Crafting Social Robots for Neurodiverse Individuals: Prospects and Challenges

A Thesis Proposal

by

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Table of Contents

1 Abstract

This study explores the potential of robotic dogs as tools for neurodivergent individuals in therapy, focusing on their socio-emotional well-being. The limitations of traditional animal therapy were considered, as we investigated the design and impact of robotic dogs as another option. Two robot dog models, Aibo and A1, were introduced to neurodivergent students in a university setting, putting them in various workshops to assess their responses, preferences, and difficulties. The study's methodology included co-design workshops where students interacted with the robot dogs. They then created use case storyboards and addressed potential robot failures. Through these interactions, students' perceptions of the robots' physical appearance, responsiveness, and potential use cases in daily life were examined. The findings revealed a preference for robot dogs combining Aibo's dog-like and more approachable appearance with A1's responsive behavior. They didn't appreciate Aibo's lack of quick decision making and A1's robotic and unnatural look. Students wanted robot dogs in diverse roles, from companionship and emotional support to practical tasks like safety monitoring. A significant part of the study involved understanding student responses to robot malfunctions or failures. Students expressed a desire for clear communication from the robots during failures, indicating a need for intuitive and empathetic design in robotic companions.

2 Introduction

Animal therapy with dogs is a popular form of social therapy for neurodivergent individuals that provides a diverse set of benefits. Research has shown the efficacy of animal therapy in promoting healthy social behavior and regulating emotions in autistic and intellectually disabled individuals ranging from an increased willingness in interacting with others and an improved ability to focus. Such a form of therapy plays a crucial role in the lives of neurodiverse individuals, as their ability to socially interact with others and regulate emotions is often a primary concern. However, several downsides exist that limit the potential of animal therapy such as cost and animal life, among others. To address this, we aim to research the use of robotic dogs as a more sustainable and effective alternative to traditional animal therapy.

In order to build an effective robotic dog that is capable of catering towards the social and emotional needs of neurodiverse individuals, we aim to understand the components that comprise such a robot. Existing research in this area is limited, thus we plan to recruit, interview, and record participant interactions with different models of robot dogs (e.g. A1, Aibo, etc) to identify what types of human-dog interactive behaviors are particularly effective in promoting positive social behavior and regulating emotions, along with how different robot dog models can influence such data. Ultimately, our goal is to build a robot dog using the data we collect from these studies as an embodiment of the robot dog therapy we envision. We believe that our research has the capability to contribute unique knowledge of how robots and humans can better interact and create a richer environment where robots can play an even more impactful role in human health.

3 Related Work

With the advent of robotics and recent work, social robotics have been increasingly shown to have the capability to support people [8, 14, 28]. Previous research conducted on social robots that have yielded promising results in benefiting individuals have spanned various demographics including the elderly [7], children [18], and neurodivergent populations [25]. Kanda et al. explored the use of an interactive humanoid robot placed in an elementary school [16]. A 2 month study was held to understand the relationship between the students and the robot. Students were found to have formed a friendly relationship with the robot, as demonstrated by the students in their interactions and reported intentions on wanting to become friends with the robot. Carros et al. conducted a ten-week study on human-robot interaction in a care home and found that the elderly displayed curiosity followed by positive reactions and acceptance of the humanoid robots, especially in group settings, but did not want the robots to replace the caregivers [10].In a related domain, Lee et al. explored creating a methodology for the design philosophy of social robots for older adults with depression. Participants used their knowledge of the capabilities and applications of robots to surmise how their issues and concerns could be most effectively addressed. Participants valued the ease of use and maintenance in the home as a very important aspect, as they wished for these new robots to augment the roles of previously lost companions [19]. These uses included providing companionship through greeting the owner, discussing news with the owner, and going on walks with the owner. Both previous studies were longitudinal studies conducted over a period of time. In the field of interactive robotics, the extended period of time these studies use provides researchers with a more holistic and accurate representation of data and user feedback. Most importantly, study participants are given more time to reflect on their experiences and become accustomed to the study.

