Long-Term Integration of a Robot in an Inclusive Daycare: An Ethnographic Study Focused on Children and Caregivers

Jan Ole Rixen
Karlsruhe Institute of Technology
Karlsruhe, Germany
jan.rixen@kit.edu

Kathrin Gerling
Karlsruhe Institute of Technology
Karlsruhe, Germany
kathrin.gerling@kit.edu

Barbara Bruno
Karlsruhe Institute of Technology
Karlsruhe, Germany
barbara.bruno@kit.edu

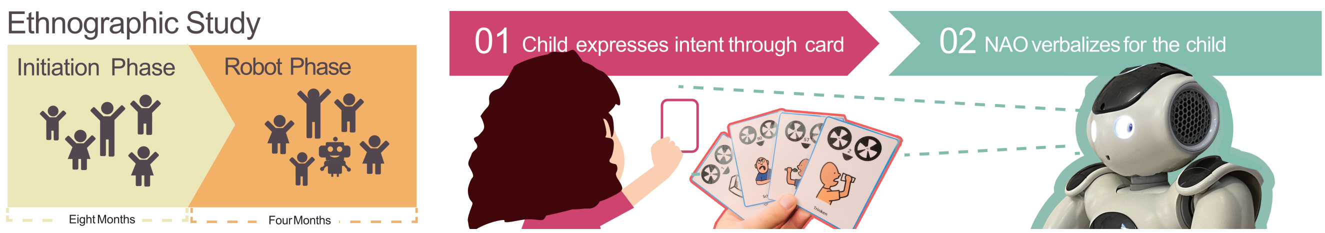

Figure 1: Overview of the ethnographic study (left) and application based on non-verbal communication cards (right).

Abstract

Embedding social robots in educational and/or childcare settings has potential to engage children while supporting caregivers. However, little is known about the practical, long-term integration of robots in such settings. Our work addresses this gap through an ethnographic study that adopts a year-long perspective toward a socially assistive robot in an inclusive daycare with a four-month robot deployment phase. Through Thematic Analysis, we highlight children's ability to develop a variety of self-determined interactions with the robot, while unveiling caregivers' need for its integration into structured routines such as meal times, as well as challenges for robustness of the robot in our research setting. On this basis, we make recommendations for the design of social robots for daycare environments.

CCS Concepts

• **Computer systems organization → Robotics**; • **Human-centered computing → Field studies**; **Ethnographic studies**.

Keywords

Children, Daycare, Human-Robot Interaction, Inclusion

ACM Reference Format:
Jan Ole Rixen, Kathrin Gerling, and Barbara Bruno. 2026. Long-Term Integration of a Robot in an Inclusive Daycare: An Ethnographic Study Focused on Children and Caregivers. In *Proceedings of the 21st ACM/IEEE International Conference on Human-Robot Interaction (HRI '26), March 16–19, 2026, Edinburgh, Scotland, UK*. ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3757279.3785578

HRI '26, Edinburgh, Scotland, UK

ACM ISBN 979-8-4007-2128-1/2026/03
https://doi.org/10.1145/3757279.3785578

1 Introduction

There is large potential in the integration of Socially Assistive Robots (SARs) in educational and/or childcare settings, for example, to engage and support children in communication [23], and to help caregiving staff deliver educational activities [13]. Harnessing their ability to interact with users [48], SARs can also offer support for disabled children, for example, Autistic children [11, 53, 59] or children who have cerebral palsy [9, 26]. Here, Human-Robot Interaction (HRI) has contributed a wide range of systems addressing child-centred research. However, many of such systems are exclusively evaluated in lab settings and, only few long-term studies of Child-Robot Interaction (CRI) are available [54, 71]: Jung and Hinds [36] argue that "a robot can affect its social environment beyond the person who is interacting with it" [36][p.3]. Together with others calling for more on-site and long-time involvement in CRI [54, 71], they plead for more long-term field studies that explore a robot's influence on others, group dynamics, processes and the resulting consequences.

In the context of CRI in daycares, previous long-time on-site studies were often focusing on interactions between robot and child during specific times and activities [4, 29, 38, 46, 49] as well as in unguided interactions [38, 60]. While prior work mentions additional actors like caregivers in side-notes or involves their perspective as part of specific activities [4], there is still little knowledge of how a SAR impacts a daycare's complex (social) fabric between children, caregivers, and existing organizational structures in everyday life. Thus, we raise the following research questions (RQs):

- **RQ1:** How do children interact with the SAR, and which interactions emerge over time?
- **RQ2:** How do caregivers approach the SAR, and how do they mediate children's interactions?
- **RQ3:** Which contextual factors in the daycare setting help or hinder long-term integration of the SAR?

We address these questions through a year-long ethnographical study that included a four-month deployment of a SAR - a NAO 6 robot using a software setup that enabled it to act as a social mediator addressing disabled and non-disabled children (see Sec3.3) - within an inclusive daycare facility in southern Germany. During this time the first author acted as a participant observer [45], immersing themselves in the daycare context and growing into the role of a part-time caregiver, building trust and becoming a usual part of the context for all actors, minimizing disruptive factors introduced through the observation of the robots impact. Through Thematic Analysis [10] of our observations, we share insights on (1) how children's interactions with the robot developed over time and (2) how children's interactions and behaviours affected and were influenced by caregivers and their approach to the robot. Considering the greater context, we also report on the (3) contextual factors in daycare settings in Germany that help or hinder long-term integration of robotic technologies. Our results show that children developed a variety of self-determined interactions, but that the robot also led to disruptions in routines and interactions with their peers. While caregivers first had difficulties fitting the robot into routines that needed children to focus on certain activities, they developed ways to include the robot over time. Our paper makes the following two key contributions: (1) we provide a long-term study of integrating NAO in an inclusive daycare, adding to the growing body of research studying HRI in the field, and (2) we provide practical implications for the design of robots and applications intended for integration in daycare settings.

2 Related Work

2.1 CRI in Childcare and Education

Childcare offers a multitude of situations and areas in which SAR can be beneficial. They can support children's health [17] and education in differing roles spanning three main areas: companionship, therapy, and teaching. Researchers have suggested many companion activities, e.g., accompanying waiting times in paediatric practice [63], distraction during medical sessions [44, 61], or to alleviate anxiety, loneliness and stress in long-term and short-term hospitalization [2, 5, 18, 44]. SARs can also act as an assistant or general tool in therapy situations. This might be assisting in speech therapy [21, 35, 41] or by providing serious games in neurorehabilitation therapies [12]. In the context of disability, SARs might be especially appropriate for autistic children as interactions can be implemented in a predictable and consistent way that is suspected to be favoured by some autistic people [39]. The SAR can for example act as a social mediator between child and therapist [11], or as playmate during one-to-one therapy sessions [53] or movement therapy [59]. In many cases, robots have been shown to successfully act as a teacher and one-to-one tutors. This education can for example support children with chronic diseases and disabilities, e.g., educating children with diabetes about their condition [31] or by teaching children therapeutic exercises [9, 26, 50]. More broadly, SARs seem capable of facilitating knowledge acquisition in a wide variety of disciplines and skills. While language learning [19, 48, 55, 64] is one of the most prevalent tutoring activities, SARs have also been shown to being able to teach music instruments [58], physical exercises [27] or maths [6, 32]. In group settings, SARs often act as a teacher [22, 68] or teacher's assistant [3, 72], e.g. in teaching language [3, 34, 72] or maths.

