

Investigating the gap between research and practice in Robot-Based therapy for Autism Spectrum Disorder

by

Sabrina Saiko

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Applied Science
in
System Design Engineering

Waterloo, Ontario, Canada, 2025

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Examining Committee Membership

The following served on the Examining Committee for this thesis. The decision of the Examining Committee is by majority vote.

Supervisor: Catherine Burns
Professor, Dept. of System Design Engineering,
University of Waterloo

Internal Member: Jenny Howcroft
Associate Professor, Dept. of Systems Design Engineering,
University of Waterloo

Internal-External
Member: Yue Hu
Assistant Professor, Dept. of Mechanical and Mechatronics
Engineering, University of Waterloo

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The use of social robots as therapeutic tools for children with Autism Spectrum Disorder (ASD) has emerged as a promising area of research in recent years. Numerous studies have demonstrated the potential of these robots to support the development of social skills, including improvements in eye contact, verbal and physical communication, joint attention, and other interpersonal behaviors. Researchers such as Dautenhahn, Dickstein-Fisher, and initiatives like AskNAO have documented positive short- and medium-term outcomes across diverse populations and robotic systems. Despite this growing body of evidence, the real-world adoption of social robots in clinical or home-based ASD therapy remains limited.

This study investigates the barriers that hinder the practical implementation of social robots in ASD care by analyzing current research trends and comparing them with the perspectives of key stakeholders — namely, clinicians and parents of children with ASD. We employed a mixed-methods approach to gain a multidimensional understanding of these challenges. First, a systematic literature review was conducted using major academic databases, including PubMed, IEEE Xplore, and Scopus. Studies published between January 2016 and December 2024 were examined, focusing specifically on robot-child interaction and therapeutic application in the context of ASD. Our review revealed that although all studies reported measurable benefits for children, none of the robot systems had been systematically integrated into regular therapeutic practices. Several limitations were identified, including a general lack of user testing—most studies involved fewer than ten participants—variation in robot appearance and behavior due to the absence of a standardized design framework, and inconsistent metrics used to assess therapeutic effectiveness.

To complement the literature review and gain insight into real-world expectations and constraints, we conducted semi-structured interviews with clinicians and distributed surveys to parents. These qualitative and quantitative methods allowed us to explore stakeholders’ attitudes toward social robots, identify their practical concerns, and gather suggestions for how these technologies could be improved for clinical use. Preliminary findings highlight concerns about inconsistent robotic design, including differences in personality, appearance, and level of customization. In addition, participants cited the lack of intuitive interfaces for therapists and caregivers as a significant obstacle to implementation. Many also pointed to the absence of evidence-based clinical guidelines that would support decision-making and evaluation in real-world therapy settings.

Through this research, we aim to bridge the gap between research success and real-life clinical integration by identifying key areas where standardization and clearer communication with users could improve both the research process and product development. Specifically, future work can focus on establishing core therapeutic activities that robots can support, ensuring robots are adaptable and customizable to meet individual needs, defining cost-effectiveness benchmarks to guide adoption decisions, and promoting the development of ASD-specific robotic solutions.

The findings from this study offer a roadmap for researchers, designers, and healthcare providers to collaboratively address the challenges preventing broader adoption of social

robots in autism care. By aligning technological innovation with stakeholder needs, this work contributes to a more realistic and practical understanding of how to transition social robotics from research labs into everyday therapeutic contexts.

Acknowledgements

I would like to express my deepest gratitude to my supervisor, Dr. Catherine Burns, whose support and guidance have been truly invaluable throughout this journey.

Dr. Burns, your collaborative approach created an open and intellectually stimulating environment that encouraged me to think critically and explore new ideas. Despite your many responsibilities, you always made time to provide patient guidance and thoughtful feedback. Your kindness and dedication to my growth were a constant source of motivation. The knowledge and insight I have gained under your mentorship have profoundly shaped my academic and professional path. Thank you.

I would also like to extend my sincere thanks to the members of my thesis committee, Dr. Jenny Howcroft and Dr. Yue Hu, for their careful reading of my work and invaluable feedback. Your constructive critiques and insightful suggestions have greatly enhanced the depth, clarity, and rigour of this thesis. Thank you.

