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Lessons From Teachers on Performing HRI Studies with Young Children in Schools

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Abstract—We deployed an autonomous social robotic learning companion in three preschool classrooms at an American public school for two months. Before and after this deployment, we asked the teachers and teaching assistants who worked in the classrooms about their views on the use of social robots in preschool education. We found that teachers’ expectations about the experience of having a robot in their classrooms often did not match up with their actual experience. These teachers generally expected the robot to be disruptive, but found that it was not, and furthermore, had numerous positive ideas about the robot’s potential as a new educational tool for their classrooms. Based on these interviews, we provide a summary of lessons we learned about running child-robot interaction studies in preschools. We share some advice for future researchers who may wish to engage teachers and schools in the course of their own human-robot interaction work. Understanding the teachers, the classroom environment, and the constraints involved is especially important for microgenetic and longitudinal studies, which require more of the school’s time—as well as more of the researchers’ time—and is a greater opportunity investment for everyone involved.

Index Terms—Education, user studies, learning, social assistive robotics, robotic learning companions, teachers, field work.

I. INTRODUCTION

Social robots are now being developed and tested in various educational settings. Children are playing with robots in our labs [1], in therapy rooms or other secluded spaces in their schools [2]–[4], as well as in their classrooms [5]–[8]. These robots provide a variety of educational content, such as games for learning language [9], [10] and handwriting [11]. They interact socially, responding to children’s emotional states and their learning progress—usually via a teleoperator, but sometimes autonomously (e.g., [12]). Many different robots are tested, such as the Nao (e.g., [10], [11], [13]), RUBI-4 (e.g., [8]), DragonBot (e.g., [12]), and Robovie (e.g., [6]).

One theme common to nearly all the current explorations of the use of social robots in education is that they focus—perhaps quite rightly—on the children: Are the children learning? What do they think of the robot? How can we make this a more effective learning experience? How can we make the robot safe for them to play with? Relatively few papers describe the views that other stakeholders in children’s education may have—e.g., the opinions and feelings of parents, teachers, and other educational staff. Teachers in particular are a mostly untapped, potentially rich source of information and insight about the use of social robots in children’s education. In the future, teachers may be some of the primary users of educational social robots. As such, we need to know what teachers think about these robots, what they want these robots to do, and what we as

researchers can do better to as we design, develop, and test our current systems in their classrooms.

Serholt and colleagues [14] explored some of these questions through semi-structured interviews with eight teachers from four European countries. The teachers were presented with a hypothetical scenario for a robotic tutor that helped students in a map-reading task, then were asked a set of questions probing their general views on robotic tutors, such as whether they might want a robotic tutor in their class, the pros and cons of using a robot, and what roles it could play, as well as questions about logistics of having a robot in the class, such as the number of students it should work with at once, and ways in which the robot could monitor students. Serholt and colleagues [14] found that teachers had concerns about robots being disruptive in the classroom—they might introduce competition between students, increasing the teacher’s conflict resolution workload. They worried that a robot might replace them, and wondered whether the robot’s social connection would be “real” [15]. On the positive side, they thought robots could be helpful: They could manage group work, perform automatic assessments, promote independent learning, and track the progress of individual children. But, as was noted in [14], these teachers were speculating about an unfamiliar technology. This was a good first step. The next step in understanding teachers’ views of robots in education was to interview teachers who had actually seen social robots in the classroom.

To this end, this paper has two goals. First, in conjunction with a two-month deployment of an autonomous social robot in three classrooms at a public school, we interviewed teachers and teaching assistants who worked in the classrooms to find out what they thought about having a social robot in their classroom and its potential as an educational aid. This sample of teachers is not representative of all teachers, especially not cross-culturally around the world, nor is the situation presented representative of all types of interactions with educational social robots in classrooms. These teachers’ responses are, however, informative, and they expressed concerns, questions, and ideas that may be familiar to many educators, and that may reflect common themes to be found among educators world-wide.

The second goal of this paper is to shed light on actual methods used to engage a school in an HRI research study, in order to help future researchers conduct HRI studies at schools. Many published papers present a polished view of the research process and do not discuss specifics. Thus, we aim to provide guidelines and practical suggestions for smoothly carrying out HRI research in a school. Some of these guidelines may feel intuitive or not specific to HRI. However,

many researchers could benefit from seeing how others dealt with these issues in real studies, especially researchers who have less experience in the field. Thus, we include both the more intuitive suggestions as well as the less obvious.

II. RESEARCH QUESTIONS

Our research questions were twofold. First, we wanted to know how teachers view social robots in their classrooms. Are these robots disruptive? What activities might teachers want these robots to do? How does experience with a social robot present in the classroom change teachers' opinions about the use of these robots in education? Second, because our study was not a design or co-development project, but rather an empirical study testing a particular social robotic learning companion created for a particular learning task, what could we learn from our experience and from the teachers' experiences to make future research in classrooms progress more smoothly?

