Learning and Teaching Experiences with a Persuasive Social Robot in Primary School – Findings and Implications from a 4-Month Field Study

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Abstract. In the field of child-robot interaction (CRI), long-term field studies with users in authentic contexts are still rare. This paper reports the findings from a 4-month field study of robot-assisted language learning (RALL). We focus on the learning experiences of primary school pupils with a social, persuasive robot, and the experiences of the teachers of using the robot as a teaching tool. Our qualitative research approach includes interviews, observations, questionnaires and a diary as data collection methods, and affinity diagram as a data analysis method. The research involves three target groups: the pupils of a 3rd grade class (9-10 years old, n=20), language teachers (n=3) and the parents (n=18). We report findings on user experience (UX), the robot's tasks and role in the school, and the experience of the multimodal interaction with the robot. Based on the findings, we discuss several aspects concerning the design of persuasive robotics on robot-assisted learning and CRI, for example the benefits of robot-specific ways of rewarding, the value of the physical embodiment and the opportunities of the social role adopted by the learning robot.

Keywords: Child-Robot Interaction, Robot-Assisted Learning, Persuasive Design, User Experience, Field Study.

1 Introduction

Social robot is an autonomous or semi-autonomous robot that communicates and interacts with human beings, and obeys the behavioral norms set by humans [1]. Social robots have many possible uses, including education [2,24]. Social robots can be beneficial agents in children's *robot-assisted learning*. Their benefits may result from e.g. robots' motivational factors [22], ability to patiently repeat tasks [3], capability to adapt the learning tasks [18] and human-like interaction and presence [2, 16]. Motivation plays a strong role in learning, and due to social robots' characteristics, they have potential to act as motivators for learning [27]. *Persuasive Design* approach, e.g. [17], offers many techniques for designing technologies that can engage people and support motivation. In this article, we discuss Persuasive Design implications and considerations on robot-assisted learning and *child-robot interaction (CRI).*

Despite being popular research topics, robot-assisted learning and CRI have space for long-term studies conducted in natural settings. *Naturalistic studies* that utilize qualitative methods are still quite rare in the field of social robotics [9], and the studies that have been conducted in natural settings have actually often been restricted to a pre-defined space [4]. Social robots have a strong novelty effect that can soon wear off [10, 13], and long-term field studies are required to evaluate how long users' interest in a robot is maintained. In the research thus far, "long-term use" has usually meant "serial short-term interaction", and interaction with the robot has not taken place as a part of natural teaching and learning practice, but in a situation that has been defined and supported by the researchers [4].

In this paper, we report a 4-month user experience (UX) study that was carried out in *authentic context of use*, in a primary school setting, at the time when the school started to use a social robot for teaching languages. The use of the robot was defined entirely by the users, not by the researchers. Our research investigates the use of the robot from three perspectives: *pupils, teachers* and *parents*. We focus on *the robot's tasks, social role* and *interaction/behavior* as suggested in the design framework of socially interactive robots by Deng et al. [9]. This paper addresses the following research questions:

1) What are the teaching and learning experiences with the social robot focusing on the A) tasks, B) social role and C) interaction/behavior of the robot?

2) What are the considerations for the further design of social, persuasive robots for CRI?

2 Related Work

2.1 Robot-Assisted Learning and Child-Robot Interaction

Research on social robots in education focusing on children is a popular topic [2, 16]. A recent meta-review reveals 101 articles in the area of educational robots, most of them focused on children [2]. On the field of robot-assisted language learning (RALL), the **typical tasks** of a robot in learning include teaching vocabulary [13, 25], reading and speaking skills, grammar and sign language [24]. Usually the robot's tasks are defined by the researchers. Thus, there is a need to explore the tasks that a robot is used for when it acts as a natural part of the learning environment. This relates to our *RQ1A*.

In general, children have a positive attitude towards robots [26], and studies have shown some evidence of better learning outcomes when studying with the robots, e.g. [12, 24]. A robot can adopt **different roles** in teaching: teacher or tutor, peer or learning companion, and novice [2]. The role of the teacher/tutor has been the most popular role so far (ibid.). However, research has shown that children perform better and are more focused when the robot behaves like a peer rather than a tutor [27]. Presenting the robot in the role of peer may also increase the acceptance towards unexpected behavior of a robot, e.g. if its speech recognition fails [3]. In their study, Tanaka et al. [22] found out that children started to treat the QRIO robot as a peer rather than a toy, and they expressed plenty of care-taking behaviors towards the robot, also discussed by Turkle [23]. Kanda et al. [14] found that children wanted to become "friends" with Robovie robot. Thus, it seems that children tend to develop social bonds with educational robots. Our *RQ1B* focuses on the roles that the robot adopts in a naturalistic school setting.

