Co-Learning around Social Robots with School Pupils and University Students – Focus on Data Privacy Considerations

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Figure 1: University students and elementary school pupils co-learning about social robots together. Image: Anriika Photography

ABSTRACT

We adopt a novel approach of co-learning between elementary school pupils and university students around social robots and robotics. Social robots provide a motivational learning tool for various learning tasks. Having different learner groups together may bring in new insights, perspectives and learning. Although social robots provide an interesting platform for learning, they have challenges in terms of data privacy, as they track, process and transfer personal data. These matters should be carefully considered. We describe a qualitative and exploratory study including two phases: 1) design of co-learning activities (N=16), and 2) evaluation of co-learning activities (N=56). All co-learning tasks were developed by utilizing privacy-sensitive robotics approach and the tasks included some learning content about data privacy. The evaluation was conducted as co-learning workshops with school pupils of 10 to 15 years and international university students. We report findings about the co-learning experience of these learner groups, as well as their data privacy learnings on social robots. We also present considerations for educational robotics from the data privacy perspective.

CCS CONCEPTS

• **Computer systems organization → Robotics**; • **Human-centered computing → Empirical studies in HCI**; **User studies**.

HAI '23, December 04–07, 2023, Gothenburg, Sweden

ACM ISBN 979-8-4007-0824-4/23/12.
https://doi.org/10.1145/3623809.3623816

KEYWORDS

Social robots, Educational robots, Co-learning, Data privacy

ACM Reference Format:
Aino Ahtinen, Aparajita Chowdhury, Valentina Ramirez Millan, Chia-Hsin Wu, Gayathri Menon. 2023. Co-Learning around Social Robots with School Pupils and University Students – Focus on Data Privacy Considerations. In *International Conference on Human-Agent Interaction (HAI '23), December 04–07, 2023, Gothenburg, Sweden.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3623809.3623816

1 INTRODUCTION

Social robots provide a motivational platform for various types of learning tasks for different learner groups. This is due to their various modalities, physical embodiments, perceived presence and customizable roles and learning tasks. Robots, which are used for educational tasks, are called as *educational robots* (ER). ERs include both social robots as well as other types of robots, such as robotic toolkits. ERs can be used to teach multiple subjects, such as robotics itself, but also in broader sense science, technology, engineering and mathematics (STEM) [6],[31],[32] and languages [4],[11],[48]. They can also be utilized in the learning of soft skills such as creativity and teamwork [7],[33],[43],[51].

Previous research has found out that in robotics projects we can successfully bring in learners from different fields and skills to learn together, and different expertise areas are beneficial in these projects. *Collaborative learning* (co-learning) refers to the model, where learners are engaging actively together [51]. For example, Eck et al. [26] studied robotics co-learning among pre-school children, school pupils and grandparents. Co-learning between family members with social robots and other types of robots have been studied by [3],[12],[40],[49]. The cross-generational aspect on learning about the robots seems to be a growing topic in the field of human-robot interaction (HRI) and child-robot interaction (CRI). Now, we bring together elementary school pupils and international university students to learn together about robots. With this novel combination of learners, there can appear unique opportunities for learning, when the expected open-minded creativity of younger learners meets with the university students' experience, technical knowledge and cultural backgrounds. We expect both groups to learn something new when they are working together.

While social robots have proven their strengths as motivational companions for learning, especially with children [4],[10], and as efficient icebreakers between humans [9],[19],[47], their possible privacy issues need to be carefully considered. *Privacy-sensitive robotics* is focusing on the privacy aspects of robots [17],[30],[42]. Social robots can interact with users by collecting and storing personal data, such as image and audio. They are often connected to the internet and external cloud for the data processing [34],[39]. Understanding and being aware of the data collection and processing of the social robots is relevant both for the researchers and educators in the HRI field, not to speak about the vulnerable end users, who are interacting and learning with them.

Goal, research questions, and contribution. The goal of this research is *to explore the co-learning experiences between the novel combination of learners, school pupils (10-15 years old) and international university students (Master's level), focusing on data privacy aspects*. Having a vulnerable target group (children), we decided to pay attention to the data privacy aspects and implement our robotic co-learning activities with privacy-sensitive robotics approach [17],[30],[42]. We also created data privacy materials of social robots as part of our co-learning model. Thus, we would like to raise more awareness and discussion on the possible data privacy issues concerning the social robots and their broad usage in educational sector and other sectors, where the learners and users can be from vulnerable groups. The research questions are: 1) What are the learning experiences from the social robot activities for school pupils and university students? 2) What are the perceptions of these learner groups concerning the data privacy learning activities and solutions on the social robots? 3) What are the considerations for the safe and secure educational robotics?

2 RELATED WORK

This section provides relevant knowledge about two areas related to our research: 1) co-learning as a concept and the findings around it, and 2) privacy-sensitive robotics.