Similar research in understanding the dynamics between robot and human has also been conducted for neurodivergent populations. To explore more practical applications, Wing-Chee So et al. demonstrated that social robots are capable of assisting autistic children in applying skills like gesturing to express feelings and needs [31]. Other studies have shown that social robots are capable of teaching more complex skills to autistic children including sign language [2] and musical skills [33]. Kumazaki et al. investigated the robot appearance preferences of individuals with autism [18]. Children with higher levels of ASD symptoms were found to prefer robots that were more mechanical or mascot-like, which followed the common notion that autistic individuals prefer simpler, mechanical objects [28]. Another study explored how robots can be implemented into education and therapy interventions for children with autism spectrum disorder (ASD) through a series of focus groups and co-creation sessions involving people with autism, parents, and professionals [15]. Huijnen et al. found that while requirements such as appearance and voice are certainly important for maximizing the appeal of the robot, personalizing the robot such that it caters towards the unique needs and preferences of each child is just as important. In a separate study, Ricks et al. looked at trends in robot-assisted autism therapy that suggest children with autism exhibit positive social behaviors while interacting with robots. These behaviors include being more engaged in and paying more attention to less-humanoid robots [28]. Additionally, findings suggest that humanoid robots can be more generalized, as children can engage in emotion recognition activities. In addition to humanoid robots, other work featuring animal robots have also shown promise. Advantages that robotic animals have over their living counterparts including safety (lack of biting or scratching their owners) inconvenience (not having to care for a living being) [11] have motivated studies to explore the potential of animal robots. Kim et al. investigated the usage of a robotic dinosaur to understand how generic robotic-animal interaction promoted social behavior [17]. The study involved a child with autism interacting with an adult, along with either another adult, a computer game, or a robotic dinosaur. The results suggested that animal robots may be a useful tool for promoting social behavior given that children were found to be most verbal with a robotic dinosaur when posed as their interaction companion [17]. In another study, Stanton et al. explored the potential for the Sony AIBO robot dog to aid in the social development of autistic children and compared its effects to a mechanical toy dog [32]. Children were found to spend more time, speak more words, and engage in more social interactions with AIBO compared to the toy dog. The childrens' increased willingness to communicate was later suggested to potentially be carried over to human-human interactions.

While robotic dog interactions can elicit engaging, positive responses from individuals, it is important to consider scenarios where robots can generate negative responses from users. Carros et al. explored the use of social robots as companion robots for the elderly and discovered that participants felt distanced from the robot when they did not understand the intentions behind its actions [10]. From a technical standpoint, Wróbel et al. determined that robot dogs that produce delays in responses to a command or mispronounce words can be jarring and confusing for children [36]. Given that designing a robot companion requires a multitude of factors to be considered such as personalization and error handling, it is important to understand how to design a robot companion in such scenarios. We structured our co-design study around this notion in order to understand how users may expect the robot dog to behave in event of a failure.Robot dogs can be viewed as alternatives to live dogs in settings such as therapy. When designing robot dogs for therapy, researchers must consider the advantages and difficulties of replacing live dogs with robot dogs. Prior studies indicate that live dogs excel in enhancing social communication behaviors over robot dogs [30]. However, contrasting research suggests that interactions with robot dogs yield higher enjoyment and positive emotions than those with live dogs [3, 4], highlighting the necessity for additional investigation.

4 METHODS: WORKSHOPS

In our study, we outline four unique co-design workshops that take place as classroom activities where study participants are encouraged to engage in active discussions. Each workshop features some type of participant engagement where either a lecture-style presentation is given and questions are asked to motivate discussion from the class, or a class discussion is held by splitting the study participants into small groups led by a researcher that guides the discussion. Throughout each workshop and discussion, participants are encouraged to reflect and share their thoughts for the relevant discussion topic. The co-design study was conducted in a university class setting that took place on a 4-year Inclusive Post-Secondary Education (IPSE) Program for students with Intellectual Disabilities (IDD) university campus. We invited [n=13] students from the university's program designed for students with intellectual and developmental disabilities (IDD). Students in the IPSE program are exposed to a curriculum that teaches students academic, career, financial, and life skills and also attend classes and socialize with their neurotypical peers. We integrated this study into the curriculum where students participated in 4 workshops we designed that individually captured distinct goals of our study. Students attended 75 minute classes twice a week and participated in the workshops for the entire duration of the class. Over the course of 7 weeks, a teacher presented students with information on each workshop and provided context for the following workshop's details and goals. During each workshop, the teacher worked with researchers to engage students with each workshop and delivered lectures afterwards that encouraged student discussion and reflection.

Fig. 1. Classroom where study took place. The room was split into two for both robot dogs.