Social robots utilize **multimodal interaction** to aim for more natural communication. It seems that any social behavior and cues built on an educational robot improves learning outcomes and experience [3]. The most obvious form of social behavior is the use of speech as an interaction modality, e.g. [13, 15, 25]. However, technical challenges still limit the proper use of natural dialogue in robot-assisted learning [15]. In addition to verbal interaction, social robots are capable of non-verbal communication, e.g. using gestures, movements and proximity. For example, De Wit et al. [8] found higher level of engagement during learning activities when gestures were used. Also, Leite et al. [16] present an empathic model for CRI by utilizing, e.g. facial expressions on the robot. They found that it had a positive impact on long-term interaction with the robot. As Serholt et al. [20, pp. 7] note, it is *"important for the future of CRI to consider what modes of communication come naturally to children."* This relates to our *RQ1C*.

2.2 Persuasive Design in Robot-Assisted Learning

Motivation plays a strong role in learning. The field of *Persuasive Design*, e.g. [17] utilizes many techniques to design technologies that can persuade and support motivation, e.g. by *goal setting, tracking performance, showing progress, adoption of a social role, supporting rehearsal, giving feedback* and *providing virtual rewards*. In addition, they can give *information and advice, remind,* and *utilize social support and competition* as motivational factors. According to research, robots can act as motivators in learning [7, 27]. *Persuasive Robots* mean social robots that are designed to change people's attitudes and/or behavior [4, 21]. Persuasive robotics is still mostly unexplored ground although some research has been conducted [4, 11, 19, 21]. Bertel [4] summarizes the possibilities of the social robots as persuaders through *alignment of appearance, behavior and tasks (personalization), emotional expressions, distinctive features of speech, gestures, positioning and posture (multimodal interaction)* and through *the perceived social role.* Leite et al. [16] present a list of guidelines for the design of social robots for long-term interaction. Their work suggests that the robot's *appearance* needs to fit its *purpose* – attention needs to be paid when selecting appropriate physical embodiment for the robot to be used with the children. The robot should be able to show *incremental novel behaviors* over time, also stated by Kanda et al. [14]; information about the user and their *affective state* needs to be used for the *adaptation* of the robot's behavior and expressing empathy, and the robot would need to remember the past actions with the user [16].

Robotic persuasion is multi-modal and thus, it might provide stronger persuasive effect than persuasion that uses less modalities. Physical embodiment provides benefits in tasks that require a relationship-oriented approach: physical embodiment increases the feeling of social presence and thus improves multimodal communication, perceived trust, pleasurable experiences, attractiveness and perception of how helpful the robot is [9]. Our *RQ2* extends the discussion around the Persuasive Design on the robot-assisted learning and CRI by addressing persuasion on social robots in the long-term naturalistic setup.

3 Methodology and Study Procedure

3.1 Participants

Three user groups participated in the study: the pupils of a 3rd grade class (9-10 years old, n=20), language teachers (n=3) and the parents (n=18) of the participating pupils. The language teachers were between 41-50 years old, female, had at least ten years of teaching experience, and had no prior experience with robots. The parents were 70% female and half of the parents were 36-45 years old. Research ethics and data security were strictly considered in the study. Identification information was not collected of the children, all data were anonymized and observations were not linked to a specific child in any phase. The participation to the study was voluntary and the participants were able to end participation at any time. The permission to conduct the study at the school was obtained from the city's education and learning services and the school's rector. The consent for pupils' participation was obtained from their parents. The interaction and tasks between the pupils and the robot was defined by the teachers.

3.2 Data Collection

The 4-month user experience study was carried out in a Finnish primary school in September-December 2018. The data was collected with a multi-method approach including observations, online diary, online questionnaires and semi-structured interviews.