2.2 SARs in Daycare Settings

Similar to educational applications in the context of schools, SARs were also employed to teach younger children in educational kindergarten/daycare activities or pre-school lessons. One popular activity in robot-induced early education is storytelling [47], with in-situ studies showing children enjoyment [24] and ability to retaining robot told stories [15]. Long-time studies also revealed that stories matching a child's developmental level [69] boosted their engagement and word retaining ability [49, 69]. More general pre-school lessons held by a SAR showed that children displayed desirable behaviour like critical thinking, imagination and creativity [13].

Additionally to research targeting pre-defined interactions, researchers also presented children with robots without a specific teaching goal, letting them explore SARs on their own terms. In a long-time study Tanaka et al. [60] let toddlers decide how to approach a robot, finding that children progressively treated the robot more as a peer than a toy. In free-play sessions Raja Vora et al. [51] deployed a teleoperated SAR and found that children displayed increased physical activity. Kozima et al. [37] deployed Keepon, a little teleoperated robot able to show attention and emotes through movement, in a playroom of a pre-school (20 times) and in a daycare center for children with developmental disorders (80 times). In 90 minutes free play sessions, children were free to decide if they wanted to interact with Keepon, or play with other toys. The researchers observed different interactions between children and Keepon including violent behaviour, protective and caring behaviour, trying to teach Keepon, or seeking its validation.

While the above works research the interaction between robot and child, the perspectives of caregivers/pre-school teachers as the other important actor are less often researched. State-of-art caregiver-focused research also addressed children by questioning caregivers how they might benefit [70] or how they helped children play a certain game with a robot in the field [4]. Conversely, Crompton et al. [16] looked at how teachers in pre-schools could integrate a robot into their class. Deployment in two teaching sessions unveiled that that teachers lacked experience and knowledge in the integration and operation of the robot. In addition, some prior work mentions caregivers in passing, e.g., describing that they put away the robot from time to time [37] or, contrary to the researchers' instructions, told children to be careful with a deployed robot [60]. We build on these insights into children's and caregivers' perspectives, and expand it with a bigger picture in which we explore how children and caregivers interact with a robot in their everyday environment, and how interactions change over time.

3 Method

Ethnographic inquiries allow us to "study people in their natural settings" [56, p.541]. In such inquiry, a researcher is participating in the subjects' daily lives for an extended period of time while "watching what happens, listening to what is said and/or asking questions through informal and formal interviews" [30, p.3]. During this time the researchers commonly collect data in the form of fieldnotes that can be supported by further audio- or visual-recordings and further documents [30]. While this umbrella of ethnographic research encapsulates a multitude of different roles a researcher can take within the context, the sensitive nature of the inclusive daycare necessitated an approach that allowed to build trust from a multitude of involved stakeholders.

In consultation with the daycare, the first author took the role of a *participant as observer*[56] or what Musante and DeWalt [45] call, in the context of anthropology, *participant observation.* To gain insights into the researched context "the ethnographer engages in almost everything that other people are doing as a means of trying to learn the cultural rules for behavior." [45, p.24]. With inclusive daycares being a sensitive setting, we choose *participant observation*approach as it "involves an emphasis on participation and social interaction over observing in order to produce a relationship of rapport and trust" [56, p.545]. Within this role the ethnographer makes observations recorded in field notes, which "consist of fairly concrete descriptions of social processes", and "set out to capture their various properties and features" [56, p. 557]. These qualitative observations allow insight-driven research and have been a valuable tool of HRI research in the past [66].

3.1 Research Site

Our research site is an inclusive daycare in a medium-sized city. It caters to about 45 disabled and non-disabled children, and comprises about 9 caregivers; the facility has indoor spaces for groups of children as well as an outside play area.

3.1.1 Children, staff, and their environment. The children in the daycare are divided into three groups (e.g., *red group*) each cared for by specific caregivers. Each group consists of 12 to 15 children and two to three professional caregivers. Due to the inclusive nature of the facility each group includes one to three disabled children, with many of them having complex communication needs (CCN) [7], not yet being able to or not preferring to verbally express themselves. Children's ages range from one to six years when they typically transition to school; According to the summary of developmental stages by Rudenko et al. [54], we categorize these children into *toddlers* (1-3 years old) and *pre-schoolers* (3-6 years old). While all groups are hosted within the same building, each group has access to a set of three individual rooms not shared with other groups: One bigger main room in which the children eat and spend the most time playing, a sleeping room in which younger children can nap, and a dedicated room for construction play. The daycare also includes shared locations like a gymnasium, therapy rooms, a kitchen, and a sensory room. The daycare building is connected to a fenced garden area in which the children have access to a multitude of outdoor play opportunities like a sandpit, scooters, a slide, multiple swings and other amenities.

3.1.2 Daily routine. Typically, days at the daycare followed a strict agenda, influenced by the weather and access to the outdoor area: The day starts with a free play and drop-off phase in which parents bring their children to the daycare. At 9:00, the free play phase concludes and the day officially starts with children and caregivers sitting together in a *Morning Circle.* Here, children are shown the agenda of the day using cards with pictograms. Then, children are invited to share individual experiences, and two children are randomly selected to be the *kids of the day* who have special rights and desirable duties (e.g., fetching the food from the kitchen). This is followed by breakfast, with each activity including food consumption preceded by a mandatory hygiene routine. Depending on the weather, children then either engage in free play inside or - on most days - outdoors. At 12:00, children eat lunch, followed by a quiet period during which the younger children take a nap while the older children are read a story. Afterwards, children are engaged in structured activity (e.g., playing board games). This is followed by a final phase of free play intermitted by an afternoon snack. While some children are already picked up at earlier points, this phase also marks the main collection phase.

3.2 Ethnographic Phases

Following this approach, the first author took a caregiver role over the course of a year, immersing himself in the daily life within the daycare for one day a week and in turn, becoming an *active participant* and part of the context. To achieve this, we structured the stay in an *Initiation Phase* and a subsequent *Robot Phase* in which the SAR was introduced into the context.

3.2.1 Initiation Phase (IP). Successful ethnographical research is enabled by trust and building rapport with the observed persons [45]. To allow such relations to form between the different actors, the researcher had to spend time with children and caregivers. This is especially relevant for children with disabilities, as both related work (e.g. [65]) and caregivers on-site noted that they can be especially sensitive to changes. The researcher regularly meet with management, participated in parents' evenings and daycare internal events to inform parents about the study. Throughout this period, the researcher grew into his role as a part-time caregiver, transitioning from an actor requiring caregivers' time to a role of support. This initial phase spanned eight months (July 2024 to February 2025), during which the researcher spent twenty Mondays at the daycare. Four Mondays were holidays, and six days were missed due to illness.

3.2.2 Robot Phase (RP). Once the researcher had settled in, felt comfortable in the role as caregiver, and had built trust with all stakeholders, the *RP* began by introducing the robot into the daycare context. On every following Monday (unless ill, see below), the researcher set up the robot in the morning and handed over control to children and caregivers. He only intervened when the robot malfunctioned, or when explicitly asked by staff. We provide a detailed report of the events during this phase as part of the results (see Section 4). The robot phase spanned four months (February 2025 to July 2025), during which the researcher spent fourteen Mondays at the daycare. Two Mondays were holidays, and five days were missed due to illness.