III. METHODOLOGY

A. Study

We conducted a 2-month microgenetic study in three "special start" preschool classrooms at a public school in the Greater Boston Area (described briefly in [7]). Thirty-four children ages 3–5, with 15 classified as special needs and 19 as typically developing, participated in the study. The children played an interactive game individually with an autonomous socially assistive robot and a virtual agent situated on a tablet. The game was designed to support second language acquisition. The robot and the virtual agent each took on the role of a peer or learning companion and accompanied the child on a make-believe trip to Spain, where they learned new words in Spanish together.

The study took place over 9 sessions. The first session was used for initial assessments. During each of the next seven sessions, each child played the language learning game individually with the robot for about 10 minutes. During the last session, children said goodbye to the robot, and we performed posttests.

The robot interaction was designed as an activity that could take place during "Choice Time" at a preschool, to supplement existing curricula around language learning. Choice Time is a period of time during the school day present in many American preschools, during which children get to select one of several available activities to do. We found that this can be an ideal time for robot interactions targeted at individual children or small groups, as the robot is presented as just another activity in the classroom.

A primary goal of this study was to test the educational merit of the particular one robot/one child activity prior to developing a full curriculum/class activity with the robot and teachers together. Thus, the robot did not interact with the whole class at once nor did teachers directly interact with the robot. Teachers received a demo of the activity, were shown how the robot worked, and observed it during its use in the classroom over two months. This testing scenario is not uncommon in HRI education work for development and testing of educational social robots. While participatory design and educator input are often used for the development of a robot-centric activity, sometimes, the robot is later tested with children at schools that were not part of the initial development (often for logistics reasons).

B. Setup

The study took place in three classrooms during the regular school day. We were provided with a small table and chairs in the corner of each classroom, as well as dividers/barriers to seclude the robot's space from the rest of the class. The barriers served two purposes:

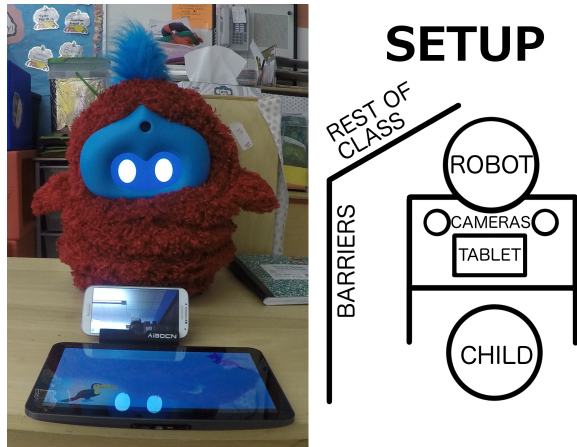


Fig. 1. The Tega robot was set up on a small table with the tablet and our data collection devices. The table was secluded from the rest of the classroom by a set of moveable barriers. The child sat at the table to play with the robot.

to help the child playing with the robot to stay focused on the robot, and to help other curious children wait their turns, and not crowd the child who was currently playing. The robot was placed on the table with the tablet and our data collection equipment (e.g., video camera). Figure 1 shows the robot in one of the classrooms. This kind of setup is not uncommon for activities available during Choice Time in a classroom. The teachers told us that the children were familiar with using dividers to portion off parts of the classroom for different activities or to give a child space. Thus, this setup was determined in conversation with the teachers about what would work best in their classrooms for less disruption. Children came to play with the robot, then returned to the rest of the class.

One important concern we had to address was the fact that since we were in the classroom, we needed to minimize setup time—i.e., the time between us walking in the door to children actually playing with the robot. To this end, we set up as much as possible prior to entering the classroom. For example, we turned on tablets and computers ahead of time. We used untethered devices where possible—e.g., both the robot and the video camera ran off battery power. All the equipment that needed power—such as the router and the robot's off-board control computer—was plugged into a single power strip and placed in a bucket, so that we could simply carry the bucket into the classroom and plug in the one power strip cord.

Another accommodation we made involved headphones. Since one important aspect of the study was language, both the robot and tablet spoke during the interaction. However, classrooms tend to be noisy places, and to minimize disruptions, we could certainly not add to the noise with a loudly conversing robot. One of the teachers suggested the solution: on her request, we added headphones to our setup, so that the child could sit quietly in the corner with the robot and hear the robot speaking in one ear, and the tablet in the other. Although some children may be uncomfortable wearing headphones, the teachers in these classrooms told us that their children were used to using headphones to listen to storybooks, so in this case, it was a good addition—children could better hear the robot and tablet, they were less distracted by the rest of the class, and the rest of the class in turn was not disrupted by the sounds.