Observations. Four observation sessions, one each month, were conducted in the classroom context during 3rd grade English language classes. Each session lasted for two hours and was conducted with the same class. Two observers were present in the sessions and used a semi-structured observation sheet. The observations focused on interaction with the robot, tasks conducted with the robot, children's emotional reactions, atmosphere in the class, challenges in use, and the teacher's role in robot-assisted learning. Classroom observations took place under the supervision of a teacher.

Online diaries. The teachers were instructed to fill in an online diary after each time they used the robot in teaching. The diary included nine questions. Six of them were close-ended and concerned the teaching context: taught language, teaching situation (classroom or small groups), grade of pupils, number of pupils using the robot, how many times the pupils had used the robot before, and duration of use. The rest of the questions were open-ended and dealt with the task(s) conducted, feelings and experiences, and challenges. In total, 49 diary responses were received from three teachers.

Online questionnaires for teachers. The teachers filled in two online questionnaires: the first one before the study began (in April 2018), focusing on their expectations towards using the robot in teaching. The second questionnaire was conducted in October 2018 with the focus on teachers' experiences of robot-assisted teaching related to e.g. children's motivation, ways to utilize the robot, and the challenges in use.

Online questionnaire for parents. Parents were invited to complete an online questionnaire during the latter half of the study period. The questions focused on e.g. things that children had said about the robot at home and how did they describe the learning with the robot. It also included questions that parents were instructed to ask from their children, such as their experiences with the robot.

Interviews with teachers. Interviews were conducted for three teachers in the end of the usage period. The interviews lasted for 30-45 minutes and followed a semi-structured discussion guide that dealt with e.g. the teaching experiences with the robot, the perceived role of the robot in class and the challenges teachers had encountered with it.

3.3 Data Analysis

The Affinity Diagram technique [6] was used for the thematic analysis of the qualitative data collected from observations, interviews, and open-ended answers from online questionnaires and diaries. Observation notes were written by hand, and they were transcribed and coded after the session. The data were transferred as affinity notes including a single observation and the session code on each note. Open-ended answers from questionnaires and diaries were formulated into affinity notes with user codes. Interviews were audio recorded and transcribed verbatim, and affinity notes were formulated from the transcripts. The affinity diagram was built by two researchers. We focused on specific topics related to the research questions of this study, excluding themes that were out of scope. The final Affinity Diagram focusing on our research questions consisted of 7 main categories and 37 sub-categories. The quotes from participants have been translated from Finnish for this article. The name of the robot has been removed.

3.4 The Language Learning Robot and App

We used the language learning robot Elias (eliasrobot.com) on our research. It is a mobile app that, in our case, worked together with a 60-cm tall Nao (softbankrobotics.com), social humanoid robot (see Fig. 1). The Nao robot is capable of e.g. walking, talking, gesturing, playing audio files and face recognition. The learning content for the app has been developed by an educational technology company and co-designed together with the language teachers.

Fig. 1. The language learning robot and the mobile app (eliasrobot.com).

At the time of the study, the robot was able to teach English, French and German, and it had two difficulty levels for English and one level for German and French. It included several learning themes, e.g. greetings, colors, foods and emotions. The basic structure of the robot-assisted lesson was the following. First task was to repeat vocabulary of the selected theme. The mobile app showed images about the selected theme, e.g. emotions, foods, numbers, or colors; the robot said the word aloud, and the child repeated it. This was done three times per each word. After that, the child was expected to remember the learned words. The mobile app showed the images and the child said the words aloud for the robot. The next step was the dialogue: the mobile app's images guided the dialogue between the child and the robot. The final phase was the free dialogue with the robot about the selected topic. During the learning session, the robot provided various rewarding gestures and movements, such as cheering, nodding, dancing and clapping, as well as verbal feedback for the performance.

4 Findings

4.1 Overall Learning and Teaching Experience

During the study, the robot was used in teaching in two primary settings: 1) with the whole class, or 2) with groups of 2-4 pupils who completed 5-15 minutes lessons with the robot in corridor while the rest of the class worked on other tasks in the classroom.