3.3 A Socially Assistive Robot Using Non-verbal Communication Cards

In our work, we focused on a simple socially assistive robot that leverages communication cards commonly used for structured communication in daycare settings. We built on an existing approach for the development of a *socially mediating robot* [52] that was adjusted for integration at our research site.

The system aims at serving as social mediator, verbalizing for children with CCN that are unable to speak and thereby giving them the opportunity to express their needs and wishes in a auditory manner. Additionally, the system also acts as an easy-to-understand interaction partner for verbal children to experiment with. Leaning on Zimmerman [73]'s Empowerment theory, the system aims at empowering non-verbal children by raising their autonomy in-situ. Intentions are expressed through so called "non-verbal communication cards" (NVCCs), physical cards made from paper or cardboard containing a specific symbol that is used as a representative for a certain intention. The daycare facility already utilized such cards in the context of teaching communication through PECS [8] and as visual indicators of items on the daily agenda presented to the children in the *Morning Circle* (see Section 3.1). Once a card is shown to the robot, it identifies it and verbalizes its embedded intent. We implement this utilizing a NAO 6 (NAOqi Version: 2.8.7.4) and the NAOqi python API, and leveraged Naomarks[1] to ensure a robust identification of the NVCCs by the robot. The detection of a card triggers playing a corresponding pre-recorded mp3-file containing intent verbalization. To allow caregivers easy access to the robot we implemented a rudimentary web-interface able to start and stop the detection script, control general values like volume, and provide an easy to use Text-To-Speech (TTS) feature aimed at giving more flexibility in how to utilize the robot.

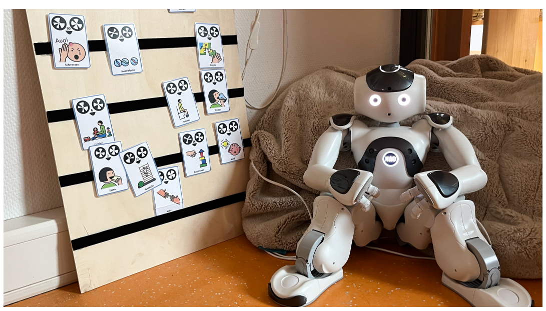

Figure 2: NAO waiting to be approached by children.

3.4 Data Gathering and Analysis

Our research was approved by the institutional ethics board, and reviewed by daycare management. We obtained informed consent from parents and staff, and followed an oral assent procedure with children. Throughout the study, we actively discussed consent with all actors and were available for questions and wished adaptations of any consent preferences. As the researcher did not want to inhibit his ethnographical role as caregiver and to not disturb the happenings within the daycare, in-situ note-taking was deemed as too obstructive. The researcher therefore took field notes about morning observations during break times, while afternoon observations were recorded after leaving the facility and returning to the office. Notes were analysed using Thematic Analysis introduced by Brown and Clarke's [10]. Like other insight-driven research in HRI [66], and given the exploratory nature of the study, an inductive coding process was chosen. The main researcher first initially coded field notes while allowing the possibility of having multiple codes on the same note. Afterwards codes were clustered into initial themes. The themes where then discussed with a co-author and subsequently revised and refined. These additional steps were executed to allow additional perspectives on the underlying notes and situations and ensure the quality of the progress.

3.5 Positionality

Considering the subjective and reflexive nature of our qualitative research approach, we reflect on our own positionality to allow readers to contextualize our work in an effort to ensure rigor [28]. The first author and participant observer has a background in human-computer interaction (HCI) and HRI. Others describe him as outgoing, friendly, and easy to talk to. While his prior experiences with daycare facilities was limited to a one week internship at a kindergarten, he is intuitively able to work with children. This was repeatedly highlighted by caregivers and management. While not the only male caregiver in the daycare context, he was one of only three self-identified and perceived-as-male persons, while children were mainly cared for by women. The other authors have backgrounds in HRI and HCI, and have many years of experience in participatory and field research, as well as technology and disability. One of the authors has personal experience with disability and childcare.

4 Results

Based on the field notes and aligning with our RQs, we identified the following four themes: "*A Typical Day in the Life of a SAR*","*Interactions with NAO*","*Reacting to NAO's Presence and Actions*", and "*Temporal Changes*". We leverage vignettes [33], small storytelling elements that illustrate themes with lived experiences.

4.1 A Typical Day in the Life of a SAR

A typical day with a robot at the daycare is split into three phases: A setup-phase, a period in which children can freely play, and times during which children's activities are structured by the caregivers.

4.1.1 Setting up NAO. "After I arrive at the daycare, I greet the caregivers and children. The caregivers seem happy to see me, a few children come towards me and hug me. I go towards the sleeping room adjacent to the main room to get NAO. Two younger children guess my intention, follow me, and express the wish to help set up the robot. After carrying the robot to its usual spot within the main room, they want to insert the loading cable and push the button to turn the robot on. While NAO is booting and I am setting up the laptop, the children already impatiently start showing communication cards to the robot, which NAO cannot recognize in the current state. This attracts further children, leading to four children gathering around NAO trying to show cards. One asks me if NAO has woken up yet. Once everything is running, the children show NAO differing cards for a few minutes and are entertained by the verbalization. It does not seem that they want to express anything through the cards but randomly pick those that catch their eyes. After a few minutes NAO is left alone, and sits in his corner in solitude. This vignette illustrates a common occurrence when setting up the robot. While not all children were interested in

[1] http://doc.aldebaran.com/1-14/naoqi/vision/allandmarkdetection.html - Accessed - 16 September 2025

the process, for some toddlers it was a recurring event they wished to participate in, with the appearance of the robot sparking their curiosity. Often, children of all ages were attracted by the turmoil, interrupting their participation in other activities.

4.1.2 Free playing time. *"After breakfast children are allowed to choose what and where they want to play. As it is a cloudy day, only few children choose to play in the garden. The rest is spread out over the premises, pursuing differing kinds of activities. A child asks me to solve a puzzle with them. While doing the puzzle I keep one eye on the robot that is sitting in the corner. After a while, a child actively approaches the robot, starting to show seemingly random cards to it while repeating what it verbalizes. This, in turn, attracts another child. They now take turns showing cards to the robot."*
This vignette presents an example of times in which the children were free to choose their activity. During these times, phases of interest in the robot alternated with phases in which children did not engage with NAO. The vignette presents two of three observed *Reasons to Engage with NAO*, i.e., the ways in which children were drawn to interacting with the robot. Similar to the first child approaching the robot, children often approached the SAR with an *(1) intrinsic interest.* Without outer influences, these children developed an idea to interact with the robot and decided that they wanted to peruse one of a multitude of observed activities (see Section4.2). Such interactions, in turn, often *(2) triggered interest* of further children. Being made aware of NAO, they either copied actions or brought their own agenda. While other children were the main reason to result in this *triggered interest*, interactions were sometimes also initiated by the robot making random noises, or caregivers playfully utilizing the TTS feature. Finally, *(3) guided initiation* by a caregiver also led to interactions with NAO. Such initiation mostly happened for disabled children. Overall, we note that access to NAO was weather-dependent: Being spatially isolated from the robot when playing in the garden prevented both children and caregivers from interacting with it.