C. Teacher Questionnaires

We asked the teachers to fill out a paper questionnaire before we brought the robot to the classroom regarding their current use

TABLE I
TEACHERS' QUESTIONNAIRE RESPONSES

Category	Question	Median	Mode	Range	Inter-quartile Range
Feelings about robots in their classroom	Excited	4	5	3-5	2
	Worried	2.5	3	1-3	2
	Afraid	1	1	1-3	0.5
Expectations about how children will feel	Excited	5	5	4-5	1
	Worried	2.5	2	1-4	1
	Afraid	3	3	2-4	1
Expectations about robots for learning	Help learning	3.5	3	3-5	1.25
	Hinder independent learning	2.5	3	1-3	1
	Support independent learning	3	3	3-5	1
	Beneficial	3	3	3-5	1
	Disruptive	3.5	3	3-5	1.25
Opinions on robot monitoring and data access	Unnecessary	3	3	1-4	0
	Teacher access	5	5	2-5	0
	Children's access	3	3	1-5	1.5
	Children's knowledge of access	3	1	1-5	4

of technology in their classroom, their expectations about having a social robot in their classroom (e.g., would it be beneficial, disruptive, unnecessary, exciting), their expectations about what children would think of the robot, potential risks and problems, potential benefits, and ethical questions regarding robot monitoring of children. Some questions were free response; the others used a 5-point Likert-type scale where "5" referred to very much of that attribute (e.g., "very excited") and "1" referred to very little (e.g., "not excited at all"). The full set of questions is available for download¹. We also asked teachers to fill out a follow-up questionnaire with the same questions after the last session that children had with the robot. Twelve teachers and teaching assistants who worked in the classrooms where the robot was deployed filled out the pretest; only nine filled out the post-test. All the teachers were female.

D. Teacher Interviews

In addition to the paper questionnaire, we interviewed 13 teachers and teaching assistants (all female). Each interview took place in a secluded space in the classroom during or after the last session that children had with the robot, lasted 5–10 minutes, and was video recorded. We asked six main questions during each interview:

- 1) *What was most surprising to you?*
- 2) *What did you learn from the experience that was of value to you?*
- 3) *Do you think the interaction of the children with the robot was useful? How? For which kids?*
- 4) *How might you want to use social robots in the classroom in the future?*
- 5) *How would you suggest to help with transition to the home to reinforce learning in home with social robots?*
- 6) *Do you have any suggestions for us as experimenters, if we run the study again?*

E. Data Analysis

The interview videos were transcribed. Two authors read the full interview transcripts. They noted possible themes and patterns in teacher responses (e.g., surprise that the robot was not distracting). They used these patterns to define main themes for the paper (e.g., 'robot in the classroom') and sub-themes (e.g., 'disruptions'). Quotes

¹The full questionnaire is available from figshare at: <http://dx.doi.org/10.6084/m9.figshare>.

were selected from relevant responses. For example, for the subtheme 'Teachers were surprised by...', quotes were taken from teachers' response to the question 'What surprised you?'. Disagreements were resolved through discussion.

IV. RESULTS

A. Questionnaires

All the teachers reported sometimes using iPads or tablets in their classrooms for activities such as video demonstrations, pretend play, and story time. One teacher noted that teachers were in control of the technology at these times; children had "zero ability to touch technology."

During the pretest, teachers had positive feelings about the use of robots in classrooms, insofar as they said they were very excited, not very worried, and not very afraid about having the robot in their classroom. Table I summarizes the teacher responses. They expected the children to feel similarly, reporting that they thought the children would be excited as well, but perhaps a little more worried and afraid, growing more comfortable over time. One teacher said she thought the robot would "generate excitement and curiosity."

The teachers were generally optimistic about the robot's potential usefulness, insofar as they said that having a social robot in their classroom could help children learn, could support independent learning, and would not hinder independent learning. However, they also thought robots may be unnecessary in classrooms. Several teachers suggested that robots would probably take on the same kinds of roles that iPads, tablets, and computers currently play in classrooms. The robot could be used as a "motivator/reinforcer," and could provide "positive feedback," "more specialized attention," and a "non judgmental safe learning space." Two teachers said the robot, as an engaging new activity, might "get them [the children] to do activities they might not otherwise do."

Teachers also expressed concern over the robot's possible disruptiveness. It might be a distraction, might cause children to "engage in negative behaviors," could be "addictive," "take children's attention away from other tasks," or lead to a "loss of interaction with peers." One teacher thought the robot would be "an initial disruption, but will normalize."