To the study participants — both parents and therapists — I offer my heartfelt gratitude. Your willingness to share your experiences and perspectives was vital to this research. Your reflections on the opportunities and challenges of using social robots for autism therapy provided indispensable insight for both the academic and ethical considerations of this work. Thank you.

A special thank you goes to Brendan Wylie-Toal and Ilona Koshy from the KidsAbility Centre, and to Carla Girolametto from the Waterloo Regional Health Network, Ontario, Canada, for their invaluable support in facilitating participant recruitment for this research. Your timely and dedicated efforts throughout the recruitment process made the insights of this thesis possible and actionable. Your enthusiasm and reliability left a lasting impact. Thank you.

Thank you to Serhiy Yarusevich and the University of Waterloo for making my studies here possible. These two years of my degree have been truly unforgettable and transformative — they changed my life completely. I am deeply grateful.

I am also grateful to the members of the Advanced Interface Design Lab for their advice, encouragement, and camaraderie. The supportive and lively environment of our lab made even the most demanding moments far more manageable. I will always cherish the thoughtful discussions, collaborative spirit, and laughter we shared along the way.

Lastly, to my family and friends, I owe my deepest thanks. Your unconditional love, patience, and unwavering support have been my anchor throughout this journey. Your belief in me has been an endless source of strength, and I could not have done this without you.

To everyone who has contributed to this thesis in any way, I remain sincerely and forever grateful. Thank you.

Dedication

I dedicate this thesis to those who need it and who may benefit from it. To the children with autism, their parents, therapists, and researchers—I hope you will find ways to integrate new technologies that make the challenges less overwhelming and the days more enjoyable for everyone involved.

I also dedicate this work to the Ukrainian students who pursued their education from bomb shelters, without electricity, and under missile attacks. Your resilience was both inspirational and invaluable to my own motivation. I especially dedicate it to my dear Ukrainian students who were unable to complete their degrees, those who lost their lives because of the Russian invasion of Ukraine. You will never be forgotten. Rest in peace.

And last, but never least, I dedicate this thesis to the defenders of Ukraine. Your courage and sacrifice protect my life and the lives of my loved ones — from death, captivity, and the suffering of occupation. You are true Heroes. I wish you happiness, love, and the pride of knowing that those you protect are building the future of Ukraine. Glory to Ukraine and its defenders! Слава Україні та її захисникам!

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List of Abbreviations

ABA Applied Behaviour Analysis [6](#)

ADDM Autism and Developmental Disabilities Monitoring [1](#)

ADOS-II Autism Diagnostic Observation Schedule, Second Edition [12](#)

AI Artificial Intelligence [48](#)

ASD Autism Spectrum Disorder [1](#), [3–5](#), [7](#), [8](#), [11](#), [13](#), [46](#)

CDC Centers for Disease Control and Prevention [1](#)

CRI child-robot interaction [8](#), [20](#)

DOF degrees of freedom [19](#)

DSM-IV Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition [5](#)

EMR Electronic Medical Record [48](#)

MPT Matching Person and Technology [9](#)

NAS,2003 National Autistic Society [5](#)

P1 Participant 1 [30](#)

P2 Participant 2 [29](#), [30](#)

P3 Participant 3 [31](#)

P4 Participant 4 [32](#)

P7 Participant 7 [33](#)

PEOU Perceived ease of use [9](#), [10](#)

PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses [13](#)

PU Perceived Usefulness [9](#), [10](#)

RCT randomized controlled trial [8](#)

TAM Technology Acceptance Model [ix](#), [x](#), [9](#), [22](#), [34](#), [43](#), [47](#)

TD typically developing [11](#), [15](#)

UTAUT Unified Theory of Acceptance and Use of Technology [9](#)

WRHN Waterloo Regional Health Network [26](#)

Chapter 1

Introduction

[Autism Spectrum Disorder \(ASD\)](#) is a developmental condition characterized by difficulties in social communication and interaction, alongside patterns of restricted or repetitive behaviours and interests [\[1\]](#). Recent estimates from the [Centers for Disease Control and Prevention \(CDC\) Autism and Developmental Disabilities Monitoring \(ADDMM\) Network](#) suggest that approximately 1 in 36 children are diagnosed with [ASD](#), with some individuals remaining undiagnosed or misdiagnosed until later stages of life [\[2\]](#). Numerous projects have been developed to facilitate therapy for children with autism and enhance interaction. Among other approaches, social robots have become a focus of research since 1998.[\[67\]](#)