2.1 Co-learning with robots between different learner groups

Typical characteristics of the robotics projects are the conduction of hands-on tasks, and the learners working with tangible objects, i.e., robots. Robotics learning projects are typically versatile and they can potentially bring people with different interests, ideas and skills to work together [51]. A single project can include activities such as programming, constructing and designing [51]. They can naturally enable collaboration between different learners and team members, as robots are good in icebreaking between people [9],[19],[47]. According to Yuen et al. [51], *"collaboration is important to the learning process because it brings together multiple perspectives, ideas and abilities."* (p. 39). The main values of a co-learning environments include, e.g., reframing the hierarchies in the room, building trust and relationships with all stakeholders, valuing collective creativity and allowing space for feedback and reflection [41]. These principles mean that co-learning aims for a change from the traditional and hierarchical learning towards active, participatory, creative and collaborative learning activity.

Eck et al. [26] studied cross-generational learning about robotics in a scientific kindergarten experiment day. There, the participating children visited several hands-on experiment stations with their grandparents. They recognized the value of discovery and experimentation in learning. According to their findings, the cross-generational concept worked out well. Chung and Santos [20] explored the Robofest Carnival, which is an informal learning program with multiple learning stations with robotic tasks. The parents were integrated into the program to manage the learning stations. It was found out that the parents were positively able to inspire and motivate their children by teaching and instructing them in the STEM challenges. In Robocamp study [3], the family members' co-learning around social robots was explored in the home context, which was found out to be a comfortable setting. Angel-Fernandez and Vincze [5] arranged a co-learning activity with children (6-18 years old) and university students (Master's level) to conduct a storytelling session. The participants were required to create and implement stories in small groups where both children and university students participated. They realized that the participants worked best in multidisciplinary teams possessing different skills.

2.2 Privacy-sensitive robotics

Pagallo [39] describes social robots as *"a specific set of robots, namely, the class which is connected to a networked repository on the internet, in order to allow such machines to share the information required for object recognition, navigation and task completion in the real world."* (p. 501). This means that for the multimodal interaction with the users, the robots are full of embedded sensors [45], which gather user data, such as voice and images, i.e., personal data [22]. For example, embedded cameras are used for the facial recognition, based on which the robot can learn the user and customize its behavior. For this interaction, the robot needs to capture, process and store the image data of the user. The speech recognition needs microphones to gather audio data, to enable the spoked dialogue with the robot. Chatzimichaili et al. [17] describe: *"These human-robot interactions are as good as the data we feed them."* (p. 160). The robots are typically connected to the external cloud for the data processing [34],[39] because the robot's hardware may not be powerful enough to run heavy AI algorithms to process the data, and they also need to have access to databases for making interpretations of the collected data [18]. Since the robots use cloud services to process data, they are mostly connected to internet, which escalates the risk of hacking [35]. For example, popularly used social robots, such as Pepper, Nao and Alphas, can be vulnerable to hacking due to authentication issues, insecure communication while connected to

WIFI or mobile networks, privacy issues of sending data to remote servers without users' permission, etc. [16],[29].

Privacy notice form is a document that informs about the register holder's data register contents, and the rights of the person, whose data has been stored into the register [17],[44]. There seems to be gaps and variation in how the companies are communicating the privacy information to the users [17]. According to Chatzimichaili et al. [17], it is hard to gain enough trust in robots, when it comes to their data privacy information. The data collection can also easily remain unknown and misunderstood by the users [25],[34].

As social robots are used in home settings [14],[27], schools [4],[11], hospitals and rehabilitation centers [21],[23] including vulnerable user groups, such as under-aged persons and patients, it is important to raise more awareness of their data privacy concerns. When used in public spaces, they may track data about passers-by [39]. At home settings, they can collect sensitive data [13],[28],[39]. The data privacy aspects are especially important in social robots [17],[30],[38],[46]. With these embodied and interactive agents, the users tend to form stronger emotional relationships and bonds than with some other type of technology, which does not have such a social role. Wang and Rau [50] explain that being in the same physical place as the social robot can make people instinctively trust it more and therefore make humans more willing to interact and thus, deliver their data.

Privacy-sensitive robotics [17],[42] has started shaping a more data safe future for HRI. The data collecting and processing issues are getting attention in the design of social robots. Heuer et al. [30] describe that *"In order to foster user acceptance, trust and to address legal requirements as the General Data Protection Regulation of the EU, privacy needs to be integrated in the design process of social robots."* (p. 509). They adopt a Privacy by Design approach [15] and present privacy enhancing measures for the robots. They present potential techniques for intervenability (e.g., option switch off the sensors and/or network), data minimization (e.g., reduction of collected data, anonymization of data), transparency (e.g., clearly visible sensors and status sign of the sensors/network) and confidentiality (e.g., standard security measures). In addition, Lutz and Tamò-Larrieux [36] provide valuable implications for the robotic companies in the area of privacy-sensitive robotics. According to them, the robot companies should consider privacy sensitivity as an important design guideline, or otherwise they should expect a huge decrease in the robot purchases and popularity due to the decreased trust. They state that *"robotics firms should construe privacy as a key part of their development philosophy and not as an afterthought."* (p. 8).