Teachers were generally in agreement that the robot should work with more than one child at once, but were split over what the ideal student-to-robot ratio should be (two said individual, three said pairs,

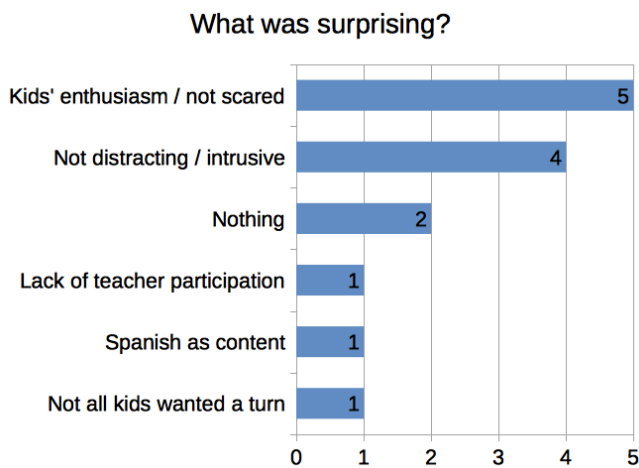


Fig. 2. Teachers were most surprised by children’s enthusiasm for the robot and by how non-disruptive the experience was. One teacher was surprised both at the lack of disruption and at the Spanish content of the game and is thus counted twice.

six said groups, two said the whole class). This was counter to our study setup, in which the robot played with just one child at a time.

Teachers agreed that the robot should monitor and report data about the children it interacted with, such as academic skill development, attention, participation levels, and social skills such as eye contact and verbal responses. One teacher said the robot might let her see her students with “different eyes,” a “neutral check in children’s progress.” Nearly all agreed that teachers should have access to the data the robot collects about children, and that preschool children should generally not have access to the robot’s monitoring. They were split over whether children should be told that their teachers could access the robot’s monitoring. One teacher said that how much access children would have should be dependent on their grade level, implying that older children would be told more.

Teachers’ opinions did not change significantly from the pretest to the posttest, except on two measures. Wilcoxon Signed-Rank tests showed that teachers’ excitement about having a social robot in their classrooms significantly decreased from before to after the study (pre *Median* = 4, *Mode* = 5, *Range* = 2, *IQR* = 2, post *Median* = 3, *Mode* = 3, *Range* = 3, *IQR* = 1), $z = 1.84$, $p < 0.05$. In addition, teachers’ perception that having a social robot in their classroom would be beneficial decreased (pre *Median* = 3, *Mode* = 3, *Range* = 2, *IQR* = 1, post *Median* = 3, *Mode* = 3, *Range* = 3, *IQR* = 1), $z = 1.94$, $p < 0.05$. This result should be interpreted in light of the teacher interviews. Several teachers said that they expected a social robot could be beneficial, if it was doing a different activity, helping children learn a different set of skills, or if it was used at a different time of the school day. Their responses to the questionnaire likely reflected their thoughts about this particular robot, rather than an “ideal” social robot that could teach whatever the teacher thought was most appropriate.

B. Interviews: Main Themes

We divide our discussion of teachers’ interview responses into three main categories: (a) the robot in the classroom, (b) children’s interactions with the robot, and (c) the educational content of the interaction.

C. Interviews: Robot in the Classroom

Teachers were pleasantly surprised with how non-disruptive the experience was. Four teachers expressed surprise in their interviews that the robot was not disruptive to the classroom environment or distracting for the children, saying it “was not the least bit distracting,” and “overall like this setup wasn’t intrusive to this classroom” (see Figure 2). One teacher said she “thought the kids would be more excited and sort of competitive around getting close to the robot,” but, “No, they went very calmly.” Another teacher praised us, saying, “I think where you guys did a really good job of not being a big presence in the classroom, you were very quiet when you entered, and you kept a quiet space, and you tried very hard not to interrupt, and I thought that was spectacular.” This comment reflects the effort we took to enter the classroom fully prepared—e.g., setting up equipment before entering the room or behind the divider/barrier, minimizing setup time, using headphones to keep the interaction quiet. Several teachers agreed that the barriers/dividers in the classroom were necessary to reduce the distraction that the robot might cause. That said, in the written questionnaire, one teacher noted that the robot’s presence in the classroom meant they “lost a lot of usable space,” and that in the future, the robot should be used in a separate room.

Teachers wanted all the children to be involved. After the first several days of the study, we brought the robot into the middle of the classroom to show it to the whole class. Teachers thought we should have done this earlier: “When you brought this in and showed all the kids how it worked, I think if you could do that before, would be great.” Several teachers suggested that this would help the children whose parents did not consent them for the study see what was going on sooner, mitigate some of their excitement and curiosity, and ultimately make it easier for us to run the study with the consented children. One teacher said, the robot “might be better received if the whole class could do it.”

Teachers wanted more involvement themselves. One teacher noted that she did not get to see much of the interaction, and said, perhaps implying that she had expected more disruption, “I expected to see more of it. I didn’t know you were going to be behind this [the barrier].” Several teachers expressed frustration or surprise at the relative paucity of interactions that they had with us, the researchers, before the start of the study. Several noted that they knew fairly little about the study before we started it—they speculated that this may be both the fault of their administration’s knowledge dissemination as well as our fault, recommending that we do a better job introducing the robot and the study to the whole staff beforehand. One teacher said, “maybe you would introduce it to all the staff first, so that we had a better idea of what it was and what it could do.”

These teachers were fairly accepting of technology, which was supported by their responses to these questions as well as the questionnaire. The teachers had prior experience using technology in their classrooms, were excited about having a robot present, and thought the robot could help children learn. Prior research has found that teachers will use technology that they think will be easy to use [16] and that they think will help children learn [17].