Positive Feelings and Motivation to Learn. The robot appeared to evoke positive feelings such as happiness and curiosity in pupils: *"It's nice, I like it, it's funny."* When learning with the robot, they laughed and smiled, encouraged each other and even the robot: *"Everything that the robot does, [the pupils] laugh and giggle. It's amazing."* (Teacher1). When the robot was used in a corridor outside the classroom, other pupils passing by looked at it and sometimes shouted its name eagerly or clapped their hands. The teacher who taught the observed class was excited and eager to use the robot in teaching: *"For me this has been really inspirational. After each lesson, I have the feeling that this is so great."* (Teacher1). Most pupils appeared enthusiastic and motivated to learn English with the robot and did the tasks that it asked them to do. Teachers appreciated the robot's ability to create **a relaxed and focused atmosphere** in the class: *"Pupils were able to concentrate surprisingly well, even the rascals."* (Teacher2). While most pupils appeared eager to interact with the robot when it was in the class, they patiently waited their turn. Over-excitement was only seldom observed: a few times the pupils in a small group started making fun of the robot's utterances after they had completed the lesson. However, while just the presence of the robot was enough to evoke enthusiasm in the initial use, over time the novelty wore off and the teacher had to plan more carefully how to use the robot in the actual teaching: *"If I haven't planned myself something to do with the robot, it's no longer a surprise element that it's here. Then it's my responsibility to have a lesson plan which utilizes the robot."* (Teacher1). Also the role of the relevant and varying learning content on the robot became much stronger after the initial excitement towards the robot itself slightly decreased. Although the strong excitement towards the robot mildly decreased, **the motivation to learn** with the robot remained high on the pupils throughout the study period – they were willing and motivated to study with it even in the end of the 4-month research period.

Negative Experiences. While negative experiences were rarely observed or reported, they are important to point out. Situations in which the robot did not work as expected occurred during the study, causing frustration in teachers because they felt that time was wasted, although technical problems did not bother pupils as much: *"Pupils still wait unusually patiently, even though the robot doesn't do what it's asked to do, and are delighted about the things it does."* (Teacher2). Still, frustration related to the robot's imperfect speech recognition was expressed also by some pupils: *"Sometimes it gets confused and you cannot talk to it or it doesn't listen"*. Two of the teachers felt their enthusiasm to use the robot in their own teaching was dampened by technical problems, although they were generally positive towards the robot. Disappointment, possible feeling of failure and loss of motivation were mentioned by two teachers when they described a situation in which pupils in the class spoke with the robot and got a response from it, except for one pupil who the robot ignored, i.e. its speech recognition did not work: *"One pupil was not understood and didn't want to come [to speak with the robot] after that. The child was crushed when [the robot] didn't understand."* (Teacher3). A couple of pupils also expressed wariness and hesitation when the robot was first introduced, and occasionally the robot's sudden movements frightened a child for a moment.

4.2 Tasks of the Robot and Teacher-Robot Collaboration

While the robot was originally intended primarily for language learning, **various other uses for it were invented at the school**. One of the teachers was especially active in engaging in various projects with the robot and pupils, e.g. writing and filming the story of the robot: *"There was writing, mother tongue, and television/media skills and coding. Well, there was also language when the writers also translated [the story] into English, so that it became bilingual."* (Teacher1). The robot also had a role in a school festival. Moreover, another teacher saw that the positive side of technical problems was that pupils got a learning experience of turn taking and that things do not always go according to plan. We observed that **teachers had a strong role in integrating the robot into teaching.** The robot was a new tool to the teachers and thus there were no ready-made practices or guidelines in how to integrate it into teaching. Creativity and flexibility were needed from the teachers to integrate the robot into lessons. Planning of a robot-assisted lesson required extra effort compared to a traditional lesson.

The robot was likewise new to the pupils and especially first uses of the robot required a lot of help from the teacher, who had to go back and forth between the classroom and the small group who was interacting with the robot. *"During the first lesson I was busy to be in the classroom and in the corridor. Differentiation [of teaching] was challenging. For the second lesson I got an instructor and it helped."* (Teacher1). Furthermore, help was not always available when the robot had technical problems such as stopping responding to commands. The teachers felt they lacked time to get deeply familiar with the robot and develop their own ways of using it in teaching. *"I think the school should have a tutor [to help with the robot]."* (Teacher1). During the study, we noticed that the best way to support the formation of robot-assisted teaching practices and manage the possible technical challenges is the **peer-support inside the school** –

the most enthusiastic teachers could act as instructors. It would also be important to have some guidelines and scenarios about how to use the robot in teaching.