13 total student participants from the IPSE program were recruited for the study. Prior to the study, students were asked to fill out a form detailing demographic information such as age and disability. Ages of participants ranged from 19 to 23 years old (M=20.9, STD=1.3). 7 of the students were freshmen, 3 were sophomores, 2 were juniors, and 1 student was a senior. One student identified with intellectual disability, another with Down Syndrome, another with ADHD, and two other students with Autism. 3 students answered "Other", 1 of whom responded with Learning Disability and 2 of who did not respond with any further specifiers. 8 of the students were white, 1 was Latino, and 1 was of white and Latino descent. 3 students were African American and 1 student elected to not respond. The class was an elective centering around science and technology, indicating student interest in technology.

4.1 Introduction to robot dogs

First, the students were familiarized with the robot dogs. To introduce students to our study, the teacher briefed students on the roles generic service animals played in peoples' daily lives. The idea of robot service animals was then proposed and students were subsequently encouraged to brainstorm differences that a robotic service animal would have when compared to a live service animal. The teacher prompted students to ponder the advantages a robot service animal has in order to prepare them for later workshops where they consider how robot service animals can be leveraged to support them in their daily lives. Before students went on to interact with the robot dogs, videos and pictures of each robot dog were shown to the students.

4.2 Workshop 1: Interactive session with robot dogs

To familiarize students with social robot dogs, each student was given the opportunity to interact individually with the A1 and AIBO robot dogs. Workshop 2 was conducted across 3 full class days with 6 students present the first day, 8 students present the second day, and 10 students present the third day. A large classroom where the study was being conducted was split into two with a dividable wall (see Fig. 1). Each robot dog was placed in a separate room and the students were divided into two equal groups. In each room, students took turns interacting with the robot dog according to the policy described later.
In addition, the experiments for A1 and AIBO were structured differently to determine preference for certain dog behaviors. We operated A1 under a Wizard-Of-Oz protocol, giving it the appearance of being significantly more responsive compared to the AIBO robot dog, as researchers were able to operate A1 in response to participants' cues through a camera inside the classroom. For the AIBO robot, we left the response mechanism up to the dog itself which was frequently unable to receive user commands. This difference in response times was combined with the difference in visual appeal to determine which combination of characteristics was most valued by participants. A1 and AIBO exhibit differences in their physical appearance and behavior with AIBO being smaller, lighter, and more closely resembling a puppy while A1 was much bulkier, larger, and less resembling a dog. With a robot dog that was significantly more responsive but less visually appealing compared to the other robot dog, the contrast between the structure of the two experiments provided researchers with feedback on which characteristics were more preferred. The students followed a set interaction procedure for each robot dog with sessions lasting for 2 to 3 minutes. To fully physically engage students with A1, students were told to start several feet away from A1 and were instructed to issue commands in the following order: come (dog moves from origin to the student), follow (dog moves alongside a walking student), fetch (participant throws a ball and dog runs over and lays down next to it due to not having the capacity to carry it), stand up, and sit down. Upon completion of all interactions, each student was given the opportunity to conduct a "free-play" behavior, where the student was allowed to come up with a command or re-use a command from their interaction protocol. The free-play behavior was included to provide researchers with insights on behaviors that students would have liked to conduct with the robot dog, but were not necessarily included in the predetermined procedure. During Workshop 2, a set of events influenced the flow of the workshop. By the end of the workshop, a subset of students interacted twice with A1 and Aibo due to an optional program-wide event. Students who elected to not participate in the event interacted with the dogs when other students were participating in the event, and another time when the students returned from the event. In addition, one student called in during the last day of the workshop and participated virtually. Additionally, there was an intersocial challenge between students in the Aibo classroom this day which disrupted the discussion.

4.3 Workshop 2: Creating use case storyboards

The second workshop lasted for 3 full class days, and students were split into 4 groups with one group having 4 students and the rest three having 3 students. Each group had a class teacher or teaching assistant serving as a group leader who was responsible for guiding the discussion. During the initial phase of discussion, students in each group came to an agreement on a practical use case that they found would be applicable to their daily lives. To support the discussion, students were given play-dough and small figurines to help describe their use case. Students were then asked to describe the use case in chronological order to explain how the situation would look if enacted. An example scenario involving a student bringing a robot dog to school could start with the student and the robot dog entering the school premises. The robot dog would then join the student in their classroom, offering emotional support whenever the student experiences stress. The description of the use case was recorded on a storyboard where pictures were drawn by either the group leader or a student to represent the progression of the use case with labels that described each scene. After completing the storyboards, each group exchanged their storyboard with that of another group to get feedback on use cases created by other groups. The feedback was separated into strengths, weakness, opportunities, and threats (SWOT) analysis to help students organize their thoughts. Group leaders reviewed use cases pertaining to different groups and discussed with their own group about how the advantages, disadvantages, other ways the use case could be applied to other scenarios, and how the use case may not work. The feedback was categorized appropriately with respect to the SWOT analysis.