Social robots are increasingly accessible tools that could provide a therapeutic experience and lead to meaningful improvements in children’s behaviour. Extensive research, including studies by Dautenhahn, Abbasi, Dickstein-Fisher, and the AskNAO initiative [\[5, 6, 7\]](#), has demonstrated the potential of robots in therapeutic sessions and home-based interventions for enhancing social skills. Investigations of both short-term and limited long-term outcomes by Amirova et al. [\[16\]](#), Jain et al. [\[49\]](#), and Javed and Park [\[50\]](#) have shown measurable improvements in key social interactions, including eye contact, verbal communication, and physical interaction. Robots are reported to be beneficial in autism therapy due to their capability to provide consistent interaction for extended periods, and the simplicity of the behaviours they can be programmed to exhibit. Robots such as QTrobot [\[59\]](#) and Buddy [\[58\]](#) are commercially available at prices ranging from approximately 1,980 to 4,179 USD.¹ In contrast, the NAO Robot [\[60\]](#), which may be more suitable for clinical settings, is priced between 6,600 and 14,000 USD¹. Cost is an important contextual factor influencing adoption decisions; however, it was not explicitly addressed in the analysis, as the market for social robots remains limited and there are currently no open market studies to guide cost-related considerations. Although the research presents positive results and social robots are available for purchase, the adoption of these tools remains limited.

According to the study by Vishwakarma et al.[\[61\]](#), social robots are primarily popular in the travel, tourism, hotel, and hospitality industries. Among the robots discussed, Pepper by Aldebaran Robotics was one of the first to adapt its behaviour based on customer mood,

¹All prices have been converted to U.S. dollars (USD) based on the exchange rate at the time of writing this thesis. Prices are subject to change at the manufacturer’s discretion.

which led to its widespread adoption for various customer service applications [62, 63]. The 2024 Social Robots Market Report by IMARC [64] identifies healthcare as the largest segment of the social robotics market. However, the results of the Statistics Canada Robotics Technologies Adoption Survey reveal that the actual adoption rate of robotics technologies in the healthcare sector is only 1%, including surgical, rehabilitation and mobility robots highlighted by Morgan et al. [66] as key focuses of robotic development. This discrepancy suggests that, despite optimistic market projections, the practical implementation of social robotics in healthcare remains minimal.

We observed that existing research has predominantly focused on demonstrating therapeutic efficacy for children [17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 44], often overlooking the critical perspectives of key decision-makers in the choice to adopt social robots—namely, parents and clinicians. However, beyond positive outcomes for children, factors such as cost-effectiveness, usability, and practical implementation play a significant role in the adoption of technology by caregivers and healthcare providers. The objectives of this thesis are to:

- Investigate current trends and focus areas in research on social robots used in autism therapy.
- Examine the expectations and perceptions of therapists and parents, as key early adopters of this technology.
- Identify existing gaps between research priorities and the practical needs and expectations of end users.

To achieve these goals, we first conducted a literature review to identify prevailing themes and directions in current research. This review was followed by interviews with therapists and surveys with parents to gain insight into their expectations and experiences with social robots in therapeutic contexts, and to assess how well these align with the research landscape.

This research makes several key contributions to the field of social robotics for autism therapy:

- Conducted a comprehensive review of the literature to systematically identify and analyze the gap between the technological capabilities of social robots and their real-world application in autism therapy.
- Identified opportunities to better align social robotic solutions with therapeutic needs, offering a roadmap toward more practical and impactful implementations.
- Collected and analyzed insights from key stakeholders - therapists and parents - to ensure that recommendations are grounded in real-world contexts and address the needs of those directly involved in therapy.
- Provided actionable guidance to help researchers, developers, and clinicians leverage social robotics more effectively, moving the field closer to realizing its potential to support and benefit autistic individuals.