3 RESEARCH PROCESS AND METHODOLOGY

Our qualitative and exploratory research process consisted of two phases: 1) co-learning activity design including two co-design workshops with school teachers and university students, and data privacy inspection, and 2) co-learning evaluation in three workshops with university students and elementary school pupils. The research was conducted in Finland in spring 2022, as a collaborative project between university and elementary schools. The research process followed the human-centered design (HCD) process [1], where the main idea is to involve users as part of the whole design process by utilizing several phases in iterative manner: planning, understanding the context, specifying the user requirements, producing the design solutions, and evaluation of the solutions. Table 1 summarizes our research phases. The research permission was applied from the local city officials, because the research involved school pupils and teachers. Participation to the research was voluntary. Informed consent was asked from all participants, and the pupils' guardians also needed to give their consent. The participants were allowed to quit participation at any time. We removed all identification information of the participants in the data transcription phase and all data analysis was conducted for the anonymous data. All data was stored in the secure drive of the university.

Table 1: Research phases, N of participants, data collection methods, time frame, and the outcome

	Phase 1: Co-learning activity design	**Phase 2: Co-learning evaluation**
Participant groups and N of participants	Researchers (N=5); elementary school teachers (N=3); university students (N=13)	Elementary school pupils (N=42); university students (N=14)
Methods	2 co-learning workshops (online); data privacy inspection of the robots; developement of safe modes; co-learning activity design and iteration	3 co-learning workshops (live): observations and produced materials during the workshop, essay text (pupils), focus group and blog post (students)
Time frame	February – April 2022	May 2022
Outcome and results	Co-learning activities in data secure modes	Learning experiences and insights of the co-learning activity

3.1 Co-learning activity design (Phase 1)

Co-design workshops. In February 2022, we organized two co-design workshops, where the goal was to discuss and get input for the upcoming co-learning activities around social robots, to take place between elementary school pupils and university students. These workshops were arranged online in Zoom and each of them lasted for two hours. Voluntary elementary school teachers (N=3) and Master's level international university students of human-technology interaction (N=13) participated these workshops. The participants were recruited by spreading an announcement of the study in the local elementary schools and in a university course. The workshops consisted of ideation of the co-learning activities in small groups by using the breakoutrooms, and evaluation of initial co-learning concept ideas. The participants also marked down their ideas and thoughts on a collaborative Mural canvas tool [2]. The ideas and insights from these workshops provided inspiration for the design of the co-learning activities.

Data privacy inspection of the robots and development of secure modes of use. We conducted an inspection of the data privacy of the robots that we have in our laboratory: Pepper, Nao, Alpha Mini and ClicBot. We conducted this inspection in spring 2022.

The goal of the review was to find out how our robots are collecting, using and transferring personal user data. Two researchers were collaborating on this activity. One researcher had a non-technical background, and one researcher was from computing engineering. If we found some uncertainties or challenges in our robots' data privacy, we tried to contact the companies to ask questions. We developed solutions (secure modes) to use the robots as safely as possible if there were still some uncertainties.

Co-learning activity design. Based on the input and inspiration from the co-design workshops, the data privacy inspection and previous literature [17],[24],[26],[42],[43] we designed three co-learning activities including several different learning tasks, to be described in section 5. The design of these activities was done in a team of five researchers, who sketched the activities on paper, circulated the ideas between each other and also asked agile feedback from the elementary school teachers.

3.2 Co-learning evaluation (Phase 2)

The evaluation of the co-learning activities took place in May 2022 in three workshops together with the elementary school pupils from 8th, 6th and 4th grades (10 to 15 years old, N=42) and the international university students of human-technology interaction (N=14). The recruitment of the school classes was done based on the co-design workshop participation – two teachers from them wanted to bring their class to the evaluation, and in addition one of these teacher's colleague wanted to bring her class. The workshops were arranged in the university's learning space for social robotics. The first workshop with the 8th grade (9 pupils, 6 university students) was 1,5 hours long and we evaluated two activities there: Robotic safety material and Robotour. The second workshop with the 4th grade (15 pupils, 10 university students) was 2 hours long and we evaluated all three activities: Robotic safety material, Robotour and Robotic storytelling & theater. The third workshop with 6th grade (18 pupils, 10 university students) was similar to the second one. The university students acted with the pupils in the co-learning activities so that each activity had dedicated students. The qualitative research data was collected by hand-written observations during the workshops, the materials produced by the learners in the co-learning tasks, audio recorded focus group discussion with the university students after the workshop, reflections of the university students on two blog posts, and essay text written by the pupils as homework. The audio files of focus group discussions and hand-written notes were transcribed. Possible identification information was removed from all data. Data was analyzed with an inductive content analysis [37]. All data were coded in spreadsheets and grouped into themes by two researchers. In this article we report four main themes, which all focus on co-learning experiences and insights according to our research questions 1 and 2.