D. Interviews: Children’s Interactions with the Robot

Teachers were surprised by children’s positive engagement. In describing how children interacted with the robot, three teachers cited concern for the children’s wellbeing: “I didn’t think the kids would like the robot, I thought it might scare some of them, especially the ones that are just slightly on edge anyway, but they were, um, but that was fine, they were happy with it. Not a problem.” This similar

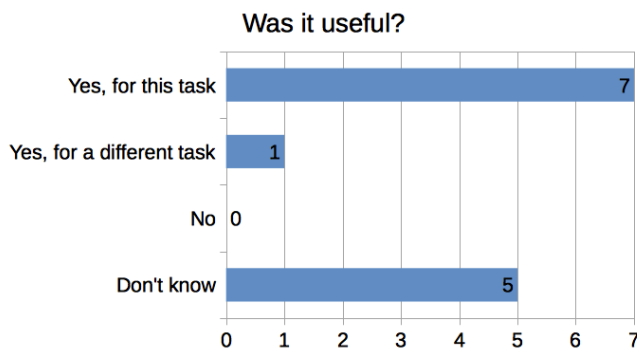


Fig. 3. Nearly two-thirds of the teachers thought the robot was useful in helping children learn, but several said they did not know or that the interaction was too short to tell.

to another teacher’s comment, “They [the children] were really very excited about coming here, they looked forward to it, it wasn’t a scary thing at all, and I thought maybe it would be a little scary or frightening but it wasn’t.” A third teacher had similar concerns at first, “I was thinking there’d be more kids that’d be a little more wary of it, you know, not sure,” but, she pointed out, “they seemed to really be very excited to come and play.”

Teachers loved seeing children’s enthusiasm. In general, however, the teachers thought the children enjoyed the robot, saying phrases like, “the children were quite natural with it,” “they were very enthusiastic,” and “the kids really enjoyed it was different.” One teacher observed that, “as with many stuffed animals, the children seemed to have an attachment to the robot.” In prior work, researchers have found that children are indeed attached to the robots—e.g., they call robots their friends and they are willing to share secrets to robots [2], [18]. Another teacher observed, “they loved the little postcards [that we gave them at the end of the study] and they felt special, and I think that they’re so attracted to the robot and sort of curious so that’s why what held them, if it weren’t something they were scared of.”

Several teachers expressed delight and fascination with how the children interacted with the robot. One teacher said the most surprising thing, for her, was “just watching them listen so intently and then use the iPad, like I had no experience with a robot before. I liked to watch them interact with it.” Another teacher described watching one child in particular, who “she looked up, and she was like, adjusting the robot to look at her,” which was “pretty cool.” One teacher liked that “it showed me that they were willing to try something new and something different.”

Encouraging a sense of inclusion is important. There were a few children who did not want to play with the robot—one in particular seemed very intimidated by it. One teacher said she was surprised “that not every child wanted to have a turn” playing with the robot. This serves to point out that not all children will be enamored of robots. Some may be uncomfortable. A classroom that uses robots should make sure alternative activities are available for any children who do not want to play with the robot. One teacher explained that, when something special happens in the classroom—like bringing in a robot—“the kids are either super into it or they really don’t like their routine to be messed up.” Another expressed similar thoughts, saying, “[T]he thing I realized is how much kids are set in their routines ... the routines were very, very important.”

Another teacher said that “the hardest thing for us is that it’s so

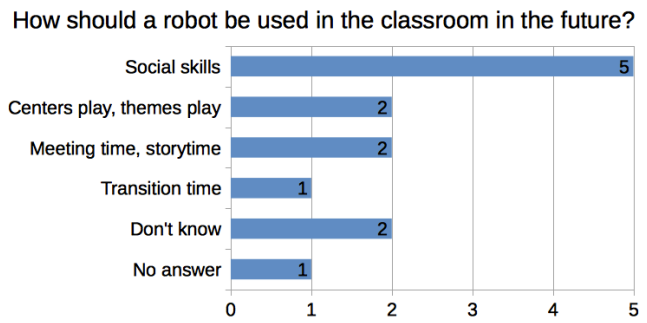


Fig. 4. Several teachers thought the robot would be more useful if it helped children learn social skills, such as sharing and turn-taking. Others thought it could play a bigger role in classroom activities, such as center and theme play, or in leading storytime.

separate ... it almost needs to be part of the meeting time, it needs to run the meeting, so it’s more of a something that everyone can listen to or everyone can see.” The children whose parents did not consent them for the study had a harder time (fewer than half the children in the classroom), “They would look and it’d be like, ‘I want a turn,’” but the choice would be denied. We did allow these children one turn each with the robot without collecting any data (with parents’ and teachers’ permission), but they did not get as many turns as the children who were in the study.