1.1 Thesis Structure

This thesis is organized into seven chapters, each building upon the previous to investigate how social robots are perceived, evaluated, and potentially adopted in autism therapy settings. To address the research objectives, a mixed-methods approach was employed—integrating a systematic literature review, qualitative interviews with therapists, and quantitative surveys with parents. This design supports a triangulation strategy, allowing for the convergence of multiple data sources and strengthening the validity of the findings. Quantitative insights from closed-ended survey responses are complemented by qualitative data from open-ended questions and interviews, offering a holistic understanding of stakeholder attitudes and highlighting gaps between research trends and real-world expectations.

1.1.1 Chapter 1 – Introduction

The opening chapter introduces the research topic and situates it within the broader context of autism intervention and human-robot interaction. It outlines the central research questions and objectives, discusses the significance of the study, and provides a brief overview of the thesis structure.

1.1.2 Chapter 2 – Background and Related Work

This chapter offers the conceptual foundation necessary for understanding the study. It begins by discussing the characteristics of autism and the therapeutic needs of children on the spectrum. It then explores the development of social robots, their capabilities, and their applications in autism therapy. The chapter concludes with a review of current literature to identify themes, gaps, and emerging directions in this field.

1.1.3 Chapter 3 – Literature Review

Chapter 3 details the methodology and findings of a structured literature review on the use of social robots for [ASD](#) interventions. It outlines the eligibility criteria, data sources, and study selection process. Findings from the selected studies are synthesized around key categories including participant profiles, robot types, therapeutic objectives, outcomes, and methodological limitations. This review helps identify both the therapeutic potential of social robots and the barriers to their integration into clinical practice.

1.1.4 Chapter 4 – Interviews with Therapists

This chapter presents the methodology and results of qualitative interviews conducted with therapists who work with children with autism. It outlines recruitment strategies, data collection procedures, and the analytical approach used. The chapter then presents

themes that emerged from the interviews, including perceived usefulness, expected roles, preferences for robot design and customization, implementation challenges, and ethical concerns.

1.1.5 Chapter 5 – Surveys with Parents

Chapter 5 shifts focus to the perspectives of parents, presenting the design, implementation, and results of a structured survey. The chapter details recruitment, analysis methods, and summarizes the survey instrument. The findings are organized into thematic categories such as general beliefs about robots, attitudes toward their use in education and therapy, perceived benefits and concerns, and potential use cases in home environments.

1.1.6 Chapter 6 – Discussion

This chapter integrates findings from the literature review, therapist interviews, and parent surveys. It highlights areas of convergence and divergence between stakeholder expectations and existing research. The discussion addresses key ethical considerations, usability barriers, and the absence of clear clinical guidelines, as well as practical limitations encountered during the study. It proposes standardization and design priorities that could facilitate broader adoption of social robots in [ASD](#) care.

1.1.7 Chapter 7 – Conclusions

The final chapter summarizes the main findings and reflects on the research questions. It outlines the study’s contributions to both academic literature and practical implementation, and offers recommendations for future research and design. This chapter also emphasizes the importance of aligning technological innovation with the values and expectations of end users—namely, caregivers and clinicians—when aiming to integrate social robots into therapeutic settings.

Chapter 2

Background and Related Work

2.1 Autism

Autism is a developmental disorder defined by the [Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition \(DSM-IV\)](#) (1994), characterized by a wide range of strengths and challenges that vary significantly across individuals. Despite this diversity, all individuals diagnosed with autism share a core set of symptoms. According to the [National Autistic Society \(NAS,2003\)](#), these include three main areas of impairment:

- Social interaction – difficulties forming meaningful relationships, appearing aloof or indifferent, and struggling to understand others’ emotions or mental states.
- Social communication – challenges in both verbal and non-verbal communication, such as interpreting gestures, facial expressions, and tone of voice.
- Imagination – limited imaginative play and repetitive or rigid patterns of behaviour.

Additionally, individuals with autism often show resistance to changes in routine and display repetitive behaviours and narrowly focused interests. These traits reflect difficulty in understanding and adapting to the social aspects of the world, rather than physical limitations. Autism can be accompanied by learning disabilities, but this is not always the case. For instance, individuals with Asperger Syndrome, found at the higher-functioning end of the spectrum, may live independently and succeed professionally, often by learning explicit social rules rather than intuitively grasping social cues.