4 DATA PRIVACY INSPECTION FINDINGS AND DEVELOPMENT OF SAFE MODES

As we are located in Europe and our robots are for sale in European markets, we could find privacy notice policies for all of our robots online on the companies' websites. The privacy notice forms of our robots Pepper, Nao, Alpha Mini and ClicBot were reviewed by two researchers. We found many challenges in the documents, first they were hard to find. Second, the forms included lots of information about the privacy policy of company's product and robotic parts. This made finding of information focusing on specific product challenging. The forms were usually written in a complicated, technical language, which was not clearly understandable for at least the non-technical reviewer. It was hard to perceive a proper understanding of what data the robots are collecting, how this data is used and processed, which parties have access to the data, and where it is stored and transferred. To understand the third parties' role in data processing, one should have been able to understand many technical terms. By reading these forms, plenty of questions emerged. When trying to contact the companies for more information, the companies did not either respond at all, or they forwarded the message to some other department, which did not respond. In conclusion, after the data privacy inspection we were either too confused or uncertain about our robots to use them in direct interaction with the vulnerable users.

Based on our inspection, out of which we could not find proper or fully understandable information about the data privacy of our robots, as well as relying on the findings by Chatzimichaili et al. [17] and Heuer et al. [30], we decided to generate tailor-made data safety modes for all of our robots. With these procedures, we needed to accept that some functionalities and ways of interaction would be restricted. All robots' cameras were manually blocked by using a dedicated lid or piece of Blu-Tack. This solution prevented the tracking of visual data, and it was simple to implement. However, for the audio data tracking we needed to figure out some other solutions. Some manual work and creativity were needed to implement them.

We used Nao by connecting it with an internal router without any connection to external networks or cloud. Heuer et al. [30] explicitly states that *"The use of local storage and data processing would be preferable to cloud services from a security and privacy point of view."* (p. 523). We installed the app to be used into the robot itself. All possible user data from the robot's local drive was cleaned with the factory reset functionality. For extra security, we temporarily disabled the microphone of Nao. This was done by accessing the robots' sensors by secure shelling (ssh) into the robot. Secure shell or ssh is a secured way of communication between two computers to transfer data [8]. We accessed into the robot securely by providing necessary credentials and disabled the microphone using a shell command (./sound_off.sh). In order to enhance the quality of interaction, we used Pepper robot with an external connection. Pepper's microphone was disabled in the same way as we disabled Nao's microphone.

Alpha Mini's and ClicBot's apps did not work without the external cloud. We decided to take even more secure approach with them, and only let the participants to operate them through the glass window. The glass window prevented the robot to track any audio data, but the participants were still able to see and operate them by using a tablet.

5 CO-LEARNING ACTIVITIES

According to the co-design workshops, different kinds of robots, hands-on activities and creativity would be valued. The teachers commented that data privacy is not strongly taught in schools, and they welcomed learnings on these matters. We designed three different co-learning activities, out of which we could customize the whole co-learning workshop by utilizing 2-3 of the activities based on the learner group's size and available time. The basic structure of the workshop was the following: 1) welcome, introduction and Robotic safety material (all together), 2) hands-on co-learning activities with the robots (in small groups) and 3) wrap up, discussion and certificates (all together). The main learning goals of the activities were to get familiar with different social robots and discuss the data privacy aspects that related to them. The role of the university students varied from the facilitator to the co-learner depending on the activity. The hands-on co-learning activities took place in small groups. There were 1-2 university students and 3-5 pupils in each small group.

Co-learning activity #1: Robotic safety material. The co-learning workshop started with the introduction. There, we introduced people, the learning space, the aims of the workshop, as well as basics of the data privacy aspects concerning social robots. We had developed inspirational learning material about data privacy - a short 5-minute presentation. The material was implemented as a story to raise the attention of the learners, and to explain the serious topic with a playful and engaging way. The story had several scenes: what data does a typical social robot collect and how, why does the social robot collect this data, how is this data processed, stored and transferred, and concerns about the data's safety. The story was not a full technically detailed description of data privacy, but an understandable and easy-to-perceive introduction to the topic to raise awareness and questions. This phase did not include any hands-on activities, but the hands-on activities (described next) included discussion about each robot's safety solution in the end of activity.