4.3 Roles of the Robot

The robot became a popular **”dude” or mascot of the school** with whom children liked to act in many ways and projects. Throughout the study period, the children were curious and interested about it and they considered it as motivational for learning. Children seemed to express **empathy and tenderness towards the robot**. They were petting, hugging and tickling it, and asked empathic questions from it. Even the oldest boys expressed caring behavior towards the robot and played with it. The robot seemed to have become everybody’s friend and a positive character. We recognized two specific roles for the robot: encourager and learning companion.

Encourager. Two teachers pointed out that some shy and quiet children were encouraged by the robot to speak aloud: *“It’s been great to see that the quietest pupil in the class can be the most proactive and enthusiastic when working with the robot.”* (Teacher2). Some pupils also referred to this characteristic of a robot as something that motivates them to learn: *“The robot is kind-hearted and encouraging.”* While the robot was generally perceived as a peer, even a friend, its encouraging and friendly characteristics appeared to give it a sense of authority so that pupils obeyed its suggestions and followed instructions most of the time.

Learning Companion. Many pupils experienced that the robot inspired them to learn because it was a fun learning companion and provided variety in teaching methods: *“[The robot] inspires because learning with it is different than with a teacher.”* One pupil also stated that the robot is nice because it is cute and helps in studying. While learning outcomes were not assessed in this study, there were signs that at least some pupils felt they learned better with the robot: *“I remember words much better with the robot.”*

4.4 Multimodal Interaction and Behavior of the Robot

Verbal communication. Most pupils were approaching the robot and interacting with it naturally and bravely. Speech seemed to be the most natural interaction modality: *“Kids are very excited about the robot and brave to talk, and they want to talk to it.”* (Teacher2). Children talked to it spontaneously. There were challenges in speech recognition, and the robot did not always understand what children were speaking. The pupils usually remained patient and tried to talk louder or closer to it, or raise its attention by shouting it by name. Speech recognition was more successful with older children.

Nonverbal communication. Physical embodiment with gestures and movements seemed to make the robot to appear as a lively creature for the pupils. Pupils often greeted the robot, tried to take contact with it, looked it into eyes, liked to be close to it and touch it. The robot had several different kinds of gestures and movements, which made the interaction pervasive and interesting, and made learning a rewarding experience. Pupils imitated the gestures and movements of the robot, e.g. clap of hands, cheers and nods, and they were happy to receive a gestural reward after the learning task. For example, when the robot was nodding, one child commented *“It showed that I did it right.”* Gaze contact with the robot was very important for children, and they were constantly seeking for it, e.g. by moving their face into very close distance to the face of the robot: *“Don’t look up, look at me!”* They also made comments about whom the robot was looking at.

The robot had some **robotic ways of interaction**, too. Based on our observations, ”the candy eyes”, i.e. colorfully lighted eyes with a sound effect, acted as the robot’s strongest rewarding element. Collecting “candy eyes” motivated pupils to repeat the words all over again and they started to compete about how many candy eyes each group got: *“Let’s try to collect 25 candy eyes!”* We observed that the rewarding elements of the robot worked best when they were not presented too often. In this way, pupils waited for them to appear, and did not get bored on them. Entertaining movements, like dancing, cheering and dabbing, also acted as good rewarding elements as well as active breaks for the pupils. Some movements were designed to support learning directly, e.g. a song “head, shoulders, knees and toes” and movements while learning verbs. The movements of the robot were well noticed and remembered by the pupils.

We observed that the **robot’s appearance and embodiment** were suitable for schoolchildren. Most children approached the robot without hesitance and seated themselves at a very close distance. When they talked to the robot, they set their face next to the face of it. They often wanted to touch and pet the robot, especially its head and hands, hold its hand and tickle it. One characteristic that made the robot seem more lively was its “own life” – due to occasional bugs and technical faults, the robot sometimes seemed to live its own life by making sudden, funny comments and reactions. For example, it could suddenly tell a joke in between the lesson: *“I like the unexpectedness of the robot, otherwise it would be boring.”* (Teacher1).