4.1.3 Caregiver-structured times. *At noon, free play is concluded, the children who were in the garden return, and the complete flock is led to the pre-meal hygiene routine of visiting the toilet and washing their hands. Two children are tasked with picking up the food from the kitchen. While the children start returning from the bathroom, I help the other caregivers prepare the meal by putting down plates and cutlery. During this time the children are asked to sit quietly and wait for the meal. One of the more active children jumps up and starts interacting with NAO. The resulting sounds and visuals stir up movement and verbal excitement in other children. After a small endeavour, one caregiver succeeds in detaching the child from the robot, making the child sit down again. She looks at me, and subsequently takes the robot to the sleeping room. Out of sight and out of mind, the children now patiently await their meal.*
The vignette above illustrates one of the many *caregiver-structured times* spread throughout the day. Activities are not chosen by the children, instead set by the caregivers with firm expectations for behaviours, often asking children to stay in a certain place and carry out a specific activity. This, on the one hand, leads to all children being united in a certain area, allowing the entirety of caregivers to have a close eye on them. On the other hand, the activity dictated upon the children in combination with grouping all kids in one place raises the chances of disruption. These situational properties influence whether caregivers perceive NAO as appropriate, resulting in three distinct patterns of behaviour. First, caregivers reacted to the (potential) disturbance by NAO and the possibility to make it talk by (visually) *(1) removing NAO from the context.* However, after children repeatedly asked for NAO to be included in structured activities, e.g., telling a story about its weekend in the morning circle, one technology-savvy caregiver started to *(2) incorporate NAO into structured activities*, for example involving it in wishing everyone a tasty lunch, or using it as a tool to verbally ask for silence during the lead-up to mealtime. Another recurring pattern was to simply *(3) ignore NAO's presence* and disregard childrens' intentions and attempts to interact with it.

4.2 Interactions with NAO

During the study, children and caregivers engaged in a variety of interactions with NAO that we categorized according to *actor*, *focus*, and *goal* (see Figure 3). Here, we illustrate interaction categories through short examples based on specific observations.

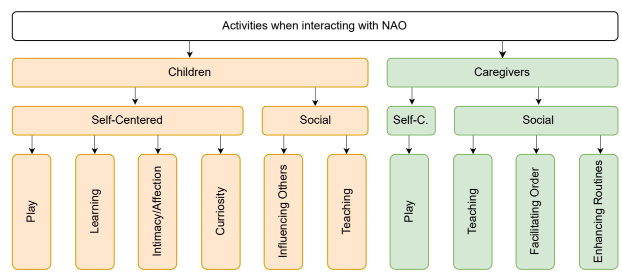

Figure 3: Overview of children's and caregivers' activities when interacting with NAO.

4.2.1 Children's interactions with NAO. A majority of the observed interactions were happening either between a child and NAO or a small group of children that wanted to interact with the robot in a self-centred way, with big variations in interaction patterns.

Self-Centred The most prevalent and recurrent way of play was children showing alternating (random) cards to NAO, listening to the verbalization and subsequently restarting the process by showing further cards. In a more sophisticated manner, older children started to further gamify the approach: There was one instance where two children spent almost 30 minutes showing random cards to the robot, and acting upon expressions. For example, NAO's verbalization of "I want to go to the garden" was met by the kids running to the garden, just to then return and show another card. In contrast, for toddlers and one of the disabled children, the concept of showing cards was physically challenging, and they started to interact with NAO's glowing chest-button, triggering the default announcement of the connection status. Additionally to verbal output, children also incorporated NAO into pre-existing patterns of play, e.g., in an imaginative knight-themed role-play NAO was made a princess. While intersecting with the act of playing, multiple children seemed to utilize NAO as a *learning opportunity*. In this context, a disabled child repeatedly spent time showing different cards, listening, and trying to reproduce the words the robot vocalized. Similarly, two toddlers also tried to repeat robot output.

Extending to direct physical interaction, one of the toddlers repeatedly sought physical contact, often trying to hug NAO. However, given the fragility of NAO, the robot would often fall over, upsetting the child who attempted to put the robot up again. While not observed frequently, such acts of seeking *intimacy or expressing affection* were also observed in other children sharing details about themselves and their lives with NAO while sitting close to the robot.

Finally, a common pattern that was observed was the children's wish for *exploration*. Many children were curious and e.g. tried to move NAO's arms and legs, or were fascinated by the LEDs activated through touching its pressure sensors. Especially the more active and outgoing children tried to test NAO's physical limits by forcefully moving parts, or knocking it down. Taking a more cautious approach, other children asked the researcher or caregivers to make it "dance" or stand up from its sitting position.

Social While children mostly entertained themselves with the robot, we also observed *social* interactions that were not directly aimed at the robot, but utilized it as a medium to communicate with others. For example, one child utilized NAO to announce that they wanted to go to the toilet, while another toddler wanted attention for a scratch they got on the weekend, and showed the "hurt" card to NAO as the researcher approached. While following the main concept of the SAR, some older children utilized the concept to *influence others*, trying to test boundaries by utilizing NAO's verbalization. For example, after being told that they were not allowed to go to the gymnasium on this day, a pre-schooler begun showing the "gymnasium" card to NAO, and argued that the robot also wanted to go to the facility.

4.2.2 Caregiver's interactions with NAO. Caregivers only showed a smaller amount of self-centred interactions and a stronger focus on utilizing NAO as a social tool for social interactions.

Self-Centred While not happening often, and constrained to the more senior and tech-affine caregivers, they used NAO and its text-to-speech feature in a *playful* manner. This for example happened in a rare case in which multiple caregivers but no children were around, and one caregiver started making NAO address the others in a casual way. Knowing that NAO would have problems pronouncing subsequently reoccurring letters, a caregiver amused themselves on different occasions by letting NAO verbalize patterns like "AAA BBB CCC ...".

Social Caregivers typically interacted with NAO with a social goal in mind. Most commonly, they interacted with NAO with the intention of *teaching* to utilize the non-verbal communication cards, understanding that younger and non-verbal children required repeated demonstration and guidance to familiarize themselves with the approach. Other interactions with the robot were highly targeted, and established it as a tool to manage the group. As has been described in Section 4.1, in one session caregivers started *facilitating order* by utilizing the TTS feature, or enhancing existing routines they engaged children in.

4.3 Recurring Reactions to NAO's Presence, Actions, and Appearance

We observed a variety of reactions to NAO, some of which were recurring patterns of positive or negative behaviours.

4.3.1 Shared access to NAO may lead to conflict, but also fosters support. Similar to when playing with other toys, there were many instances in which children showed a self-centred approach to playing with NAO. This often led to multiple children wanting to interact with the robot at the same time. Often, children naturally found a rhythm that was acceptable for all parties. Yet, in some instances, physical conflicts emerged. Depending on group size and dominance of the children, it also happened that younger and non-verbal children were pushed out by others. Yet, we also observed multiple occasions where older children noticed that their younger counterparts did not manage interact in the right way, and guided their hands, or explained how to show the cards.

4.3.2 Unexpected robot behaviour can trigger strong reactions. During deployment, card recognition generally worked well. However, for younger and some of the disabled children it was more difficult to hold the card at an angle that could be recognized by NAO, leading to failure in recognition. Often, children would simply lose interest at this point. However, there were some instances of rather extreme reactions to unexpected interactions such as children beginning to cry after accidentally knocking the robot over and not being able to put it up again. In another case, NAO remained in the *autonomous life* mode after setup in which motors are stiff and it orientates its head towards detected humans. One of the more outgoing children was not pleased with the fact that although they were directly in front of the robot, it continued to look at another child. In a quick, violent move, the child then turned NAO's head and its stiff motors around to finally make the robot look at them.