Co-learning activity #2: Robotour. Based on the input from the co-design workshops and inspired by Eck et al. [26], we designed a co-learning activity called Robotour. Robotour is an adjustable tour, where the learners get to know different social robots on the learning stations and can operate and interact with them. The number of stations can be easily adapted based on the size of the visiting group, their preferences for learning, time resources and robots available. In our tour we had three stations, each of them lasting for 20 minutes, and the small groups of pupils (3-5 persons) were circulating between these stations. In each station, we had 1-2 university students as facilitators or co-learners of the activity. The structure of each station activity included a short introduction to the robot and activity, hands-on activity with the robot, and a discussion about the robot and its data privacy solution. The pupils were offered a card for which they were collecting a stamp on each station to increase some playfulness to the tour.

In one station, we had *a Zoo with ClicBot robots.* Two ClicBots were constructed to look like mystical creatures, and they were placed inside the fence. Due to the security considerations the ClicBots were viewed and operated through the glass window by using the tablet app. The university students were introducing the ClicBot and the privacy aspects, and guiding the hands-on activity. The pupils were playing with the ClicBots (mystical creatures) by making them to walk, climb on the wall, dance and interact with each other. They also tried to move the ClicBots on the track, where they needed to make it to drag an object and transport it to the other end of the track. In the end, the experience with the robots and their data privacy solution was discussed.

In another station we had *a Nao robot leading a short physical exercise break.* The students at this station introduced the pupils to the Nao robot, its data privacy aspects and the upcoming activity. Then everybody made an exercise with Nao as a group. The exercise consisted of simple moves and stretches, followed by Chinese morning exercise Tai Chi. After the exercise the experience was wrapped up, as well as the data privacy was discussed.

In the third station, *Pepper facilitated a quiz related to the local city attractions.* As on the other stations, the university students introduced the robot, its data privacy aspects and the learning task, and guided the activity. The pupils collaborated with each other when they conducted the quiz. The quiz included images from the local attractions and Pepper asked the participants to guess where the image was taken. After that the participants could launch a dance on Pepper and watch it dancing or dance with it. In the end, the experience and data privacy solution was discussed and wrapped up.

Co-learning activity #3: Robotic storytelling and theater. The third co-learning activity was designed to be more creative based on the co-design study findings and inspired by Ryokai et al. [43], who adopted a storytelling and implementation approach for the children to develop their personal and creative stories for the robot. In our activity, the pupils and university students acted as a co-learning team. First, the Alpha Mini robot, the learning task and the robot's data privacy solution was described for the pupils. They were provided a storytelling template, inspired by the work by de Albuquerque Wheler et al. [24]. The idea was to sketch the story of Alpha Mini robot on the template, and implement the story (what Alpha Mini says and how it reacts) on the robot. The data safety procedure was similar to ClicBot's. In the workshops (2nd and 3rd) where this learning activity was available, the workshop ended with robotic theater, where all Alpha Mini's stories were performed by the robot on the small stage inside the glass cabinet. The image and sounds of the robot were streamed from the glass cabinet to the external screen and speakers so that everybody could see and hear.

6 FINDINGS FROM THE CO-LEARNING EVALUATION

This section describes the main findings from the co-learning evaluation: collaborative learning experiences about 1) the robots and robotics, 2) data privacy and 3) interaction, collaboration and multiculturality. In addition, we report findings about creativity aspects.

Learning about robots and robotics. Many pupils stated that they learned several new things about robots and their features, as they were interacting with and observing many different robots. They enjoyed the opportunity to conduct a variety of learning tasks with robots: *"There were many robots, and they all were very different, and it was nice to see what they are capable of."* (Pupil, 6th grade); *"I find it interesting that there exist so many different kinds of robots :) !!"* (Pupil, 4th grade). The most popular robots among pupils were ClicBot and Pepper. They were fond of ClicBot due to the functionality of building up different shapes and being operable in completing small transportation tasks. The ability of ClicBot in climbing on the glass wall left a positive impression: *"All robots were very interesting but above all was the robot, which could climb on the wall with small support."* (Pupil, 8th grade). Pepper attracted pupils by its appropriate body size and friendly appearance. One pupil stated: *"Pepper's hands were lovely! The body was cute, as well as the eyes. So handsome :) ."* (Pupil, 6th grade). Some pupils mentioned that they gained knowledge in programming and understanding sensors implemented on robots. They also started to reflect on other tasks of robots. One 6th grade pupil shared his experiences with the robots that he had seen as a guide at the airports. An 8th grade pupil raised the idea of robots to assist in the teaching of complicated subjects, e.g., physics and math. Another 8th grade pupil had an insight that although the demonstrated robots were impressive, they did not resemble the Sci-Fi characters in movies.

According to the students' view, the pupils had more knowledge about robots than they initially expected. Two students mentioned that some pupils had acquired knowledge about robots from movies: *"They even mentioned about some movies that I didn't watch."* (P2). Four students mentioned that block programming was not difficult for the pupils as they had learned it in school or had experience of programming Lego robots. In terms of engagement, the students learned that the pupils' interest in the robot depended on the robot's skills, appearance and the subject it was presenting. For example, pupils were curious about Pepper's appearance, and they made observations about it. According to some pupils, Pepper looked like a mermaid as it had no legs. For another one Pepper was creepy because its shape was like a human, but it had no legs. Pupils seemed to be comfortable with ClicBot and its appearance as it had an animal-like shape. They also mentioned that pupils compared ClicBot with "superman" and "spiderman" as it could climb walls.