5 Discussion and Conclusion

During our 4-month user experience study of the social and persuasive robot for learning, we observed that it became a well-known and **popular mascot in the school**. It adopted a positive role as **an encourager and learning companion** for the pupils. It was able to create positive **atmosphere** for learning in class, and pupils considered it as a **motivational** “dude”. Pupils were willing to learn with the robot throughout the research period and did what it asked them to do. We consider the learning robot as an assistant for the teacher with its own strengths, with a lot of potential to be used in various ways at school and for **multiple projects**. It has power to motivate pupils, as other studies have also found [7, 27]. From the teachers’ perspective, there is a need for support and models for taking the robot into classroom as a routine part of teaching. Scenarios and guidelines about the robot-assisted learning would be needed, as well as the models about how frequently and for what tasks the robot would be taken into. The most enthusiastic teachers, the forerunners, could act as peer-supporters.

Related to the interaction between the children and the robot, we observed many **persuasive and motivational principles** presented on the persuasive design models, e.g. on [17]. Next, we discuss the most striking aspects. **The physical embodiment**

and appearance of the robot seemed to be well accepted and suitable for the children. It is no wonder that Nao is the most popular platform for robot-assisted learning [2]. The physical and lively robot itself acted as a very strong source of initial excitement and motivation. In general, children approached the robot very naturally. They stated it looked cute and they were willing to interact and learn with it by using several modalities (speech, gestures, gaze, movements and touch). Being close to it, seeking for its eye contact, talking to it and touching it happened spontaneously. Thus, **the physical presence** of the robot seemed to be an important factor in interaction and learning. As Deng et al. [9] discuss, physical embodiment is best suited for robots that act in social tasks. Due to its physical embodiment and liveliness, the robot adopted a clear **social role** in the school as a popular and friendly encourager and learning companion. The robot's ability to **"live its own life"** partly due to some bugs and technical flaws increased the perception of it having its own interesting personality and will. The role of the learning content inside the robot seemed to increase dramatically after the initial excitement about the robot itself slightly decreased. The relevancy of the learning tasks given by the robot and how the teacher integrated the robot to the teaching started to play a strong role then. There needs to be a lot of variation on the robot's learning content, and it needs to **evolve**. It would also be important to develop it to be able to adapt to pupils' levels and states, as also noted by e.g. Leite et al. [16]. In any case, the physical robot and its learning content together, when integrated efficiently to the teaching, seemed to support and motivate **rehearsal** and repetition, which are the main keys in language learning.

Robots have special "robot-like" ways for non-verbal communication, such as lights and sounds. **The robot-like rewarding** was one of the most striking persuasive element on the robot of our study. The "candy eyes" and special movements gained a lot of interest and excitement from the pupils and made the robot appear as a different kind of a character than the teacher – the robot had some different and special elements when compared to the human teacher. It appears possible to design strong rewarding elements on social robots to boost pupils' motivation to accomplish learning tasks. Especially candy eyes raised **competition** among pupils, which made them repeat the vocabulary endlessly. In future designs, we would like to emphasize the role of robot-like ways to persuade. This may also relate to ethics. Especially small children tend to perceive social robots as friends rather than tools, and create social bonds with them [14, 22]. It would be important for the children to understand that robots are just technological devices and not human-like creatures. That is why we would prefer to design more robot-like persuasive behaviors, rather than too human-like, for robots that interact with children.

We noticed also social persuasive principles on the interaction between children and the robot. The robot initiated **collaboration** – we noticed that the children were encouraging each other and even the robot itself when working in small teams. They were behaving well with the robot, and showed characteristics of empathy during the interaction. Even for the oldest boys it was socially acceptable to show empathy and play with the robot. Bertel [5] and Turkle [23] have made similar observations about the caring behavior towards the social robots. This potential to support learning of social skills could be further explored in future research.

Naturalistic long-term studies can reveal users' experiences that would remain unnoticed in one-time or short studies, and provide insight into contextual factors that cannot be investigated in the lab. Naturalistic studies are still quite rare in the field of human-robot interaction [9], giving much novelty value for our research. Our qualitative approach aims at understanding the phenomena on CRI that lasts for several months, and the user experiences of robot-assisted learning both from the pupils' and teachers' perspectives. Learning outcome was not in the focus of our study, but it is an important topic that is being studied by several other research projects. Our future work will focus on robot-specific ways of persuasion in CRI and the ethical aspects of robot-assisted learning and persuasion. We are also interested in exploring more about the possibilities of haptics as an interaction modality on CRI, as touching and being close to the robot was very natural for the children.

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