4.3.3 Common prescription of human attributes to the robot. While NAO was roughly handled in some cases, the robot was often anthropomorphized by the children. This was for example evident in children calling NAO by his first name - *NAO* - rather than calling it *robot* during our research. Likewise, there were multiple instances in which children asked the researcher about NAO's clothes (or the absence thereof), leading to self-amusing statements like *"Nao is naked"*. While NAO was mainly referenced using male pronouns, a pair of girls informed the caregivers that they were able to *"see her vagina"*, utilizing the female pronoun and organ. A toddler also took it upon themselves to dress NAO by placing a small plush-octopus on its head, replacing it when it fell down. On one instance, NAO overheated and radiated a light soldering scent, leading to the children calling NAO *"stinky"* and needing to shower, again interpreting its state against the backdrop of personhood.

4.3.4 Bystander self-reflection. While some children did not actively interact with NAO, they showed signs of self-reflection based on NAO's verbalizations triggered by others. For example, a non-verbal child who is supported by caregivers when going to the toilet ran towards the door and waited for a caregiver just after another child triggered NAO's "I need to go to the toilet" verbalization. Likewise, when one child triggered an "I have hurt myself" verbalisation, this reminded another child that they had scratched themselves, and they subsequently showed the small wound to the researcher and demanded help.

4.4 Understanding How Life With NAO Changes Over Time

Throughout our research, interactions with and perceptions of NAO changed, hinting at three distinct phases: (1) The *initial phase* spanning the introduction of NAO via two sessions, followed by (2) a circa ten session long *intermediate phase*, which ended in a (3) two session *habitual phase* representing the final state of the integration after which the researcher left the site. Each phase was marked by distinct interactions with and approaches to NAO.

4.4.1 Initial phase. The initial phase was characterized by a strong interest from all but one children that was scared by NAO on the first interaction (but approached it in the second session). The phase was marked by curiosity, with children learning how to show cards and observing how NAO would react. The only interaction going beyond this structured approach was exhibited by one child who started to utilize NAO as learning tool by actively showing cards trying to reproduce sounds (see Section 4.2). Toward the end of this phase, children also started to demand NAO being included in the daily routines. During these first sessions, caregivers only interacted with NAO to teach children how to interact with the robot. Here, they voiced first concerns that interactions may be quite challenging for younger and disabled children. It also became clear that NAO's audio output was too quiet in the noisy daycare context, necessitating modifications to increase volume in the subsequent phase.

4.4.2 Intermediate phase. New forms of play started to emerge in the intermediate phase (see Section sec:themetwo). First, children started to experiment with the verbalization feature, finding new ways to play with it, later they also utilized NAO in their regular play, e.g., by including it in role-play or talking to it. While new concepts of interaction emerged, the frequency of use deteriorated over time, and children showed a lower amount of general interactions, with a reduction in self-triggered interest. In this phase, it also became clear that children and caregivers appropriated the robot beyond the originally intended concept; while some children and toddlers utilized the concept as intended, verbalizing their needs and wishes via the robot, many disabled children did not (see Section 4.2.1). Caregivers also spent less time trying to teach children how to utilize the robot as a communication tool. In turn, they begun utilizing NAOs longer downtimes to entertain themselves and explore the TTS feature, starting to interact with children via NAO (see Section sec:themetwo). Over time it also became clear that NAO in its standing form was not stable enough and was repeatedly pushed over by excited children, leading to a subsequent deployment in a sitting pose to protect the hardware.

4.4.3 Habitual phase. Setting up NAO was an event that children always participated in, followed by a playing session that ended up in only a few interactions per child. During this time, inclusion in role-play was also still observed. Caregivers have become more unconstrained with NAOs TTS feature, even testing its boundaries when children are doing something else. In the end, the caregivers did not put NAO away anymore during structured activities, but included it by letting it talk during the *Morning Circle* in one session and making it say the table-saying in another.

5 Discussion

5.1 RQ1: How do children interact with the SAR, and which interactions emerge over time?

Our results show that children engaged in a range of self-directed interactions with NAO (see Section 4.2.1). In particular, we observed playful interactions, as well as those supporting learning, with curiosity being a strong driver for children's engagement with the SAR (see Section 4.2.1, self-centred). Many children started out to engage with NAO as a mediator for communication, but then appropriated the system within their own routines of engagement (see Section 4.2.1, social) while anthropomorphizing the robot similar to previous observations [60, 62], but only doing so within specific boundaries (e.g., calling NAO by its *name* (see Section 4.3.3), but refraining from expecting it to have meals). Children used the robot in make-believe play and made it act as knowledgeable other, providing "zone of proximal development" scaffolding that Vygotsky [67] describes as essential for learning. We also noticed age-related differences: Where older children engaged in more complex interaction, there were many instances in which toddlers sought direct physical contact with the robot (see Section 4.2.1), which is in line with Elkonin's identification of the manipulation of objects as the dominant leading activity during this developmental stage [20] and provides further support for Rudenko et al. [54]'s call for age-appropriate CRI design. Finally, while most interactions with the SAR were constructive, we observed a few instances of rough behaviour and mischief (see e.g. Section 4.3.2) that have implications for the design of robot features as well as robustness of hardware (see Section 5.4).

5.2 RQ2: How do caregivers approach the SAR, and how do they mediate children's interactions?

Caregivers who were part of our study openly approached NAO, but did so with their own intentions and responsibilities toward providing structure for the children. During the initial phase, teaching children how to engage with NAO was the most common interaction (see Section 4.4.1); during the later stages, tech-savvy caregivers appropriated NAO for their own purposes, e.g., as a medium to facilitate structure (see Section 4.2.2). Here, we observed creativity in the use of the robot. However, there were instances in which caregiver mediation was required for conflict resolution (see Section 4.1.3), which suggests that SARs may - under certain circumstances - add to their workload rather than alleviating pressure.

5.3 RQ3: Which contextual factors in the daycare setting help or hinder long-term integration of the SAR?

The long-term integration of NAO was impacted by specific contextual factors at the daycare. Firm daycare routines (see Section 4.1.3) only left limited opportunity for children's free play, which is integral to child development [25]. Here, the relatively simplistic implementation used in our work turned out to be an instance of the "interaction expands function" paradigm [14], which encouraged children to explore and design their play around the presence of NAO (see Section 4.2.1), rather than NAO providing a firm structure. We argue that this openness in interaction goals, patterns and modalities is even more important in contexts where children individual differences and preferences in communication should be respected and inclusion is key. At the same time, we note that NAO's presence was problematic during phases of structured activity, with caregivers taking action to align robot behaviour with contextual requirements (see Section 4.2.2). In this context, we also note that availability of staff was a structural challenge at our research site. In consequence, caregivers often had limited time to address the overhead caused by the presence of NAO, and staff turnover throughout the deployment of NAO resulted in a loss of knowledge regarding its integration. Here, future work should address the design of robots that are better attuned to highly fluent, dynamic environments.

5.4 Implications for the Design of Robots Intended for Integration in Daycare Settings

Our work has practical implications for the design of robots intended for long-term integration in daycare settings.