Research shows that the earlier intervention is provided, the less negative impact the disorder will have on the child [2, 3, 4, 5]. In fact, in some cases, a child can lose symptoms of [Autism Spectrum Disorder \(ASD\)](#) at a later age if diagnosed early (18-24 months old) and given intensive treatment [15].

Maciver et al. reported that waiting times for an autism diagnosis were significantly prolonged, with children and adolescents waiting an average of 525 days. This wait time is

notably longer than the recommended maximum of 252 days for all age groups. The study was conducted in Scotland [68].

Following diagnosis, families often face additional delays before receiving appropriate therapy. As of June 2024, Ontario’s autism program had 73,031 children on the waitlist for core therapy funding, while only 14,113 children were actively receiving funding at that time [86]. Moreover, the wait time to access therapy services from various providers in Ontario can range from three months to two years [87].

Autism therapies can be prohibitively expensive, with annual costs often exceeding \$40,000. These costs are especially burdensome for families without private insurance or supplementary health plans. Families living in rural areas or minority communities may face additional barriers to accessing timely and adequate care [88].

The most widely used and evidence-based approach for autism therapy is [Applied Behaviour Analysis \(ABA\)](#). The primary goal of [ABA](#) is to increase helpful behaviours and reduce harmful or disruptive behaviours that interfere with learning [89]. Therapy sessions typically last two or more hours, take place several days per week, and are tailored to each individual’s specific needs. A complete course of [ABA](#) therapy often spans two years or more [90].

A substantial portion of [ABA](#) involves repetitive learning of specific behaviours in targeted contexts [89], which presents an opportunity for social robots to support and enhance therapy delivery, especially during repetitive or routine practice tasks.

2.2 Social Robots

A social robot is an autonomous system capable of interacting and communicating with humans — and in some cases, other robots - by adhering to social behaviours and norms appropriate to its role within a group. Researchers commonly define social robots as physically embodied agents that engage in social interactions through verbal communication, cooperative tasks, and autonomous decision-making.[69] These robots are designed not only to perform functions but to foster meaningful social engagement with users. [57]

Social robots have a wide range of potential applications in society. They can serve as companions for the elderly or cognitively impaired, act as educators or teaching assistants, and support cognitive and behavioural interventions. In addition, they are increasingly used in educational entertainment, such as video games that combine fun with learning objectives [55].

Social robots are capable of fulfilling a wide range of roles. For example, they can act as conversational agents or storytellers [11], and even serve in commercial settings as service providers, such as waiters in restaurants. This role has gained attention both in recent research and the hospitality industry [91]. In everyday life, social robots appear in familiar forms such as robotic vacuum cleaners or voice-activated assistants like Apple’s HomePod with Siri.

In therapeutic contexts, social robots are most commonly used with older adults. One notable initiative, conducted in a hospital in Northern Ontario, involved using robots to help alleviate loneliness and improve communication among elderly patients. According to the project, the robots introduced new and engaging interactions that enriched the patients' daily lives [92].

Another study conducted at the University of Waterloo focuses on the use of robotic therapy pets to alleviate anxiety and stress among students.[93] Preliminary research suggests that interacting with these robotic pets can reduce feelings of loneliness, anxiety, and stress, contributing positively to student well-being.

2.3 Social Robots for autism

First, robots in the context of autism therapy were introduced in 1999 by Werry and Dautenhahn in their study "Applying mobile robot technology to the rehabilitation of children with autism," which was a part of the Aurora project. The study describes the design and iterations of Labo-1, the mobile robot platform, and discusses its benefits in therapy for children with autism.[70] The interactions were designed to be easy to interpret, safe, and non-overwhelming.

The first social robot to be developed specifically for autism therapy was Kaspar. It was designed at the University of Hertfordshire by Dautenhahn and Robins based on the research that originated in 1998 as a part of the Aurora project[67]. Key design principles included being user-driven, easy to use, reliable in real-world settings, safe for non-expert users, and affordable.

