A Robotic Learning Companion that Always Tries Hard Might Lower Children's Self-Efficacy in Challenging Learning Tasks

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Abstract— **Most of the child-robot interaction research has focused on how robot's positive affect expressions, e.g. excitement, encouragement or empathy, could assist children in educational and therapeutic context. In this paper, we explore the impact of a robotic peer learner's emotional response toward challenging tasks and failures on children's self-efficacy and persistence level. We present an experimental study in which children engage in a music-learning task with a robotic peer that demonstrates either a mastery persistence behavior or a coping persistence behavior. Children who interacted with the robot that had mastery persistence skill reported decreased level of self-efficacy after the interaction. Self-efficacy of children in the mastery condition changed more sensitively when the learners were faced with a difficult task than that of children in the coping condition. We conclude a robotic peer learner that always shows eagerness to "try again" and never gets frustrated or distress just as any child normally does could potentially hinder a young learner's learning capability by reducing her motivation. We also propose to further explore how negative affect expressions of a robotic peer learner could benefit children by potentially boosting their perseverance and resilience toward challenges and failures.**

I. Introduction

Mastering a newly learned skill requires repeated trials and practice. Yet, children easily get irritated and frustrated when faced with challenging tasks, and often conclude that they are not good enough to learn the skill. Learning to persevere in with challenging tasks allows teachers and parents take significant roles in a student's learning process, peer interactions have also been shown to induce higher motivation for learning process [1–3].

A robotic coping peer was shown to have similar effects on young learners as well. Matsuzoe and Tanaka showed that a "care-receiving" robot, presented as a peer coping model, promotes children to learn by teaching [4, 5]. In their study, children who were accompanied by a robot that incorrectly answered during an English vocabulary learning game learned more words than children who played the game by themselves. Hood et al. [6] also uses a humanoid robot as a peer-coping model to enhance children's handwriting skills. In these studies, the robot assisted children's physical/cognitive skill learning, i.e. fast mapping for second language learning and fine motor skills for cursive writing, by providing opportunities for children to teach or help the robot when it failed. However, the robot did not show no or very little negative affect, e.g. concern, frustration, shame, etc., toward their incompetency on the tasks.

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In this paper, we propose persistence and self-efficacy as emotional skills to be learned and modeled from a peer learner, and ran a child-robot interaction study, in which a robotic peer demonstrated either mastery or coping persistence skill during a music learning task. A peer-mastery robotic model shows consistently shows persistence when faced with a challenging task and/or a failure. A peer-coping robotic model expresses frustration and desires to give up trying when faced with difficulties during the learning task.

II. Method

We recruited 27 children ages (7 M and 20 F) of 4-7 through an email advertisement. All children were fluent English speakers and 20 out of 27 participants reported that they had prior experience of musical education. When the participant and her caregiver arrived in the laboratory space, the experimenter guided them to have a seat and answer the pre-questionnaires. The pre-questionnaires consisted of 19 questions, of which 14 questions assess elementary school students' self-control, academic self-efficacy, persistence and mastery orientation [7].

The robot was presented as a peer learner to participate in the music learning tasks with the child. When either the child or the robot successfully accomplished a given task, Tega expressed excitement and enthusiasm. When the child failed on a task and received a negative feedback from the tablet application, Tega responded with an encouraging remark, e.g. "I know you can do it. Try again!" All the robot utterances and singing demonstrations were pre-recorded.

The contents for the music learning activity were provided by the *Sing with Me* Android tablet application that we designed. There were six tasks introduced by the application: (1) *High/Low Pitch Recognition,* (2) *Same/Different Pitch Recognition,* (3) *High/Low Pitch Generation,* (4) *Do/Re/Mi Pitch Recognition,* (5) *Do/Re/Mo Sequence Generation* and (6) *Sing Together*. The tasks were sequenced to get progressively more difficult and we expected most of the children to experience one or more failures during the second half of the tasks. Throughout the interaction, the robot failed to answer correctly five times. The system operated autonomously most of the time. However, we created a Wizard-of-Oz (WoZ) controller for the *Sing with Me* application and the Tega robot in foresight of participant's unexpected behaviors.