Implication 1: Develop platforms that are robust enough to thrive, not just survive in the daycare setting.

Although one of the most popular platforms for child-robot interaction [42, 54], our results show that NAO was not robust enough for the daycare environment (e.g., easily and repeatedly being toppled, see Section 4.4.2; children engaging in extreme physical interaction, see Section 4.3.2 and 4.2.1). From our observations at the daycare both during all study phases, we conclude that intense physical actions and rough treatment of toys and other items are a regular occurrence, and one that is unlikely to change. Hence, this implies a need for more robust robots that can withstand daycare environments and researchers to consider robustness as a development metric. They might refer to entrenched measures to ensure that objects are safe and robust (e.g., EU Toy Safety Regulation [1]).

Implication 2: Develop robots that support age-appropriate and inclusive child-led interaction styles.

Deploying NAO in an inclusive daycare highlighted the need for interaction styles that are accessible for children with varying abilities (see Sections 4.2.1 and 4.4). In this context, we observed full-body physical interactions of younger children (see Section 4.2.1), which are in line with their stage of development [20] and previous studies [60], but not sufficiently supported by NAO. Thus, future work should explore the development of robot platforms supporting diverse interactions, and specifically capable of leveraging and integrating social and physical interaction modalities attuned to the needs of children. Researchers can consult literature on age-appropriate CRI designs (e.g., Rudenko et al. [54]) or adopt an "interaction expands function" approach [14] to explore simple interaction letting children's imagination add meaning drive self-determined, age-appropriate complexity.

Implication 3: Design applications that offer free play opportunity while respecting the need for highly structured periods in daycares.

Although interactivity and autonomy draw children to the robot, this was not appropriate during structured activities (e.g., lunch time, see Section 4.1.3). Over time, caregivers in our study developed strategies to involve NAO in ways they deemed appropriate (see Section 4.4). Here, we argue that such integration should be supported by dedicated modes of operation that restrict ability to interact to caregivers, and that temporarily suppress autonomous actions of the robot, acknowledging the relevance of periods of structured interaction for child development [57]. This could either be achieved by extending interface options for caregivers, or via automatic context recognition, e.g., leveraging robot sensors for prediction. Given children's strong reactions to unexpected behaviours or lack of interactivity (see Section 4.3.2), children should also be made aware of the mode of operation, for example, leveraging LED output of the robot, or by creatively exploring other ways, e.g., dressing the robot differently as a joint activity between children and caregivers to indicate transitions, availability, and tasks.

5.5 Limitations and Future Work

There are a few limitations to our work. We analysed field-notes through Thematic Analysis [10], yet approaches like Mayring's Qualitative Content Analysis [43] also could have been applied and might have offered another perspective. Given our ethnographic approach, we explored deployment within a specific cultural context one day a week, and while we ensured rigor and transferability via depth of description [40], future work should explore long-term robot deployment in childcare across different cultures. Likewise, we leveraged a simplistic application; future work could explore long-term deployment of more complex applications addressing different activities, e.g., games directly initiated by NAO, or structured learning activities. Here, we also want to note that we derived the application from existing work [52]. Future research efforts should directly engage children in participatory design of applications that align with their interests and routines regarding play. Finally, future work needs to address the practicality of integrating robotics in childcare through provision of robust and more affordable platforms, as well as plug-and-play setup routines that limit demands placed on already overburdened caregivers.

6 Conclusion

Our paper contributes an ethnographic inquiry into the deployment of NAO as a SAR in an inclusive daycare. Findings from our long-term study highlight that robustness of robot platforms need to be improved so that systems can brave daily life among children, and that children's and caregivers' interactions with NAO changed over time, supporting existing calls for long-term studies in HRI and child-robot interaction [36, 54].

Acknowledgments

This work has been supported by the German Federal Ministry of Research, Technology and Space (BMFTR) under the Robotics Institute Germany (RIG) and the state of Baden-Wurttemberg and its Ministry of Science, Research and Art as part of the "Real-World Lab Robotic AI (Reallabor Robotische KI)".

References

[1] 2009. Directive 2009/48/EC of the European Parliament and of the Council of 18 June 2009 on the safety of toys. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02009L0048-20181126. [Accessed 07-01-2026].

[2] Jordi Albo-Canals, Adso Fernández-Baena, Roger Boldu, Alex Barco, Joan Navarro, David Miralles, Cristobal Raya, and Cecilio Angulo. 2015. Enhancing long-term children to robot interaction engagement through cloud connectivity. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts*. 105–106.

[3] Minoo Alemi, Ali Meghdari, and Maryam Ghazisaedy. 2014. Employing humanoid robots for teaching English language in Iranian junior high-schools. *International Journal of Humanoid Robotics* 11, 03 (2014), 1450022.

[4] Jasmin Azarfar, Utku Norman, Irina Rudenko, and Barbara Bruno. 2025. Designing Robot-Mediated Phonological Awareness Activities: Child-centered Approach and Kindergarten Integration. In *34th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*.

[5] Ilaria Baroni, Marco Nalin, Paul Baxter, Clara Pozzi, Elettra Oleari, Alberto Sanna, and Tony Belpaeme. 2014. What a robotic companion could do for a diabetic child. In *The 23rd IEEE international symposium on robot and human interactive communication*. IEEE, 936–941.

[6] Paul Baxter, Emily Ashurst, Robin Read, James Kennedy, and Tony Belpaeme. 2017. Robot education peers in a situated primary school study: Personalisation promotes child learning. *PloS one* 12, 5 (2017), e0178126.

[7] David R Beukelman, Pat Mirenda, et al. 1998. *Augmentative and alternative communication*. Paul H. Brookes Baltimore.

[8] Andy Bondy and Lori Frost. 2001. The picture exchange communication system. *Behavior modification* 25, 5 (2001), 725–744.

[9] Branislav Borovac, Mirko Raković, Milutin Nikolić, Vlado Delić, Srđan Savić, Marko Penčić, and Dragiša Mišković. 2021. Robotics as assistive technology for treatment of children with developmental disorders—example of robot MARKO. In *International Conference on Machine and Industrial Design in Mechanical Engineering*. Springer, 69–76.

[10] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[11] John-John Cabibihan, Hifza Javed, Marcelo Ang Jr, and Sharifah Mariam Aljunied. 2013. Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. *International journal of social robotics* 5, 4 (2013), 593–618.

[12] Luis Vicente Calderita, Luis J Manso, Pablo Bustos, Cristina Suárez-Mejías, Fernando Fernández, and Antonio Bandera. 2014. THERAPIST: towards an autonomous socially interactive robot for motor and neurorehabilitation therapies for children. *JMIR rehabilitation and assistive technologies* 1, 1 (2014), e3151.

[13] Albert Causo, Phyo Zin Win, Peng Sheng Guo, and I-Ming Chen. 2017. Deploying social robots as teaching aid in pre-school K2 classes: A proof-of-concept study. In *2017 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 4264–4269.

[14] Wan-Ling Chang and Selma Šabanović. 2015. Interaction expands function: Social shaping of the therapeutic robot PARO in a nursing home. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*. 343–350.

[15] Daniela Conti, Carla Cirasa, Santo Di Nuovo, and Alessandro Di Nuovo. 2020. "Robot, tell me a tale!" A social robot as tool for teachers in kindergarten. *Interaction Studies* 21, 2 (2020), 220–242.