The students noticed that it was important to properly study and understand about the robot used in their station, because the pupils got curious about the robot and asked many questions about them. It was also important to learn about the robots for quickly fixing errors or problems during interaction in the station: *"We could focus on observing the pupils if we knew how to fix the problem, rather than looking for a solution to fix the problem with robot."* (P8).

The students also learned that the learning activities should be simple and hands-on. There should be some novelty element to keep the pupils engaged. One student mentioned that Nao robot was not very interesting for the pupils, but the Tai Chi exercise on it was novel and engaging for them. The speciality of ClicBot was its ability to climb on the wall. Hands-on tasks (for example, operating the robot, answering quiz, etc.) could keep the pupils engaged with the robot and gave the students the opportunity to observe the pupils' natural interaction for valuable insights.

Learning about data privacy. All together 10 pupils from 6th and 8th grades wrote about their learnings about the social robots' data privacy. 4th graders did not write anything about it, so it seems that this topic raised more awareness among the older pupils than the youngest ones. On one hand, the data privacy solutions of the robots were considered to restrict the usage of the robots and the interaction, but on the other hand the importance of the safety was well understood by the pupils: *"It was nice to act with the robots as we knew it was safe."* (Pupil, 6th grade). They reflected on the robots acting with under-aged people, and how important it is to block the robot's sensors to prevent the data to be transferred to external parties. They also mentioned that the workshop raised awareness of the data collecting and the possibilities of the data to be delivered to the unknown stakeholders. There were also reflections of trust, and how we cannot rely on all technologies being safe to use. The following quote describes this reflection very well: *"We learned a lot about the sensors and senses of different robots and how we can turn off their senses in order to guarantee our safety".* (Pupil, 8th grade). Some pupils reflected on the data privacy aspect also in wider context, i.e., concerning the smartphone apps, as the following quote reveals: *"This made me think about how many smartphone apps can listen or collect my video data if I give a permission."* (Pupil, 6th grade).

The students discovered that data privacy solutions restricted robots' user interactions, which disappointed some. Two students noted that pupils at their station wanted more voice interaction with the robot, but speech capabilities were limited. The data privacy solutions seemed to raise questions on pupils: *"When the pupils asked why we put tape on Nao, we said it was to cover its cameras so that it doesn't take your pictures. They became suspicious and started asking if there were any hidden cameras."* (P4). One student was skeptical about the pupils' behavior regarding this topic, considering their tendency to share a lot of information in social media: *"Perhaps they were expressing concern here because they were among researchers and wanted to demonstrate that they were careful, but when they get home, they will start posting pictures on Facebook, Instagram, and TikTok."* (P9).

Learning about interaction, collaboration and cultural aspects. Most pupils described the co-learning workshop as pleasant and positive. They wrote that the interaction with university people (students and staff) was interesting as they were different than themselves, friendly, relaxed and helpful. Working with young university students was explicitly expressed as a positive aspect: *"It was really nice to get learnings and act with young students to get variety, because usually we have old teachers to instruct us."* (Pupil, 8th grade). Multiculturality and the opportunity to act with different people was mentioned as a positive aspect in many writings. It was mentioned to be interesting to get to know where each of the students came from and to meet people from all over the world. The aspect that there were people from many different countries was expressed in many writings with a positive tone.

The working language of the workshop was mainly English, although some learning stations also had a Finnish student facilitator and thus those stations could adopt a flexi-language approach if needed. From the pupils' writings we can interpret that language was not expressed as a huge issue by the pupils. Although the pupils expressed that talking and understanding English was indeed more difficult than using own native language, they still perceived the interaction and collaboration positively: *"Working with people and different languages was smoother than I expected, even though sometimes I could not make sense what they said, but I assume they felt the same about us."* (Pupil, 8th grade). Some of them mentioned being a bit nervous about speaking foreign language, while some of them explicitly stated that they liked speaking English and felt comfortable about it. This quote describe one pupil's reflections on the challenging but at the same time positive side of speaking English: *"We needed to speak English and it made it more challenging, but it was nicer as we had a little bit of challenge."* (Pupil, 6th grade).

According to the students, language barrier was an issue while communicating with 4th and 6th graders. Although older pupils could communicate in English with students, the younger ones were shyer. However, the Finnish speaking students took the responsibility to translate the conversations between pupils and international students. Also, one student mentioned that once she started to try speaking "bad Finnish", the pupils were encouraged to try speaking English.