4.4 Workshop 3: Failures

Prior to Workshop 3, the robot dogs were anticipated to behave incorrectly under certain circumstances. We categorized the failures both robot dogs experienced during the interactive period and asked students the perceived impact of these failures. Students responded strongly to these failures and largely reported that they felt ignored, upset, or discouraged. To address these concerns, a fourth workshop was established to understand how failures in robotic service animals can be addressed. Workshop 4 lasted for one and one-quarter class days with 12 present students. Two core areas of failure that our own robot dogs experienced were identified in the second workshop. These were cases in which the robot dog ignored or experienced a physical malfunction (e.g. falling) when it was issued a command. For this workshop, students split up into 4 groups with two individuals posing as a "teller" and "dog" and a researcher to guide the discussion. For 2 groups, a researcher acted as the dog when students were uncomfortable with the role. Students acting as the teller were instructed to command the "dog" to role-play the failures they personally experienced during the study (see Fig. 2). Tellers were later asked on how they felt as they experienced the failure and importantly, how the dog should behave in event of such failures. Throughout the workshop, students were encouraged to report how they felt during the reenactment of each failure case. These underlying emotions were used to gauge how strongly students felt about each failure case. The end goal of the workshop was to gather and understand student feedback on how robot dogs should behave in the event of failure. Given student reports of feeling dejected, upset, and saddened in the event of robot failure, collecting feedback to handle robot dog behavior in event of failure is crucial to prevent negative user experience. As such, students were asked about how the robot dog should behave in the 3 failure scenarios that were laid out. In the event that students had difficulty ideating their own robot dog behaviors, researchers presented a set of choices based on the behaviors mentioned by students previously that the student could choose from. [the next class day, students ranked and discussed failure responses as a group].

5 Data Analysis

Recordings of each workshop were taken and reviewed for data analysis. Large classroom discussions were recorded in addition to discussions held by small groups formed during workshops 3 and 4. After the conclusion of the study, researchers reviewed each recording and transcribed the discussions that took place. Transcriptions were also used to gather insights about each workshop. Two separate recordings for each robot dog were taken during Workshop 2. The completed transcription was combined with video footage of workshop 2 to record feedback students provided regarding each robot dog. Common student responses to certain dog interactions and behaviors were tracked along with any insightful feedback.

Fig. 2. Demonstration of a small group in Workshop 4

For instance, students commonly and enthusiastically remarking about the "fetch" interaction was especially noted. Such observations were later grouped based on the type of robot dog. Workshops 3 and 4 shared a similar analysis process. Recordings of each student group were taken and transcriptions were created for later use. Since Workshop 3 held a large classroom discussion before students split off into groups, we made note of all brief use cases students brainstormed as a class prior to analyzing use cases students collaboratively storyboarded, which was more detailed. Workshop 4 was structured in a similar fashion, featuring a large classroom discussion and small group discussion. Data analysis was also conducted similar to the analysis in Workshop 3

6 Results

To gain a deeper insight into the design possibilities and obstacles for a robot dog that meets the requirements of neurodivergent individuals and supports their socio-emotional health, we presented two distinct robot dog models, Aibo and A1, to students.We discuss the results of our Workshops 2, 3, and 4 here which help us explore the best design philosophies for a robot dog. Workshop 2 revolves around students' initial reactions to interacting with the A1 and Aibo robot dog models. Use cases brainstormed by students along with thoughts and feedback they provided regarding their own and other students' use cases are outlined in our results for workshop 3. Failure cases, outlined in our workshop 4 findings, are categorized into 3 instances we experienced in our study and were determined to be generalized to all robots. Our findings here will all contribute to and aid our overall goal of understanding how to best design a robot dog that is best suited for neurodivergent needs.