E. Interviews: Educational Content

It is important to consider how the study activity supports the in-class curriculum. Teachers generally thought that the robot “could be [useful] ... depending, you know, on the subject.” Seven teachers said the robot was useful, five did not know (one said it was too short a time to tell), and one said the robot would be useful for a social-emotional task instead (see Figure 3). A few children were English-language learners (ELL), so several teachers explained how the fact that the robot was teaching Spanish was somewhat intimidating for them: “it’s new, and they’re already learning English, they were more timid at the beginning ... it was more complex for their brains. I noticed that for all our ELL learners ... it took them a longer time to want to come back again, they were hesitant.” One teacher said she was most surprised that the robot was helping the children learn Spanish. She explained, “[M]y thought on that is just that is that Spanish adds another level of complexity with the language, because also we have a number of children who have language delays, and also who have another language other than Spanish.” Another reason why teachers were less excited about Spanish language learning as an activity was because their classrooms’ curricula was currently focused on teaching social skills, such as turn-taking and sharing, and on English language development. As one teachers said, the robot “did not improve the environment from the standpoint of supporting our curriculum.” Teachers were more excited about possible applications of social robots that tied into their current curricula. One teacher said she could understand doing research on how children socialize with the robot instead, adding that if she used a social robot in her classroom in the future, she “would do it more in a form of teaching social skills.”

Teachers had many ideas for new educational activities with a robot that would help their classrooms. This suggestion that the robot should be used to teach social skills was common—five teachers suggested the same thing when asked what they would want

a social robot to do in the future (see Figure 4). They listed skills such as “taking turns,” “waiting your turn,” “not getting your first choice,” and even “could maybe be a good way to help kids learn how to share.” One teacher said this might be especially helpful “in an integrated classroom with children who are on the spectrum or who have nonverbal learning disabilities,” or, as other teachers put it, “for kids that are still learning how to interact with one another,” and “with children who have difficulties reading social cues and learning how to express themselves appropriately with emotions.” One teacher said that if the robot could help with these kinds of skills, she expected that “it’d be really spectacular for kids.” These teachers’ enthusiasm for robots teaching social skills is already reflected in current efforts of the HRI community to develop robots for, e.g., helping children with autism spectrum disorder (e.g., [19]).

Teachers had a variety of suggestions for other activities the robot could do, including: “kids could actually just sit and listen to it, during storytime,” or it could “tell children what to do when it’s transition time.” One teacher explained that in the class, they do a lot of theme play, such as “post office” or “community” themes. The robot could be incorporated into these activities. As another teacher said, “if you had scenarios for the robot, especially for the young children who for playing is a new thing with other children, if you had a similar play environment on your computer for them to simulate moving out to there, that could facilitate one-on-one that. And then they would translate it to that, something similar in a similar play roles. Because we do a lot of role-playing, I’m the buyer you’re the seller, those kinds of things, so I think if you had interactions that were similar to our curriculum it would be really helpful. Cause then it’s one-on-one with the robot and then you develop two-on-one with the robot and you build that play scenario, I think that would be very helpful.”

Teachers value educational experiences that transition from home to school. In terms of transitioning the robot from being in schools to helping in homes, the teachers emphasized the importance of tying the classroom curriculum and activities to what was happening at home. Consistency across children’s environments was important. Achieving this consistency could take several forms. For example, one teacher suggested that, “if there was like a certain game that they played here with the robot, then they could easily play it with their sibling at home.” Two teachers described how they currently have a classroom teddy bear that is sent home with a different child each weekend. The children have a little journal in which they write about the bear’s journeys, which they later share with the class. So, similarly, “they could bring the robot home and write a little story about their adventure with the robot.” Another teacher emphasized the importance of consistency in word use, saying, “you’d need to have the same words in both places, so either it’d have to be phrases that we use as teachers or that the parents use that come back into the classroom, so they know what the parents are using.” Finally, one teacher pointed out that putting a robot in the home “would take a lot of education with the parents.” However, “that would be good because it might force some parents to interact . . . versus sometimes with a screen or a TV it’s it becomes a babysitter.”

V. LESSONS LEARNED & KEY TAKE-AWAYS FOR HRI RESEARCHERS

The key lessons we learned about conducting child-robot interaction research in children’s preschool classrooms, as reflected in the teachers’ feedback, can be summarized as follows (Figure 5):

1. Consider how the study activity can complement curricular goals. Our instinct was to run the study at a school with enthusiastic teachers and school administrators—even though the children’s age

and curricula did not match as well. As is the case for many researchers, we were on a tight timeline and did not have the luxury of waiting to find another school. But this was not ideal. Some of the problems we encountered were due to the fact that the classrooms we worked with were not ideal matches for our research study. For example, some teachers thought the robot’s educational goal—to help teach Spanish as a second language—was not ideal for the children in their classrooms. This was understandable, since the robot interaction had been designed for slightly older native English speaking children (5–6 years), but the children in the classrooms were on average 3–4 years old, and some were either special needs or English language learners. We did not screen the classrooms we recruited as carefully as we should have. We recommend discussing the objectives and design of the study with multiple teachers during the recruiting process, to ensure that the curriculum of the classroom is synergistic with your research goals.