The students also learned that icebreaking is a crucial part in any activities with school pupils. Pupils could be shy to express their opinion as the students were "strangers" for them. According to the students, sharing jokes or their embarrassing moments, showing magic tricks, showing funny elements related to the topic, sharing stories about their hobbies, etc. helped the pupils to open with the students. However, it was also mentioned that: *"We also need to accept that it is just fine if some pupils are just observing – each of us have our own ways for learning."* (P5).

Creativity aspects. The Robotic storytelling and theater activity was designed to be the most open-ended and creative task. It resulted in four different stories, which were implemented on Alpha Mini robot. The first story from the 4th grade group was about Mini going to a concert. First, Mini was feeling shy due to so many people around. However, Mini suddenly noticed Pepper and they decided to eat popcorn together, and after that Pepper was invited to visit Mini's home. The second story (also 4th grade) told about boredom. There, Mini was bored and decided to play Roblox game. However, Mini's phone got out of charge and needed to be charged. Mini got bored again and it started dancing to spend time while charging. Finally, it played again and won. The other two stories (6th grade) talked about Mini's trips to moon and amusement park. The pupils seemed to be innovative when inventing themes of the stories. It seems that they drew elements from their own lives, feelings and experiences, as well as from the workshop context. They applied various expressions, movements and actions of Alpha Mini as part of the implemented stories. In their essays, many pupils described that this activity felt like playing with the robot, and it was fun. They also felt that they could collaborate well with the students in this activity. Watching the stories together was also described to be interesting. However, many of them had already worked with Alpha Mini at their school, and they felt that working with other robots would have been even more interesting.

The university students learned about some factors that affected pupils' creativity during the storytelling task. According to the students, the group of pupils who were active in discussion came up with creative concepts for their story: *"What I noticed was they asked and discussed with each other about what it is going to say or what would be its emotions. Mostly it was their idea about the story."* (P13). However, students also mentioned that, due to the language barrier, many pupils were shy to interact and open up, which negatively affected the creativity aspect. In addition, technical issues limited pupils' story creation time, negatively affecting their creativity in story creation.

7 DISCUSSION

Bringing together school pupils, university students and robots. In our co-learning activity evaluation, we observed many benefits of the proposed co-learning model that brings together different learners to work in robot-related activities. From the previous work [7],[33],[43],[51] it was confirmed that learning with robots may enable various learnings and insights also beyond robotics. In our study, the co-learning model enabled learnings about collaboration, communication, multiculturality and icebreaking, and these are valuable learnings for both learner groups. One of the benefits of the co-learning model is that the theme of the learning session can be easily adjusted based on the learners' interest. For example, in this case the learning thematically focused on data privacy, and the robots turned out to act as useful, tangible illustrators of different aspects of their data privacy considerations. Based on the findings, the related learning tasks and demonstrators seemed to increase awareness as well as reflections of data privacy among both learner groups. In general, the proposed co-learning model provided a good platform to work and reflect on with another kind of learner group, which was different from one's own group, and this aspect was valued by both groups, pupils and students.

The learning took place together, but the learnings and insights could be different for everybody. In the current activity, both pupils and students learned about robots and robotics, as the students needed to be prepared for facilitating the activity as well as to answer pupils' questions. However, there were also different learnings gained. For example, the students learned valuable insights about how younger pupils perceive robots, what kind of things they observe about robots, and how one can collaborate with this group. These are important learnings for the students who might act as designers in the future. The pupils, on the other hand, were able to work with new technology and get to know information about data privacy matters, which might not be otherwise taught in their school. One of the most valuable benefits of collaborative learning with robots is, however, their ability to bring together people to the same physical space. Tangible and physical objects offer possibilities for hands-on tasks, which is a benefit that is missing from virtual technologies.

According to Robinson and Swenson [41], the main values of a co-learning environment include, e.g., reframing the hierarchies in the room, valuing collective creativity and allowing space for feedback and reflection. In our co-learning activity, we could observe the decreasing hierarchies as the pupils considered the student facilitators as young and probably being more close to themselves than "old teachers that they usually have". The collaboration in general was smooth and comfortable, although sometimes positively challenging. The pupils had a chance to act as active collaborators and sometimes also as creators in the activity. The co-learning model allowed a rather safe space for feedback and reflection. This aspect can be even further developed in the future by taking the robots as more active icebreakers for the activity, as already discussed on the other contexts by [9],[19],[47]. In this study, we observed some elements of creativity, especially in Robotic storytelling and theatre task. Creativity and robotics has been discussed in previous work by, e.g., [43]. Thus, we believe that the co-learning model can act as a creative space by valuing and emphasising collective creativity. In the future, we are willing to add more creative perspectives on the co-learning process, e.g., by taking the university students as designers of the co-learning activity. Robots can also act as creative tools for the pupils by adjusting the co-learning tasks to include more creative freedom. For example, we can include tasks that require design of the robot and building the robot's shape.