[16] Helen Crompton, Kristen Gregory, and Diane Burke. 2018. Humanoid robots supporting children's learning in an early childhood setting. *British Journal of Educational Technology* 49, 5 (2018), 911–927.

[17] Julia Dawe, Craig Sutherland, Alex Barco, and Elizabeth Broadbent. 2019. Can social robots help children in healthcare contexts? A scoping review. *BMJ paediatrics open* 3, 1 (2019), e000371.

[18] Marta Díaz-Boladeras, Cecilio Angulo, Miquel Domènech, Jordi Albo-Canals, Núria Serrallonga, Cristóbal Raya, and Alex Barco. 2016. Assessing pediatrics patients' psychological states from biomedical signals in a cloud of social robots. In *XIV Mediterranean Conference on Medical and Biological Engineering and Computing 2016: MEDICON 2016, March 31st-April 2nd 2016, Paphos, Cyprus*. Springer, 1185–1190.

[19] Sabrina Eimler, Astrid von der Pütten, Ulrich Schächtle, Lucas Carstens, and Nicole Krämer. 2010. Following the white rabbit–a robot rabbit as vocabulary trainer for beginners of English. In *Symposium of the Austrian HCI and Usability Engineering Group*. Springer, 322–339.

[20] Daniil B El'konin. 2017. Toward the problem of stages in the mental development of the child. In *Revival: Soviet Developmental Psychology: An Anthology (1977)*. Routledge, 538–563.

[21] David Estévez, María-José Terrón-López, Paloma J Velasco-Quintana, Rosa-María Rodríguez-Jiménez, and Valle Álvarez-Manzano. 2021. A case study of a robot-assisted speech therapy for children with language disorders. *Sustainability* 13, 5 (2021), 2771.

[22] Camino Fernández-Llamas, Miguel Ángel Conde, Francisco J Rodríguez-Sedano, Francisco J Rodríguez-Lera, and Vicente Matellán-Olivera. 2020. Analysing the computational competences acquired by K-12 students when lectured by robotic and human teachers: Can a Robot teach computational principles to pre-university students? *International Journal of Social Robotics* 12, 5 (2020), 1009–1019.

[23] Evaggelos Foykas, Eleftheria Beazidou, Charalampos Karagiannidis, and Zygouris Nikolaos. 2025. The use of the social robot NAO to enhance communication skills in children with autism spectrum disorder: A systematic review of studies from 2013–2019 to 2020–2025. *Technology and Disability* (2025), 10554181251367984.

[24] Marina Fridin. 2014. Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education. *Computers & education* 70 (2014), 53–64.

[25] Doris Pronin Fromberg and Doris Bergen. 2012. *Play from birth to twelve: Contexts, perspectives, and meanings*. Routledge.

[26] Milan Gnjatović, Jovica Tasevski, Dragiša Mišković, Srđan Savić, Branislav Borovac, Aleksandra Mikov, and Rastislava Krasnik. 2017. Pilot corpus of child-robot interaction in therapeutic settings. In *2017 8th IEEE International Conference on Cognitive Infocommunications (CogInfoCom)*. IEEE, 000253–000258.

[27] Arzu Guneysu and Bert Arnrich. 2017. Socially assistive child-robot interaction in physical exercise coaching. In *2017 26th IEEE international symposium on robot and human interactive communication (RO-MAN)*. IEEE, 670–675.

[28] Hannah Gurr, Louise Oliver, Orlanda Harvey, Madhusudan Subedi, and Edwin van Teijlingen. 2024. The Importance of Positionality for Qualitative Researchers. *Dhaulagiri Journal of Sociology and Anthropology* 18, 01 (June 2024), 48–54. doi:10.3126/dsaj.v18i01.67553

[29] Till Halbach, Trenton Schulz, Wolfgang Leister, and Ivar Solheim. 2021. Robot-enhanced language learning for children in Norwegian day-care centers. *Multimodal Technologies and Interaction* 5, 12 (2021), 74.

[30] Martyn Hammersley and Paul Atkinson. 2019. *Ethnography: Principles in practice*. Routledge.

[31] Olivier A Blanson Henkemans, Bert PB Bierman, Joris Janssen, Rosemarijn Looije, Mark A Neerincx, Marierose MM van Dooren, Jitske LE de Vries, Gert Jan van der Burg, and Sasja D Huisman. 2017. Design and evaluation of a personal robot playing a self-management education game with children with diabetes type 1. *International Journal of Human-Computer Studies* 106 (2017), 63–76.

[32] Koen V Hindriks and Sander Liebens. 2019. A robot math tutor that gives feedback. In *International Conference on Social Robotics*. Springer, 601–610.

[33] Megan Hofmann, Devva Kasnitz, Jennifer Mankoff, and Cynthia L Bennett. 2020. Living disability theory: Reflections on access, research, and design. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 1–13.

[34] Zeng-Wei Hong, Yueh-Min Huang, Marie Hsu, and Wei-Wei Shen. 2016. Authoring robot-assisted instructional materials for improving learning performance and motivation in EFL classrooms. *Journal of Educational Technology & Society* 19, 1 (2016), 337–349.

[35] Kyung Hea Jeon, Seok Jeong Yeon, Young Tae Kim, Seokwoo Song, and John Kim. 2014. Robot-based augmentative and alternative communication for nonverbal children with communication disorders. In *Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing*. 853–859.

[36] Malte Jung and Pamela Hinds. 2018. Robots in the wild: A time for more robust theories of human-robot interaction. 5 pages.

[37] Hideki Kozima, Marek P Michalowski, and Cocoro Nakagawa. 2009. Keepon: A playful robot for research, therapy, and entertainment. *International Journal of social robotics* 1, 1 (2009), 3–18.

[38] Hideki Kozima and Cocoro Nakagawa. 2007. Longitudinal Child-Robot Interaction at Preschool.. In *AAAI Spring symposium: multidisciplinary collaboration for socially assistive robotics*. 27–32.

[39] Rebecca P Lawson, Geraint Rees, and Karl J Friston. 2014. An aberrant precision account of autism. *Frontiers in human neuroscience* 8 (2014), 302.

[40] Cheryl S. Le Roux. 2017. Exploring rigour in autoethnographic research. *International Journal of Social Research Methodology* 20, 2 (2017), 195–207. doi:10.1080/13645579.2016.1140965

[41] Hawon Lee and Eunja Hyun. 2015. The intelligent robot contents for children with speech-language disorder. *Journal of Educational Technology & Society* 18, 3 (2015), 100–113.

[42] Kayla Matheus, Rebecca Ramnauth, Brian Scassellati, and Nicole Salomons. 2025. Long-Term Interactions with Social Robots: Trends, Insights, and Recommendations. *ACM Transactions on Human-Robot Interaction* 14, 3 (2025), 1–42.

[43] Philipp Mayring. 2014. Qualitative content analysis: theoretical foundation, basic procedures and software solution. (2014).

[44] Clara J Moerman, Loek Van Der HEIDE, and Marcel Heerink. 2019. Social robots to support children's well-being under medical treatment: A systematic state-of-the-art review. *Journal of Child Health Care* 23, 4 (2019), 596–612.

[45] Kathleen Musante and Billie R DeWalt. 2010. *Participant observation: A guide for fieldworkers*. Bloomsbury Publishing PLC.