Such initiatives as "AskNao" [52] and "Nao robot goes to school" [48] continued explorations of the capabilities of robots for autism therapy. The results of those studies showed that children were more open towards the robot than towards a human [52] and stayed engaged for longer in the activities with the robot [48]. The collective feedback from teachers, parents, and therapists showed a positive attitude towards the new technology and satisfaction with the pilot results. The success of these studies increased the interest of researchers in the field, and different research teams have conducted numerous studies on social robots for autism therapy over the past 20 years.

As the number of studies has grown, according to Pennissi et al [53], the studies from the review revealed several trends: first, children with autism generally showed better performance when interacting with robots compared to human partners, particularly in areas such as eye contact, verbal responses, and reduction of stereotyped behaviours, such as hand-flapping, or repeating words and phrases, which are commonly observed in individuals with autism.[72, 73, 74, 75] Second, some studies found that children with ASD exhibited social behaviours toward robots that mirrored those typically seen in interactions between neurotypical children and humans, suggesting that robots can serve as effective social mediators.[76, 77] Third, higher levels of robot interactivity, such as combining gestures, speech, and gaze, consistently led to more positive outcomes than lower-stimulation interactions.[78, 79]

These trends highlighted the potential of social robots as valuable therapeutic tools, though the field still faced limitations, including small sample sizes - the studies, included in the review, had 12 participants with autism on average; inconsistent methodologies - every study used different robot and different activities to investigate the HRI; and a lack of long-term studies - the interventions didn't last longer than 2 weeks - exploring the generalization of therapeutic benefits beyond robotic sessions.

Later, the study by Huijnen et al. [50], through focus groups with developmental therapists and a systematic literature review, compiled a comprehensive list of 74 objectives across nine domains, including communication, social interaction, play, emotional well-being, and independent living, that are critical to deliver therapy to children successfully. However, their meta-analysis across multiple studies, involving 14 different robots, showed that these robots only addressed 24 of the identified objectives. These objectives were social interaction, communication, and play, domains most frequently addressed in existing research. However, objectives like self-care, preschool skills, emotional well-being, and daily functioning remained largely unaddressed by the robotic interventions in 2016, the time of the review.

A literature review by Salimi et al. [45] investigated the effectiveness of social robots for autism by analyzing [randomized controlled trials \(RCTs\)](#). The authors examined 19 studies, each evaluating robot-assisted interventions aimed at improving aspects of development in children and young adults with [ASD](#), such as joint attention, gesture production, verbal communication, and emotional regulation. Only some studies showed improvements when robots were included as facilitators or companions; others found no significant benefits compared to traditional approaches. Notably, the authors also reflected on the public and clinical perception of robotic interventions, emphasizing the current gap in clinicians' confidence due to limited long-term evidence and methodological inconsistencies across studies.

The study by Langer et al. [54] provides a higher focus on ethical considerations in [child-robot interaction \(CRI\)](#) across a broad range of developmental and educational contexts, rather than specifically targeting autism therapy. The authors explored the potential benefits and risks of long-term [CRI](#) on children's socio-emotional development, emphasizing that while social robots show promise in education, therapy, and home care, there are significant gaps in empirical research regarding their long-term psychological effects. Drawing on the perspectives of stakeholders such as teachers, parents, therapists, and children, the study identified widespread concerns about the potential for robots to hinder empathy development, replace human interaction, or foster unhealthy attachments. Though related to autism in part, the work offers valuable insights for the design of ethically acceptable robots.

Upon analysis of existing work, we noticed that the robotic designs were targeting the needs of patients with autism, which is essential. Still, it made us wonder if there is any benefit for those who will decide on the adoption of the robots into therapy, specifically therapists and parents of children with autism. Our first step is to examine the existing literature in this direction.

2.4 Technology Acceptance Model

The theoretical framework adopted in this work to investigate the acceptance of social robots for therapy is the [Technology Acceptance Model \(TAM\)](#) [94]. Other models of technology adoption, like the [Unified Theory of Acceptance and Use of Technology \(UTAUT\)](#), the [Matching Person and Technology \(MPT\)](#), and the extended TAM, were considered but had some disadvantages compared to TAM.