2. Teacher experience with the robot matters. Many of the teachers expressed surprise that their initial expectations about children’s reactions to the robot, the game’s educational content, and the potential disruption to their class were not met. The experience they had seeing the robot in their classroom changed how they thought about its potential use as an educational tool. When approaching a new school or class about collaborating on research, share as much information as possible about the experiences other educators have had while working with the robot or the lab. Share videos showing how children might interact with the robot. When running a study, check in regularly with teachers and staff to get their feedback on how they think the study is going, how the children are reacting, and whether there are logistical changes that may make the study run more smoothly—e.g., changing the time of day of the interaction.

3. Be prepared early. It may take a long time to find a classroom that is a good match for a research study. For us, the process took six months from the time we first contacted schools to the time we actually walked in the door with the robot. We recommend recruiting widely—we contacted multiple schools. Not all were interested. For the classrooms that expressed interest, we shared more information about our proposed work. As discussed in the prior point, we recommend carefully screening for classrooms whose goals are synergistic with your own. Finally, even after finding a good match, there is always bureaucratic paperwork. Some schools require researchers to submit a research proposal to the school’s ethics board for approval; some may require background checks or fingerprinting before researchers are permitted to work with children. Allow at least 1–2 months for paperwork, scheduling, and teacher briefings.

4. Identify and involve stakeholders from the beginning. We spoke primarily to a few key people at the school about the study prior to its start. We expected that these people would share the relevant information with teachers and staff. However, as described earlier, multiple teachers were frustrated or surprised at the amount of information they were given and the amount of interaction they had with us or with the robot prior to the start of the study. This may have been both the fault of their administration’s knowledge dissemination, as well as our fault; several teachers recommended that we do a better job introducing the robot and the study to the whole staff beforehand. If information about the study is only provided to a few people, we cannot assume that information will be “trickled down,” or that, if shared, teachers will necessarily have time to read it.

Thus, before locking in a classroom for a study, meet and brief all the teachers involved to make sure it is a good fit. Explain the study ahead of time to all teachers and staff, and, if possible, show them the setup and let them go through the interaction themselves so they

Key take-aways for HRI research in the classroom

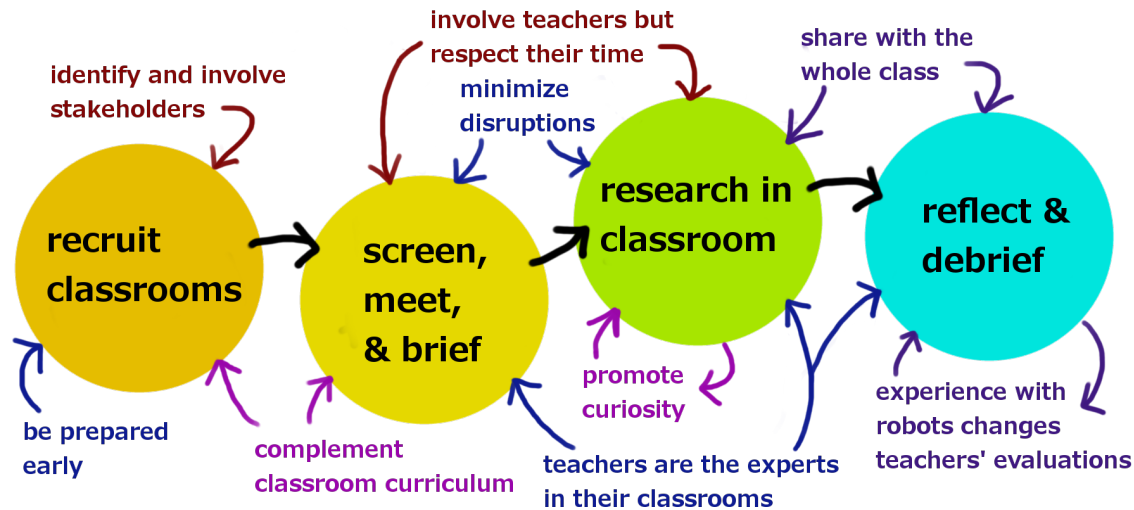


Fig. 5. Lessons we learned during research in preschool classrooms, and where this advice applies to the research cycle.

know what the children will be doing. Make sure teachers have the opportunity to observe children interacting with the robot during the study as well, if they are curious.

5. Make time to pre-pilot with stakeholders. Following the advice of value-sensitive design work [20], involve stakeholders in the study and interaction design process. Perform pre-pilot tests with stakeholders. Plan time for iteration on the study and activity design with them. Even when the primary goal of one's research is not about co-design or participatory design, one's studies and robot interactions still need pilot tests. This is a great opportunity to engage teachers and children in order to make the activities better.