Considerations for data safe educational robotics. In this research, we were concerned about the data transfer and privacy of robots, especially since we involved a vulnerable learner group, i.e., school pupils. Lutz et al. [36] highlight that social robots, through their sensors, can collect diverse user data, including personal and sensitive information like images, voice, emotions, and location, posing a high risk of potential hacking or theft. For example, Giaretta et al. [29] and Cerrudo et al. [16] identified cyber security threats in robots, which include Nao, Pepper and Alpha robots. These issues include insecure communication and privacy issues. They have also mentioned that if the hackers could hack into the microphones or cameras, they could easily monitor the users, listen to conversations, identify people using face recognition and even record videos. When taking into consideration the users' tendency to form relationships, bond and trust with the social robots [17],[30],[38],[46] we wanted to take extra measures of data privacy in our research. Based on the previous work and our findings, we generated the following considerations for data safe educational robotics to respond our RQ3. They can be beneficial also on other areas of HRI, especially when working with vulnerable user groups.

#1: Data safe robotics approach. The approach of safe and responsible robotics should be utilized whenever vulnerable learners or users are involved, as stated by Chatzimichaili et al. [17], Heuer at al. [30] and Rueben et al. [42]. We recommend all researchers and instructors to carefully inspect the data privacy aspects concerning all the robots that they want to use in education and other areas. The privacy notice form and other documentation of the robot should be thoroughly reviewed. We would recommend purchasing and using only robot models that carefully take care of and inform these matters. The data privacy of the educational robots used should be described as part of any research study information sheet, as well as part of the out coming research contribution. We also highly recommend all instructors who teach robotics or use educational robots as part of teaching, to educate pupils and students on robots' data privacy concerns.

#2: Tailor-made privacy solutions. There are some manual data privacy solutions that can be creatively developed for the robots that raise concerns regarding their data privacy. Cameras and microphones can be manually blocked, and sometimes also from the software. Background music prevents the robot to track audio from the user, masks worn by the users prevent the recognizable facial information to be collected. Both creative and technical solutions can be adapted for safe interactions. These solutions naturally decrease the quality of human-robot interaction, but they provide some opportunities to use the unsecure robots for example when we want to demonstrate the data privacy aspects on the robot.

#3: Robot-assisted data privacy. Ahtinen et al. [3] suggested that data security would be a good learning topic to be added as part of the co-learning model. Our study confirms that illustrative materials with the concrete examples of sensors and data collection on the robots can raise interest and awareness about the important topic. To make these learnings interesting, the robots itself can introduce these topics and tell about their data privacy in engaging ways, for example by utilizing storytelling and playful approaches. We call this approach as robot-assisted data privacy learning.

#4: Understandable privacy policy. The robot companies should make the data privacy aspects more visible and understandable for the users. They should very clearly indicate what and how data is being collected, used, transferred etc. The materials written in plain language with good examples and visualizations would be recommended in addition to the complicated full documents. Trust as psychological concept has been discussed in HRI widely. Humans tend to trust social robots due to their physical embodiment and presence [17],[30],[38],[46]. However, as people are becoming more and more aware of the privacy issues of the social robots [13],[28], it can be assumed that the trust towards them will decrease in the future if the robot companies, researchers and instructors do not explain the data privacy aspects properly.

Our study reveals novel aspects on co-learning and data privacy on educational robots. As in any qualitative study, the number of the participants is limited, and more studies with larger number, variety of participants, and quantitative measures would be needed to validate the findings. In the future, we would like to conduct a comparative study between co-learning and other ways of learning in order to measure the learning effects of co-learning.

8 CONCLUSION

We have presented a qualitative and exploratory human-centered design study of co-learning around social robots, including two novel approaches. First, *it brings together a unique combination of learners* (international university students and elementary school pupils) to interact, co-learn and make novel insights about robots as a team. Second, this work *emphasizes the data safe way of using social robots in learning.* After the pre-study and privacy inspection of our robots, we innovated tailor-made data privacy solutions for our robots. We also produced engaging learning materials about the data privacy of the social robots. Our research included two phases: 1) co-design activity design (N=16), and 2) co-learning evaluation (N=56). The qualitative research data was collected by several means, e.g., observations, written essays, and focus groups. The university students liked the co-learning concept and found many benefits out of that, e.g., challenging themselves and going out of their comfort zone to learn about the facilitation of different kind of people, learning about different learners, and learning about robots, too. The pupils enjoyed getting their hands-on into different kinds of robotic tasks, and they enjoyed the tasks where they could be active. The students and pupils seemed to go along together well despite of evident language challenges and initial interaction challenges. From the teachers' point of view, it was important to introduce the data privacy aspects of new technology. We suggest that researchers and educators would carefully inspect their educational robots in terms of data privacy and include some material about privacy as part of learning. We also propose the robotic companies to produce understandable information about their robots' data privacy. We will continue our co-learning activity in safe modes with different learner groups and themes in the future. We express gratitude to all pupils and students who participated this research study.

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