The [UTAUT](#) incorporates broader constructs such as social influence and facilitating conditions that may be difficult to capture in small-scale or early-phase studies. [96] In contrast, TAM emphasizes the most immediate determinants of adoption. [94] This simplicity makes it more practical to implement in studies involving novel interventions like social robots and more relevant for generating insights directly applicable to therapists’ and parents’ decision-making.

The [MPT](#) model [95] is highly valuable for individualized technology selection, as it includes assessment measures to match users with suitable technologies and investigates patterns among adopters, non-users, and reluctant users. [MPT](#) is primarily diagnostic and decision-oriented, focusing on matching individuals to available tools. [95]. However, this study does not aim to personalize technology choices for individual children or therapists, but aims to understand broader perceptions of usefulness and ease of use that drive acceptance of social robots.

The Extended TAM model broadens the original TAM by adding external variables such as self-efficacy, facilitating conditions, or system quality. [97] Although it offers broader sets of components, original TAM was chosen for this study because of its simplicity, established use in studies of health technologies, and emphasis on individual perceptions of usefulness and ease of use, factors especially relevant to therapy settings where both professionals and parents must feel confident in the deployment of new tools.

Thus TAM was considered the most appropriate framework for this study.

TAM has been widely applied in studies of innovative technology adoption and provides a structured lens to examine users’ perceptions and intentions. It originates from behavioural theories such as the Theory of Reasoned Action and the Theory of Planned Behaviour, and has since become one of the most commonly used models for technology adoption research.

The model focuses on two key constructs:

- [Perceived ease of use \(PEOU\)](#) – “the degree to which a person believes that using a particular system would be free of effort” [94],
- [Perceived Usefulness \(PU\)](#) – “the degree to which a person believes that using a particular system would enhance their job performance” [94].

These constructs shape user attitudes toward a system, which in turn influences behavioural intention and actual use. In this study, TAM served as a guiding framework for

the design of interview questions, coding of qualitative data, and interpretation of findings. By structuring the investigation around **PEOU** and **PU**, the model enabled a systematic exploration of how therapists and parents perceive the benefits and challenges of integrating social robots into therapeutic practice.

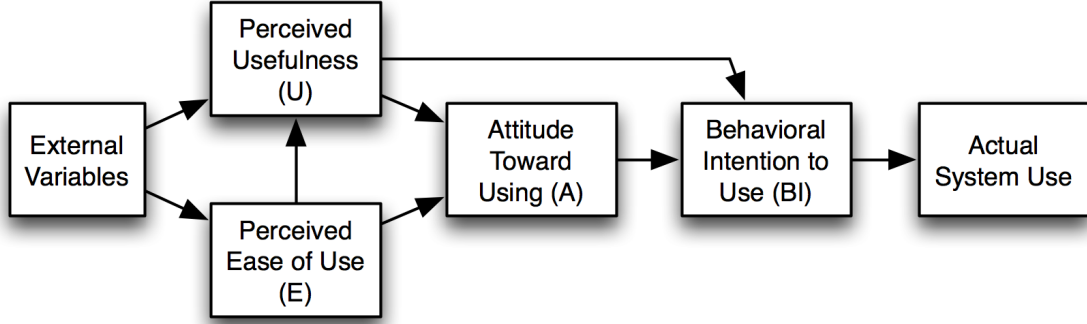


Figure 2.1: Technology Acceptance Model (TAM) [94]

This study focused on the constructs of **(PU)** and **(PEOU)** because these could be meaningfully explored through interviews and surveys without requiring participants to directly interact with or observe a social robot. By contrast, the analysis of Attitude (A) and Behavioural Intention (BI) would necessitate a different study design, where participants are exposed to a robot and their subsequent reactions, evaluations, and future usage intentions are systematically measured. Since such conditions were beyond the scope of the present work, Attitude and behavioural Intention were not included in the analysis and are important areas for future research. It should be noted that cost, while highlighted in **1** as one of the key barriers to the adoption of social robots, is not explicitly included in the analysis. Where relevant, participant comments about affordability and sustainability were considered alongside the primary constructs of **PEOU** and **PU**.

Chapter 3

Literature Review

This section outlines the specifics of the literature review conducted to achieve the research objectives and details the data collection and analysis processes.

