Enhancing Learning Outcomes: Exploring the Role of Cognitive Skills when Children Teach a Robot

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INTRODUCTION

- Children demonstrate increased learning when they teach others versus learning for themselves.[1]
- Social robots, including when in the role of a tutee, have been used to enhance children's learning outcomes.[2]
- Different robot characteristics have impacted children's engagement and learning from social robots.[3]
- However, there is a gap of research examining how children's individual characteristics relate to learning in the context of teaching a robot, as well as whether these associations differ by robot behaviour.

RESEARCH GOAL

To examine children's learning outcomes (increased knowledge, reflection on teaching and learning) after teaching a robot, in relation to:

- The robot's behaviour (type of mistakes)
- The children's cognitive skills, namely, executive functioning (EF) and verbal skills
- An interplay between children's cognitive skills and robot mistake behaviour

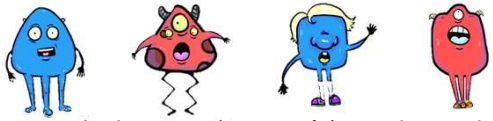
METHOD

MEASURES

- Executive Functioning: Children's Executive Functioning Inventory (CHEXI)[4], a 24-item parent-report measure of children's difficulties with EF in everyday contexts.
- Verbal skills: NIH Toolbox Picture Vocabulary Test, a task-based assessment of children's vocabulary comprehension.

PROCEDURE

- Children taught a novel classification to a humanoid robot, namely teaching where aliens were from based on physical characteristics using a classification chart.



2. Participants were randomly assigned to one of three robot conditions:

Correct – Robot made no errors	Illogical – Robot made errors on taught material	Logical – Robot made errors on untaught material

3. Childs' knowledge of the classification scheme was tested after the teaching task.
4. Children provided self-assessments of their teaching and learning using a 5-point Likert scale:
   - 1 – I think I was a bad teacher → 5 – I think I was a great teacher
   - 1 – I did not learn at all → 5 – I learnt a great deal

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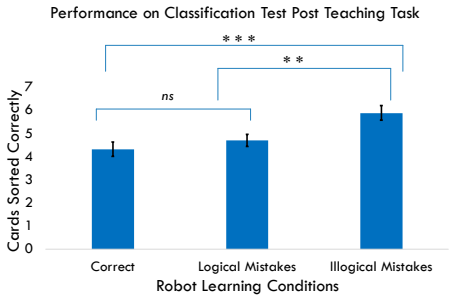
RESULTS

Fig 1. ***Mean level differences between each condition and learning outcomes***



** p < .05, *** p < .001

Table 1. ***Correlations with measures, learning, and self-assessment***

ALL CHILDREN	Learning	Self-assessment	
Measure	Classification Task Knowledge	Learning	Teaching
EF	.085	.001	.056
Verbal Skill	.168	-.073	**-.191***

Table 2. ***Correlations with measures, learning, and self-assessment for each robot condition***

2a. CORRECT ROBOT				2b. LOGICAL ROBOT				2c. ILLOGICAL ROBOT			
Measure	Classification Task Knowledge	Learning	Teaching	Measure	Classification Task Knowledge	Learning	Teaching	Measure	Classification Task Knowledge	Learning	Teaching
EF	.124	.075	-.089	EF	.139	.109	**.328***	EF	-.100	-.144	-.081
Verbal Skill	.270	-.030	.053	Verbal Skill	.192	.119	**-.387***	Verbal Skill	-.002	-.245	-.259

Notes
* Correlation is significant at the 0.05 level (2-tailed)
Higher EF = more executive dysfunction

DISCUSSION

- Children's learning was highest when teaching a robot who made illogical errors (**Fig 1**).
  - There may be more active engagement (and thus learning) when working with a robot whose responses do not follow a predictable learning pattern.
- Executive functioning and verbal skills were not related to children's learning of the classification system (**Table 1**).
  - Awaiting current behavioural coding of teaching strategies to determine whether these skills related to teaching behaviours.
- Better EF and verbal skills were associated with lower rating in self-assessment for teaching, particularly for children teaching the logical robot (**Table 2b**).
  - As the learning pattern of the logical robot was more predictable, children with better cognitive skills may have (accurately) detected that their teaching strategies had no impact on the robot's success.
- This work highlights the importance of examining outcomes in terms of both children's learning and self-reflection (in this learning-by-teaching-a-robot context), as well as the differing roles that robot behaviour and children's cognitive skills play for both outcomes.

REFERENCES 1. Duran, 2016 2. Jamet et al., 2018 3. Gordon et al., 2016 4.CHEXI; Thorell & Nyberg, 2008