6.1 Workshops uncovering robot dog use cases that identify the needs of neurodivergent individuals

Upon engaging with the robotic dogs, A1 and Aibo, the students exhibited varied reactions and feelings. Most students appreciated the approachable nature and cute mannerisms of Aibo, however, some visible frustrations were observed and expressed by the students. The majority found Aibo's friendly demeanor and endearing quirks appealing, yet there were instances of noticeable frustration. Aibo's inconsistent and sometimes delayed response to commands was a point of contention. It would occasionally take up to thirty seconds for Aibo to recognize and respond to the given command. Students became frustrated when their command wasn't acknowledged in a timely manner. When asked how they felt when Aibo didn't respond to them, one student said they felt "disrespected" and "frustrated". Therefore, we decided to explore failure cases in a subsequent workshop. When Aibo did finally respond to a command, there was a largely positive reaction. Additionally, students seemed to respond well to the approachable look of Aibo, often remarking "It's cute" and petting it more frequently compared to A1. For A1, students largely appreciated the immediate response to commands. Some students commented that A1 "didn't feel like an animal" and "felt too robotic." However, students typically preferred the quick response time to their commands and some preferred the functionality of A1 over the appearance of Aibo. One student stated: "I would like a dog that looked like Aibo but had the behavior of A1." Overall, we found that students wished for a combination of Aibo and AI's features in a robot dog. Students largely appreciated the promptness and fast reactions of A1, but some commented that they wished it had the face of a real dog and made barking sounds. Aibo was appreciated for its dog-like look and sounds but made students feel frustrated due to its delayed response time.

6.2 Opportunities

6.2.1 Use Case 1: Physical Activity.

Use cases that primarily centered around an interaction between the robot dog and the user were extensive. Participants often described use cases that they found to be relevant to their own daily lives. A student who enjoyed outdoor activities expressed a desire to be able to spend time outdoors with the robot dog, such as running at a park or going on a walk. Interestingly, students expressed concern for the robot dog's well-being as if the students viewed the robot dog as a living being. This provided us with insights that students would prefer the robot dogs to not stray too far away from their real-life counterparts. While additional features are wished for, students want the robot dog to be able to perform basic, real-life dog actions. This design philosophy is important when considering a neurodivergent individual's needs.

6.2.2 Use Case 2: Health and Safety.

Other use cases characterized student perception of the robot dog as a form of technology or tool. One student suggested that the robot dog could serve as a more interactive alarm system that could wake its owner up in the morning. A more complex version was brought up where the robot dog could act as a security system capable of sensing home invaders and calling the police without requiring the owner to do so. Several health-related use cases were also brought up where the robot dog was capable of tracking and measuring mood and physiological data, similar to a wellness app. One student proposed a situation where a robot dog accompanied its owner in the hospital and was capable of tracking the owner's vitals and alerting the doctors if something went wrong.

6.2.3 Use Case 3: Emotional Needs.

Use cases that centered around an emotional component were also frequent. Given that our participants were students at a 4-year institution, use cases that centered around school life were prevalent. One student expressed a desire for the robot dog to accompany him to school and provide support during stressful situations. Various actions were proposed for the robot dog such as laying its chin on the owner's lap or simply remaining by its owner's side. Following a similar line of thought, another student also proposed bringing the robot dog to school but was instead motivated by the potential of the robot dog to attract attention from nearby people. Interestingly, the student reported that they were primarily interested in using the robot dog as a means to form relationships with new people.

6.2.4 Use Case 4: Practical Uses.

Use cases in other settings were also introduced. One use case featured the robot dog accompanying the owner at their workplace and was capable of measuring mood and providing emotional support whenever its owner was stressed. In other cases, students also demonstrated their wish to use the robot dog to care for others. One student exhibited concerns for their family members' mental health and wished for the robot dog to help comfort them in times of need. While introducing their respective use cases, students also proposed various features and functionalities the robot dog should have to support their use case. Students frequently suggested the robot dog to play music during situations where the owner may be tense as a stress reliever. Gadgets such as a robotic arm or clamp were also proposed to aid the dog in performing tasks such as carrying objects. One particular student who had a passion for cooking suggested a role where the robot dog could assist him in basic tasks, such as handling hot pans or carrying and moving ingredients, plates, and silverware. Interestingly, this student expressed concerns for the dog's safety in dangerous situations such as burning itself when handling hot pans or slipping on a wet floor and falling, treating the robot dog as if it was a live dog.