If sufficient pilot tests have been performed and an empirical study of a particular robot and interaction is currently being developed, interviewing teachers after the study to learn how they think social robots could benefit education can bring great suggestions about ripe areas for future development. We received great suggestions from several teachers about how the robot might be helpful for teaching social skills or English language development.

6. Involve teachers while respecting constraints on their time and attention. In an earlier point, we noted that many teachers may not have time for reading detailed materials about a potential study. However, meeting with and briefing teachers about the research is very important—just make sure these meetings are short and to the point. Our research also involved teacher questionnaires and teacher interviews. Some research may additionally ask teachers to fill out questionnaires about each child in their class. During the classroom recruitment and screening process, make sure teachers know up front the time commitment that being involved in your research will entail.

7. Teachers are the experts in their classrooms. Teachers spend much more time with the children in their classrooms than researchers do. They know the children's wants and needs. Make sure to consult the teachers on what kind of experimental setup will work best in their classroom—including the location in the classroom, scheduling children's time with the robot, and how best to minimize disruption of the school day. If a teacher requests a particular feature for the robot—such as how we were asked to add headphones—it is in everyone's best interest to comply.

8. Minimize disruptions. Being in a classroom, rather than being in a lab or in a separate room at a school, requires special attention toward minimizing disruptions of the normal school day. Accommodations may need to be made in order to work in the classroom—for example, the addition of headphones. If the robot will be interacting with a subset of the class at once—e.g., with one child, pairs of children, or small groups—then consider setting up dividers/barriers to seclude the robot from the rest of the class. Minimize setup time in the classroom: turn devices on and plug equipment in ahead of time (use a bucket!). If there is a divider, do any in-classroom setting up behind the divider, so as not to distract children unnecessarily. If the setup is elaborate, try arranging to set up before children arrive in the classroom in the morning, or when they are out of the classroom (e.g., when they are at the playground). This is especially important to consider for the first day of a study—setting up always takes longer the first time when learning the layout and best arrangement of equipment for the space.

A further consideration is the timing of the study, both within the school day and within the school year. One teacher said she thought our study would have worked much better in the winter rather than at the end of the school year near summer, because in winter, the children are more accustomed to staying inside doing activities, and there would have been no interruptions from everyone going outside to the playground. For scheduling within the school day, ask the teachers what would work best. Make sure to work around the class's schedule, and around individual children's needs. If a child loves a particular activity—e.g., storytime—then make sure that that child is not scheduled to play with the robot during this favorite activity.

9. One-on-one and small group robot interactions can add value to the classroom. Many educational robot interactions are currently designed for just one child at a time or a small group of children—not the whole class at once. This can still be very beneficial in a classroom environment. As described earlier, some American preschools have Choice Time, during which children get to pick one of several available activities to do. Choice Time and other free play times can be ideal for these kinds of robot interactions. While the structure of the school day may look very different in elementary

school, opportunities for one-on-one or small group interactions with the robot may still be available.

10. Share with the whole class. Not all parents will consent for their children to participate in research studies. However, most children—regardless of their consent status—will be curious about a new robot in their classroom. If possible, arrange to introduce the robot to the entire class (unless one’s research questions require otherwise and doing so would disrupt the purpose of the study). Showing all the children “who’s visiting the class” may alleviate some of their excitement and interest. If time and their parents allow, let any children who are not consented but who want to play with the robot have a turn, without recording any data. At the end of the study, arrange a brief “goodbye” session with the robot for the whole class. This can provide closure for children who played with the robot many times, and help end children’s time with the robot gracefully.

11. Promote curiosity. If children have questions about the setup or about the robot, explain everything to them (unless it is counter to the study’s purpose). If possible, be transparent about what the equipment is used for and why. For example, if a child asks why there are headphones, we could explain that they are so we do not disturb the child’s friends while we are playing with the robot. Encourage curiosity throughout the interaction [1].

VI. CONCLUSION

Teachers are a rich source of information and insight about the use of technology in classrooms and in children’s lives more generally. Through a set of interviews and questionnaires with teachers and staff following a two-month deployment of an autonomous social robot in a preschool classroom, we gained new insights into what teachers think about social robots, what they want social robots to do, and what we as researchers can do better as we develop and test our current systems in their classrooms. While these teachers and this robot interaction were not representative of all teachers or educational robot interactions in classrooms, the teachers expressed many concerns, questions, and ideas that may reflect common themes to be found among educators world-wide when confronted with robot-centric activities. We described lessons learned while running longitudinal child-robot interaction studies in preschools, with an eye toward helping future researchers who may wish to engage teachers and schools in the course of their own human-robot interaction work. Understanding the teachers, the classroom environment, and the constraints involved is especially important for microgenetic and longitudinal studies, which require more of the school’s time—as well as more of the researchers’ time—and is a greater opportunity investment for everyone involved. As one teacher said about using robots in education, “seems it’s the way of the future.”

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