Reciprocal Peer Tutoring in Child-Robot Interaction

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The education system always seeks out new ways to improve learning experiences of children with diverse abilities and needs. In this regard, we present Reciprocal Peer Tutoring (RPT) strategy that involves a collaborative interaction between students with alternating tutor and tutee roles. Evidence shows that it is an effective method to improve learners' cognitive gains as well as social skills. With robots becoming commonplace in society, there is a great potential in using them in education. Combined, our paper discusses the possibility of using the RPT strategy for child-robot interaction.

CCS Concepts: • **Computer systems organization → Embedded systems**; Robotics.

Additional Key Words and Phrases: human-robot interaction, reciprocal peer tutoring, social robots

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1 INTRODUCTION

One of the notable educational practices is learning together with other people. Earlier research has shown that students can learn from each other through observation, negotiation, and collaboration [Bandura and Walters 1963; Lisi and Goldbeck 1999; Tudge and Rogoff 1989]. This practice has become known as peer-assisted learning (PAL) that involves various forms of peer-tutoring, peer-learning and peer mentoring [Topping and Ehly 2001]. With slight distinctions, they characterize cooperative interaction and non-professional teaching roles between learners [Gazula et al. 2016]. In particular, peer tutoring has been widely welcomed by many educational practitioners as an effective teaching method that enables one high-ability student to perform the role of "tutor" and low-ability student to be "tutee". Besides the improvements on the academic level, some researchers reported social benefits such as increased communication skills and problem-solving [Boudouris 2005; Eggers 1995]. However, some studies show that high-achieving peer may not benefit similarly well in terms of cognitive gains [Topping and Bryce 2004] and find it challenging to support the tutee student [Rohrbeck et al. 2003]. To address this challenge, reciprocal peer tutoring (RPT) as a distinct form of peer tutoring has emerged starting from the mid-1970s. It continues to thrive as an educational practice across fields, including but not limited to medicine, IT, teacher education and language learning. In this context, individuals are teamed up with alternating tutor-tutee roles for different learning activities and take responsibility for teaching academic content interchangeably [Allen and Boraks 1978; Topping and Bryce 2004].

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2 ACADEMIC EFFECTS OF RECIPROCAL PEER TUTORING

Previous studies have found that children using RPT in educational stages as low as kindergarten improve their academic or study skills that have lasting effects in later life. Peer feedback, prompting, praise, and support add up to the effectiveness of RPT, when both tutor and tutee fulfil their learning and teaching goals successfully. A study with preschool children indicated that peer tutoring results in significant academic gains for all tutees [Brady 1997]. Similarly, primary-school-age dyads using RPT gained significantly more learning outcomes in language learning [Thurston et al. 2009] and mathematics [Thurston 2015], as compared to control groups. Furthermore, RPT with children with disabilities, under-performing children, and socially vulnerable population generates positive outcomes and even may outperform traditional instructional strategies [Cheng and Ku 2009].These findings suggest that RPT serves as one of the effective means of learning in different study environments to stimulate academic productivity based on a social learning paradigm.

3 TOWARDS RECIPROCAL PEER TUTORING WITH A ROBOT

Using robots for educational purposes is not something unprecedented. The interaction between humans and robots enables new opportunities for knowledge and information exchange. An intelligent tutoring robots are capable of helping to teach a wide variety of subject content and skills. A growing body of research has explored the use of educational robots as tutors or tutees that engage with children as more knowledgeable or less knowledgeable playmate with children[Belpaeme et al. 2018a; Leyzberg et al. 2014]. Robot tutors have already been used in second language learning, mathematics, autism therapies, among many other application areas. In committing to the same goal of social learning, pedagogical approach called learning-by-teaching (LbT) guide learning experiences in which children act as the teacher and instruct so called teachable robot [Lemaignan et al. 2016; Sandygulova et al. 2020]. In fact, there is rich evidence that indicates the effectiveness of this learning framework, both in relation to cognitive gains and motivational aspects. In a quite similar way, the integration of RPT can maximize the quality of child-robot interaction. Thus far, Chen et al.[Chen et al. 2020] found that children paired with the tutor robot learned more words compared to the tutee robot. To a greater surprise, children interacting with the peer robot learned the target vocabulary above all other conditions. Apart from that, it has been relatively unexplored in current research.

4 DESIGN CONSIDERATIONS

In order to develop a successful RPT-based child-robot interaction, additional efforts are needed in view of its innovative nature. As discussed above, it has proven its effectiveness in the class-wide peer tutoring sessions whereby dyads teach and learn from each other. As distinct from it, it appears a common sense that children interacting with the social robot experience the whole process differently. Considering this caveat, we decided to provide our reflections when designing the RPT-based user study with robots.

(1) Use pedagogically-inspired interaction methods such as social reinforcement, corrective feedback, scaffolding, and praise. When a robot is introduced as a tutor, it becomes responsible for a child's learning process which requires human-like interaction format. For instance, phrases used for scaffolding should be natural and contextual. Therefore, involving a human teacher into the design of the robot is essential.
(2) Dedicate some time to get familiarized with the robot. A free play with the robot can help children feel at ease and perceive it as more human-like. It is important that children do not feel themselves as part of the experiments that potentially avoid the so-called Hawthorne effect.
(3) Maintain engagement of children by alternating roles of a child and a robot. Instead of having fixed tutor-tutee roles, RPT offers diverse experiences through shifting roles during interaction. We expect that this provides a potential solution for the long term interaction in which children are kept engaged and motivated over time.
(4) Test the RPT-based scenario through the conduct of pilot experiments. It is especially salient for multiple-session studies that aim to explore the RPT effectiveness over a prolonged period of time. This may provide deeper insights into the suitability of chosen methods and design of interaction scenario. For instance, if the robot is unable to autonomously monitor child performance, the tablet can be used as a mediator tool between them [Belpaeme et al. 2018b].
(5) Measure learning gains based on students' academic abilities. There are conflicting results regarding the effectiveness of the RPT for different-ability students. Some found that the learning outcomes to be different between high-ability and low-ability students, which may also depend on the level of peer support and feedback [Miravet et al. 2014]. Such measure provides insights into the development of RPT that can be personalized by catering to the needs of mixed-ability groups.

5 LOOKING FORWARD

In this paper, we discussed the reciprocal peer tutoring as one of the effective pedagogical approaches to social learning. Based on the current findings, the social robots seem capable of performing the alternating roles of tutor and tutee in child-robot interaction. The motivation for choosing the RPT to be used in child-robot interaction should aim at promoting the knowledge building, encouraging social learning of children, and increasing capabilities of robots to be more responsive and adaptive. The demonstrated effectiveness of the RPT strategy to enhance cognitive gains, achieve learning goals within the collaborative environment, and positively contribute to social well-being necessitates further study with educational robots. Some improvements on the robotic platform are called for to align its behaviors to the realms of teaching and learning processes. Using more adaptive and personalized system could also influence children in positive ways.

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