Post-questionnaires consisted of 22 questions regarding the interaction experience; self-efficacy and persistence on the singing game activity; and the bond with the robotic peer learner. For measuring the bond between the robot and the child, we used bond components in the Working Alliance Inventory (WAI) [8]. The self-efficacy and persistence questions were almost identical to the questions from the pre-questionnaires.

III. Results

The mean self-efficacy (*M*=3.14, *C*=3.69), persistence (*M*=3.44, *C*=3.58) and WAI-Bond (*M*=3.93, *C*=4.13) scores were higher for the coping condition than for the mastery condition. These differences were not statistically significant but there was a trend toward significance especially on the effects on participants' self-efficacy (P=0.1, df=22 with paired-t test)

For the peer-mastery model condition, the mean self-efficacy score was 3.47 before the interaction and 3.14 after the interaction with the robot. The mean persistence score was 3.39 before the interaction and 3.44 after the interaction with the robot (Fig. 6). The change in self-reported persistence was statistically insignificant but the change in children's self-efficacy levels showed a trend of decrease after the interaction (paired t test, P=0.16, df=22).

For the peer-coping model condition, the mean self-efficacy score was 3.53 before the interaction and 3.69 after the interaction with the robot. The mean persistence score was 3.50 before the interaction and 3.58 after the interaction with the robot (Fig. 6). Changes in both of the scores were statistically insignificant (paired t-test).

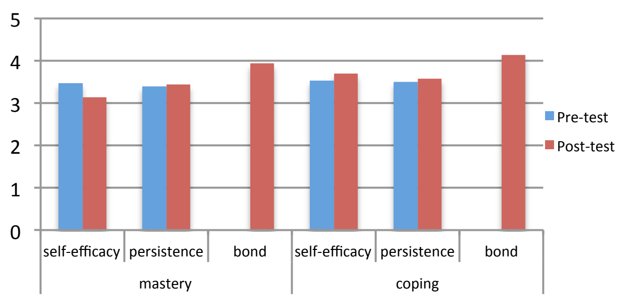

Figure 1. Children showed decreased trend of self-efficacy showed a trend of decrease after interacting with the robot with mastery behavior (P=0.1). Children who interacted with the coping robot peer showed a trend of higher self-efficacy than those who interacted with the mastery behavior

IV. Discussion

In contrast to our hypothesis, there was no significant change in children's self-reported persistence level regardless of the robot's peer-modeling behavior. This could be due to the fact that most of the children recruited for the experimental study already had high social and emotional skills for learning context. In the range of 1-4, the mean scores for self-control (*M*=3.38, *C*=3.40), academic self-efficacy (*M*=3.38, *C*=3.55), persistence (*M*=3.36, *C*=3.45) and mastery orientation (*M*=3.31, *C*=3.38) were all above 3.3. We suspect the ceiling effect might have prevented our results to show any significant increase in persistence for children in the coping condition.

However, children who observed a robotic peer-mastery model reported decreased self-efficacy after the interaction. Also, there was an almost significant difference between children's self-efficacy after the interaction between the two experimental conditions. These results align with the previous research that showed children had decreased level of motivation and self-efficacy after observing a peer-mastery model.

In addition, the decrease in academic self-efficacy for children in the coping condition can perhaps be explained by the mindset theory [9]. In our study, the peer-mastery robotic model shows a non-changing belief that it is capable in accomplishing the task by making another trial. In a way, the robot is inexplicitly expressing that its capability in succeeding is fixed and not expected to change, i.e. it has a fixed mindset on its capability. On the other hand, the peer-coping robot model initially expresses low self-confidence for accomplishing challenging tasks but proves that it is wrong by succeeding in the additional trials. When observing the peer-coping robotic model, children are witnessing the explicit change in the robot's self-efficacy on the task, and perhaps unconsciously learning the lesson that the capability to succeed in the musical learning tasks are not fixed but could change based on the efforts and trials made, i.e. obtaining growth mindset about their own capabilities on succeeding in the given task. An interesting follow-up experimental study would add a third condition, in which the robot does not recover from the failure and continues with the low self-efficacy on the task (peer-coping model with a fixed mindset). The additional condition would confirm whether observing a peer's failure and difficulties is enough to boost a child's self-efficacy or witnessing the change in peer models' attitude toward its own abilities is crucial in elevating their perception on their own ability to overcome challenges in a learning process.

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