6.3 Failure Case Workshop

Given the sensitive nature of robot dogs, it's important to understand how robot dogs should behave in the event of failure to prevent negative user experience, which was reported in our workshops. We separate the findings of our failure case workshop into three categories: sleep, ignore, and fall. These three scenarios were the distinct actions that the robot dog might've performed when it failed to respond to a command. The findings here involve the students being asked questions about their feelings and perceptions while they interact with their peers who are mimicking a robot dog failure. A student would issue a command to their peer acting as the robot dog, who then either slept, ignored, or fell.

6.3.1 Sleep.

Students wanted more information from the robot dog. Students felt confused, awkward, or frustrated when the robot dog slept on the floor after a command. One student stated that she would like communication from the robot so she understands what to do and how she can help. Another reported, "It should tell me that it needs charging." Students brainstormed that blinking lights or an audio cue that indicates low battery would be helpful for them. Additionally, one student stated that she wished for the dog to verbally tell her that the battery was low and walk to the charging station by itself. A few students shared this student's sentiment of wanting the robot dog to verbally inform the commander what the issue is.

6.3.2 Ignore.

In this case, where the robot dog would either perform a different command than the one instructed or not move at all, students in general wished for more communication from the robot. Students felt confused, frustrated, and ignored when the robotic dog ignored their commands. When asked what they wish for the dog to respond with when it ignored a command, one student responded "I want it to say it needs a break because it's been working so hard." Additionally, students wanted the robot dog to communicate that it didn't understand the command if this was the case to avoid frustration. They wanted to feel as though the robot dog was actively listening to and acknowledging them. One student mentioned "I want the dog to be able to look at me and realize he did the wrong thing." Interestingly, some students wanted the dog to inform the user of the program currently running so the owner can debug it and problem-solve. A student that shared this sentiment reported that she wished for the robot dog's data to be sent to her phone so she could understand more about the reasoning behind the robot dog's actions.

6.3.3 Fall.

In the scenario where the robot dog fell to the floor in the middle of an action, students expressed concern over the well-being of the robot. One student reported that "I am worried about him" and "I want him to let me know he's okay." A signal that gives a sign that there was something wrong with the robot was something students expressed a want for. This signal, possibly accompanied by the dog informing the user what was wrong, would allow the user to take action and fix the issue. Students also wanted to differentiate sounds or barks that indicate whether or not the dog is okay or needs help. One bark would be coupled with the respective scenario. One student specifically wanted the dog to inform the user what exactly went wrong and would use this information to prevent the same issue that caused the dog to fall.

7 Discussion

In our results section, we examined the settings of our workshop classrooms in the following manner. We recorded each workshop and carefully reviewed the recordings for data analysis. In addition to capturing the discussions that occurred in the large classroom setting, we also recorded the discussions of the small groups formed during workshops 3 and 4. After the study concluded, researchers thoroughly reviewed each recording and transcribed the discussions that took place. These transcriptions were utilized to gather insights about each workshop. Workshop 2 involved taking two separate recordings for each robot dog, and these transcriptions were combined with video footage to document the feedback provided by the students regarding each robot dog. We tracked common student responses and any valuable feedback related to specific interactions and behaviors of the dogs, such as the enthusiastic remarks about the "fetch" interaction. These observations were later categorized based on the type of robot dog. Workshops 3 and 4 followed a similar analysis process, where recordings were made for each student group, and transcriptions were generated for future use. In Workshop 3, we made a note of all the brief use cases brainstormed by the students as a whole class before analyzing the more detailed use cases that the students collaboratively storyboarded. Workshop 4 had a similar structure, with a large classroom discussion followed by small group discussions. The data analysis process in Workshop 4 was also similar to that of Workshop 3.

Overall, we found that students wished for features in a robot dog that were present in both Aibo and A1. Students largely appreciated the promptness and decisiveness of A1, but some commented that they wished it had the face of a real dog and made barking sounds. Aibo was appreciated for its dog-like look and sounds but made students feel frustrated due to its delayed response time. The limitations of our study involved the technical difficulties involving A1. Since A1 was required to be piloted by a research student outside the classroom, we ran into difficulties with the robot not responding to commands and not turning on. This caused the dog to occasionally fall over or delay the procuring of results. However, this led us to conduct our failure case workshop which became the defining factor of our study. Future studies can hone in on this failure aspect of working with robot animals for therapeutic purposes, and they can expand on what individuals would wish the robots to do when unexpected behavior occurs.

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