robot errors can influence the course of the interactions is critical. This is especially relevant in the context of education, where robots may be relied upon to deliver information in the classroom. The goal of this research is therefore to investigate *how robot errors influence how children view robots as sources of information*. In particular, effects of robot errors on two different kinds of trust; social and competency are considered. Social trust refers to affective, emotional, or integrity based trust, such as relying on someones words or actions [1]. Conversely, competency based trust refers to trust in an agent as a reliable source of information [2]. Recently, these two domains of trust have also begun to be distinguished in cHRI [3, 4].

In developmental psychology, much work has been done on how children appraise different models as sources of information, investigating factors such as reliability [5], group consensus [6], and moral behaviour [7]. There is also evidence to suggest that both information regarding the perceived benevolence of an agent, and perceived competency are relevant in deciding who to trust [8, 9]. This suggests that we need to consider robots not only as machine-like sources of information, but additionally how the social processes which surround such interactions can interact to influence the acceptance of information [2]. As such, this work derives from a social cognitive perspective, and in particular social learning theory [10, 11, 12].

2 Design

2.1 Learners

The learners in this case are children aged 6-10 years. Children in this age group are mostly in the concrete operational stage of cognitive development, where they begin to use logical thought and rule-based thinking [13].

2.2 Learning Objectives

A learning task was developed focusing on developing skills of computational thinking, including analysis, pattern generalisation and abstraction [14]. The task was adapted using material from the Cubetto Robot from Primo Toys [1].

The goal of the task is to program the Cozmo robot (Anki) around a map depicting outer space (see Figure 1). From a given starting location, children can program Cozmo to move forward, backwards, turn left, or turn right using a control tablet. Children can program a sequence of movements, then, once the sequence is complete, press a green 'play' button to initiate Cozmo's navigation around the map. Children must program a complete sequence before pressing play.

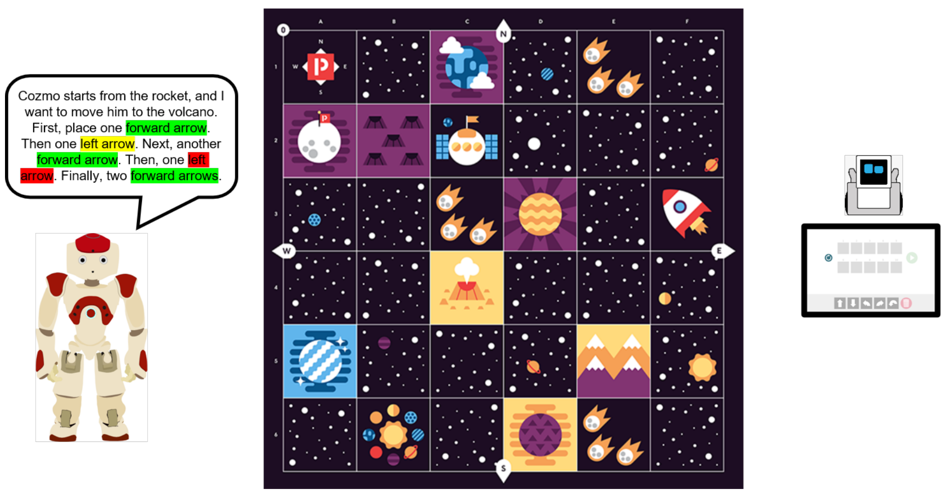

Figure 1: Graphical Depiction of Learning Task

Critical to the task, Cozmo always begins facing towards the child. Consequently, left and right for Cozmo are inverse from the child's perspective. This means that, in addition to identifying the correct pathway, children need to recognise the perspective of Cozmo as opposite to their own. Children also need to recognise that moving one square left, for example, is comprised of two separate movements (turning left + moving forward). In doing so, the foundations of programmatic thinking can be introduced.

The task was structured as a turn-taking exercise between the child and a NAO robot, where in the first turn NAO acts as a tutor to give instructions for how to program Cozmo. These instructions could be either reliable (Cozmo drives to the correct location) or unreliable (Cozmo drives to an incorrect location). Irrespective of whether NAO's instructions were reliable or unreliable, children then had 3 turns to program Cozmo from a pre-determined starting location to a chosen destination location. After each attempt, children received feedback from NAO regarding whether the location of Cozmo was correct or incorrect. If after 3 turns they did not manage to program Cozmo successfully, NAO showed them the correct pathway.

2.3 Location

Participants were recruited from sports camps held in Zurich in summer vacation 2020. However, the learning task could in theory also be implemented in schools.

[1]https://www.primotoys.com/shop/deep-space/

2.4 Robot

Two robots were used for the design of this learning task; NAO and Cozmo. The role of NAO was to act as a teacher to provide instructions to the children. Thus, we chose a humanoid robot to be able to facilitate communication with the child through verbal communication and social behaviours.

Cozmo was chosen in order to be able to send real-time information to NAO regarding its current location on the map. In doing so, NAO was able to provide feedback to the children during their turn. Communication between the two robots was achieved using Robot Operating System (ROS). This allowed for the task to be semi-autonomous, with minimal experimenter input required.

3 Assessment

Children's performance on the task was assessed by the number of turns they required to program Cozmo, and if they were correct in the end or not. Thus, performance was scored on a 4-point scale (0 = unsuccessful, 1 = successful after 3 turns, 2 = successful after 2 turns, or 3 = successful after 1 turn). In addition, we annotated the kind of errors children made whilst programming Cozmo (e.g., confusing left and right, confusing forward and back, mistaking a turn arrow for turn + move).

Embedded in the learning task was also a forced-choice paradigm designed to target children's social trust in the robot. For the child's turn, they could choose between two equidistant locations; Neptune or Venus. After giving these options, NAO randomly expressed a preference for one (e.g., 'I prefer Neptune, what about you?'). Whether children endorse or reject the preference of NAO can be considered a measure of trust.

After the conclusion of the learning task, we also included a self-disclosure phase, where NAO asked the children 3 question (what their favourite animal, colour, and place is) and allowed them to elaborate. This again targets children's trust in the robot via behavioural measures.

After the conclusion of the interaction, children completed a short self-report questionnaire regarding their trust in the robot (both social and competency), how much they liked they robot, and the perceived agency of the robot. They also completed a semi-structured interview with one of the experimenters regarding the behaviour of both NAO and Cozmo, to check how they perceived the behaviour of the robot or if any mistakes were noticed.

By including measures of both objective learning outcomes (learning performance, mistakes made) and perceptions of the robot (both subjective and objective) an understanding of how social processes relevant to child-robot-interaction can interact with learning can begin to be developed.

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