Evaluating Peer Versus Teacher Robot within Educational Scenario of Programming Learning

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***Abstract*—This research explores the concept of edutainment where the basics of programming are introduced to children while playing a game with a social humanoid robot. The goal of the game is to exit the maze: the child is asked by the robot to make the robot walk the maze to its exit. The child needs to learn the basics of programming to walk through the maze via drag-and-drop instructions on the tablet screen. This paper presents an HRI study which aims to investigate what role of the robot (peer vs. teacher) would result in more learning gains in this particular application. The findings suggest that children complete the task much quicker with the peer robot while a teacher robot is shown to be more effective for learning.**

Keywords*—*Human-Robot Interaction; Child-Robot Interaction; Educational Robotics

Fig. 1: Experimental Setup

I. Introduction

The research of social robots facilitating educational benefits is an emerging area of social robotics. Recent efforts on the role of robots in educational applications have seen the social robots acting as tutors [1], learners [2], learning companions [3]. In contrast, to date majority of educational robots used to introduce children to programming are mobile small educational robots such as Lego NXT Mindstorms [4] and Thymio [5]. This research addresses this issue with the goal to explore the use of social robots for introducing children to the basics of programming. This paper presents our HRI system which consists of the humanoid NAO robot and an android-based tablet drag-and-drop interface inspired by Scratch developed at MIT [6]. The research question of the HRI study is to investigate the role of the social robot which will facilitate engaging and effective learning of the programming basics.

In order to establish social and bonding relationships with children in public populated environments such as hospitals or educational institutions, robots need to be able to adapt to child's needs, so that educational robot is the most productive: robot is liked and accepted, provides comfort and companionship, perceived to be a friend or a peer. We would like to address and investigate this challenge by offering the child such educational robot that acts as a peer rather than a tutor which might potentially ease and relax the child for better and more efficient learning.

Zaga *et. al.* [3] (2015) investigated the effect of robot's social character on children's task engagement suggesting that children solved the puzzles quicker and better in the peer condition in comparison to the tutor character condition. Based on this finding, we hypothesize that children will tend to learn more and quicker in a peer condition since peer robot would be more effective at engaging the child in a task in comparison to the teacher robot who "instructs" rather than engages in play.

To this end, we developed two different interaction patterns for each condition: a peer-like interaction and a teacher-like interaction. The difference between conditions was in wording of the robot's utterances such as greetings, self-introduction, and goodbyes. For example, a peer robot asked the child for help to escape the maze. In contrast, the teacher robot instructed the child to move the robot through the maze. In this condition, the robot spoke with an instructor tone (professional voice), the one teachers would use. Verbal content was the only difference manipulated between conditions. All non-verbal behaviours such as waving, gesticulating, eye gaze, and other robots' behaviours were the same across conditions. The same pre-recorded male voice was used in both conditions.

II. HRI System

The HRI system had three components: a humanoid NAO robot, a printed maze and an Android tablet. It was completely autonomous throughout the interaction. All instructions and rules provided by the robot were in Russian. Children were asked to help the robot to escape the maze. In fact, they were asked to move the robot from the 'current' cell to the 'destination' cell. Throughout the interaction, the robot provided children with hints and instructions. Particularly, the robot explained how to construct an algorithm of movements to arrive to a particular cell.

At the beginning of each session, the robot was placed at the starting position of the maze (Figure 1). The tablet was given to participating child after the robot introduced itself. The interaction was according to the following phases:

1) The robot introduced itself to the child and outlined the tasks.
2) Children started the play the game which was divided into levels of increasing difficulty.
3) When each level was completed, the robot provided further instructions.
4) When three levels were finished, the robot thanked and praised the child on the good job done.

III. HRI Study

The experiment was conducted in a primary school with 26 children (12 females and 14 males) aged 9 to 10 years old. Children were randomly assigned to each condition. Each child interacted with one of the conditions: with a peer or a teacher robot. In both conditions children were free to work on their own pace. The game was stopped either by a child voluntarily or after completing three levels. The robot provided appropriate verbal feedback according to the robot condition when children finished each level successfully and when they were unable to construct a correct block of necessary commands to complete it.

The experiment was conducted in a small classroom with three researchers inside. Each child was called out of their class by the first experimenter for approximately 15 minutes. While walking with the child, the researcher started with an icebreaker warm-up talk necessary to relax and engage the youngster. Upon entering the room, children were invited to take a sit at the table with questionnaires and answer a few questions about their age, gender, mood as well as answer a few questions to assess their programming knowledge. After the first questionnaire was filled in, children were invited to stand next to the robot. on the blue chair at the table with cards facing the robot. After the interaction, children were asked to fill in the second questionnaire which compared their improvement in understanding of the basics of programming. In the end, the first researcher brought the child back to the class and called out the next participant.

IV. Results

On average, children spent 63.72 seconds interacting with the robot with a standard deviation of 33 seconds. The time children spent varied from as little as 50 seconds to as long as 77 seconds. There was a statistically significant difference between groups as determined by one-way ANOVA: $F(1, 23) = 4.373, p = .048$. A Tukey post-hoc test revealed that children spent significantly more time playing in teacher condition (76.15 $\pm$ 38.94 sec) compared to peer condition (50.25 $\pm$ 18.65 sec). Figure 2 illustrates these results.

On the other hand children who interacted with teacher condition improved much better at the programming task which was determined when comparing pre- and post-test results. Even though, it was not a statistically significant difference between conditions as determined by a one-way ANOVA ($p = .08$), the results still suggest that the robot teacher was more likely to be more effective at teaching children. It was probably due to the robot pointing out errors, as a result children took the tasks more seriously.

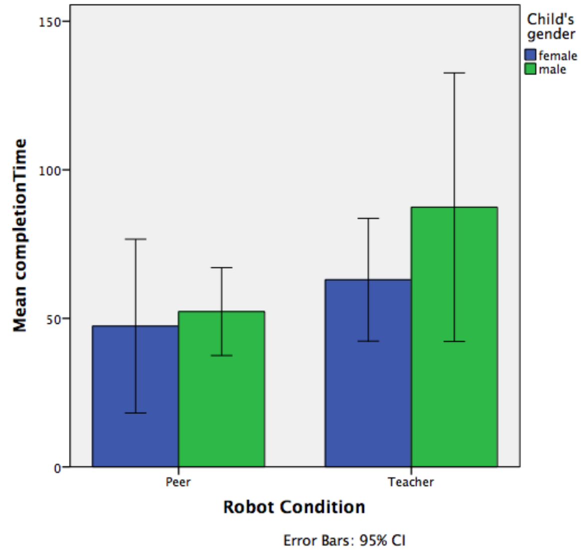

Fig. 2: Completion Time

V. Conclusion

The conducted study compared two robot conditions in their ability to contribute to children's learning of programming basics. Children were suggested to help the robot to exit the maze via drag-and-drop android tablet interface which was inspired by Scratch [6]. Our findings suggest that with the peer robot children completed the required task significantly quicker than with the teacher robot condition. In contrast, children learned more with the teacher robot than with the peer robot. This result contradicts expectations and predictions made based on other studies in the literature [**?**]. The limitation of this preliminary work is in the number of participants in each condition, however this work provides strong support for continuing the research direction of investigating robot's role within educational child-robot interaction which is important to consider in order to increase robot's perceived likeability, acceptance and engagement while still fulfilling the required educational value.

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