[46] Junya Nakanishi, Jun Baba, and Hiroshi Ishiguro. 2022. Robot-mediated interaction between children and older adults: A pilot study for greeting tasks in

nursery schools. In *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 63–70.

[47] Maria Palioura and Theodosios Sapounidis. 2025. Storytelling and educational robotics: A scoping review (2004–2024). *Computers & Education* 225 (2025), 105186.

[48] Irena Papadopoulos, Runa Lazzarino, Syed Miah, Tim Weaver, Bernadette Thomas, and Christina Koulouglioti. 2020. A systematic review of the literature regarding socially assistive robots in pre-tertiary education. *Computers & Education* 155 (2020), 103924.

[49] Hae Won Park, Ishaan Grover, Samuel Spaulding, Louis Gomez, and Cynthia Breazeal. 2019. A model-free affective reinforcement learning approach to personalization of an autonomous social robot companion for early literacy education. In *Proceedings of the AAAI conference on artificial intelligence*, Vol. 33. 687–694.

[50] José Carlos Pulido, José Carlos González, Cristina Suárez-Mejías, Antonio Bandera, Pablo Bustos, and Fernando Fernández. 2017. Evaluating the child–robot interaction of the NAOTherapist platform in pediatric rehabilitation. *International Journal of Social Robotics* 9, 3 (2017), 343–358.

[51] Joseline Raja Vora, Ameer Helmi, Christine Zhan, Eliora Olivares, Tina Vu, Marie Wilkey, Samantha Noregaard, Naomi T Fitter, and Samuel W Logan. 2021. Influence of a socially assistive robot on physical activity, social play behavior, and toy-use behaviors of children in a free play environment: A within-subjects study. *Frontiers in Robotics and AI* 8 (2021), 768642.

[52] Jan Ole Rixen, Rafik Abdalla, Victoria Coralie Kuch, Nadja Scherer, Barbara Bruno, and Kathrin Gerling. 2025. A Socially Mediating Robot to Assist Non-Verbal Children in an Inclusive Daycare Context. In *2025 20th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. 1573–1577. doi:10.1109/HRI61500.2025.10974014

[53] Ben Robins, Kerstin Dautenhahn, and Paul Dickerson. 2009. From isolation to communication: a case study evaluation of robot assisted play for children with autism with a minimally expressive humanoid robot. In *2009 second international conferences on advances in computer-human interactions*. IEEE, 205–211.

[54] Irina Rudenko, Andrey Rudenko, Achim J Lilienthal, Kai O Arras, and Barbara Bruno. 2024. The Child Factor in Child–Robot Interaction: Discovering the Impact of Developmental Stage and Individual Characteristics. *International Journal of Social Robotics* 16, 8 (2024), 1879–1900.

[55] Martin Saerbeck, Tom Schut, Christoph Bartneck, and Maddy D Janse. 2010. Expressive robots in education: varying the degree of social supportive behavior of a robotic tutor. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 1613–1622.

[56] Clive Seale. 2017. Researching society and culture. (2017).

[57] Saliha B Selman and Janean E Dilworth-Bart. 2024. Routines and child development: A systematic review. *Journal of Family Theory & Review* 16, 2 (2024), 272–328.

[58] Heqiu Song, Zhiping Zhang, Emilia I Barakova, Jaap Ham, and Panos Markopoulos. 2020. Robot role design for implementing social facilitation theory in musical instruments practicing. In *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. 253–260.

[59] Sudha M Srinivasan, Maninderjit Kaur, Isabel K Park, Timothy D Gifford, Kerry L Marsh, and Anjana N Bhat. 2015. The effects of rhythm and robotic interventions on the imitation/praxis, interpersonal synchrony, and motor performance of children with autism spectrum disorder (ASD): a pilot randomized controlled trial. *Autism research and treatment* 2015, 1 (2015), 736516.

[60] Fumihide Tanaka, Aaron Cicourel, and Javier R Movellan. 2007. Socialization between toddlers and robots at an early childhood education center. *Proceedings of the National Academy of Sciences* 104, 46 (2007), 17954–17958.

[61] Margaret J Trost, Adam R Ford, Lynn Kysh, Jeffrey I Gold, and Maja Matarić. 2019. Socially assistive robots for helping pediatric distress and pain: a review of current evidence and recommendations for future research and practice. *The Clinical journal of pain* 35, 5 (2019), 451–458.

[62] Sherry Turkle, Cynthia Breazeal, Olivia Dasté, and Brian Scassellati. 2006. Encounters with kismet and cog: Children respond to relational artifacts. *Digital media: Transformations in human communication* 120 (2006).

[63] Daniel Ullrich, Sarah Diefenbach, and Andreas Butz. 2016. Murphy Miserable Robot: A Companion to Support Children's Well-being in Emotionally Difficult Situations. In *Proceedings of the 2016 CHI conference extended abstracts on human factors in computing systems*. 3234–3240.

[64] Rianne Van den Berghe, Josje Verhagen, Ora Oudgenoeg-Paz, Sanne Van der Ven, and Paul Leseman. 2019. Social robots for language learning: A review. *Review of Educational Research* 89, 2 (2019), 259–295.

[65] Bert Vandenberghe, Kathrin Gerling, Luc Geurts, and Vero Vanden Abeele. 2022. Maker technology and the promise of empowerment in a Flemish School for Disabled Children. In *proceedings of the 2022 CHI conference on human factors in computing systems*. 1–18.

[66] Louise Veling and Conor McGinn. 2021. Qualitative research in HRI: A review and taxonomy. *International Journal of Social Robotics* 13, 7 (2021), 1689–1709.

[67] Lev S Vygotsky. 1978. *Mind in society: The development of higher psychological processes*. Vol. 86. Harvard university press.

[68] Chun-Wang Wei, I Hung, Ling Lee, Nian-Shing Chen, et al. 2011. A joyful classroom learning system with robot learning companion for children to learn mathematics multiplication. *Turkish Online Journal of Educational Technology-TOJET* 10, 2 (2011), 11–23.

[69] Jacqueline Kory Westlund and Cynthia Breazeal. 2015. The interplay of robot language level with children's language learning during storytelling. In *Proceedings of the tenth annual ACM/IEEE international conference on human-robot interaction extended abstracts*. 65–66.

[70] Jacqueline Kory Westlund, Goren Gordon, Samuel Spaulding, Jin Joo Lee, Luke Plummer, Marayna Martinez, Madhurima Das, and Cynthia Breazeal. 2016. Lessons from teachers on performing HRI studies with young children in schools. In *2016 11th ACM/IEEE international conference on human-robot interaction (HRI)*. IEEE, 383–390.

[71] Hansol Woo, Gerald K LeTendre, Trang Pham-Shouse, and Yuhan Xiong. 2021. The use of social robots in classrooms: A review of field-based studies. *Educational Research Review* 33 (2021), 100388.

[72] Zhen-Jia You, Chi-Yuh Shen, Chih-Wei Chang, Baw-Jhiune Liu, and Gwo-Dong Chen. 2006. A robot as a teaching assistant in an English class. In *Sixth IEEE international conference on advanced learning technologies (ICALT'06)*. IEEE, 87–91.

[73] Marc A Zimmerman. 2000. Empowerment theory: Psychological, organizational and community levels of analysis. In *Handbook of community psychology*. Springer, 43–63.

Received 2025-09-30; accepted 2025-12-01