The main objective of the review was to investigate current trends and focus areas in research on social robots used in autism therapy. Given the relative scarcity of studies specifically addressing adoption, we conducted a literature review to identify the patterns in social robotics research with a view to understanding the gaps better. In particular, we wanted to identify potential reasons why gaps exist between the academic and real-world expectations, discussing the challenges and opportunities for integrating social robots into therapeutic practice.

3.1 Methods

3.1.1 Eligibility Criteria

Study Design

We included studies involving more than one participant group, with at least one serving as a control group. Both types of control groups—children with [typically developing \(TD\)](#) and children with [Autism Spectrum Disorder \(ASD\)](#) not receiving robotic intervention—were considered relevant, as they allowed for meaningful comparisons of therapy outcomes. This criterion was important to ensure that studies presented comparable and measurable improvements from robotic therapy, making their findings more reliable and relevant for therapists and parents. Case studies were also recognized as an important source of evidence. However, they were not included because their outcomes are not directly comparable across participants or studies. No specific study design was required for inclusion. We excluded commentaries, letters to the editor, and study protocols.

Participants

Studies that included children aged 3 to 12 years were eligible. At least one group in each study had to include participants with a confirmed autism diagnosis. Most studies consider a child to have a confirmed autism diagnosis when they undergo the evaluation by the [Autism Diagnostic Observation Schedule, Second Edition \(ADOS-II\)](#) or another certified evaluation by a developmental specialist.

Objectives

The primary objective of the studies was therapeutic benefit. This is because therapeutic benefit is required for technology adoption. For this reason, studies focusing primarily on technological advancements rather than participant outcomes were excluded. Studies evaluating adoption or user experience for robots that had already demonstrated therapeutic benefit were analyzed together with the corresponding therapeutic benefit studies, if conducted by the same research team. If such adoption studies were based solely on robots developed by other teams, only the therapeutic benefit data were analyzed.

Exposure

Eligible studies included at least one group exposed to robot-assisted therapy. The nature of activities and outcomes varied depending on the study objectives.

Uniqueness

If multiple articles were published by the same research team on the same technology (robot or robotic framework), only one was included to avoid redundancy, unless the interventions differed significantly (e.g., different activities or robots). In such cases, both studies were included.

Publication Date and Language

The search was limited to articles published between January 2016 and December 2024 for the following reasons:

- To avoid overlap with existing literature reviews, many of which focused on articles published before 2016.
- To capture the recent state of the field, given the significant technological advancements since the 1990s.

Only articles published in English were considered.

3.1.2 Sources of Information

A comprehensive search was conducted using PubMed, Scopus, and IEEE databases.

The search strategy was developed in consultation with a librarian from the University of Waterloo.

The search query used across all databases was:

("social interaction" OR "social skills" OR "communication" OR "social development" OR "social engagement") AND ("robot" OR "robotics" OR "social robot" OR "social robotics" OR "robotic therapy" OR "robot-assisted" OR "robot-mediated" OR "robotic companion" OR "robot-based" OR "robot based") AND ("autism spectrum disorder" OR "autism" OR "ASD" OR "disorder" OR "behavioural disorder" OR "behavioural disorder") AND ("children" OR "pediatric*" OR "child" OR "kids*")

Date filters were applied to restrict the results to the selected publication window.

3.1.3 Study Selection Process

The initial search yielded 720 articles. Due to resource constraints, a single-reviewer screening process was adopted. The reviewer followed established guidelines and applied the eligibility criteria rigorously to minimize bias.

Search results were uploaded and de-duplicated using Covidence, an online platform designed to streamline screening and data extraction.

During the title and abstract screening phase, studies were included if either the title or abstract indicated that the objective involved therapeutic benefits from robotic intervention. This screening resulted in 200 studies that focused on the use of robots for therapy.

Full-text articles of potentially relevant studies, and those without available abstracts, were reviewed in detail by the same reviewer. The study selection process was documented using a [Preferred Reporting Items for Systematic Reviews and Meta-Analyses \(PRISMA\)](#) flow diagram, including reasons for excluding full-text articles (Figure 3.1).

Ultimately, 28 articles were included for final analysis. Among these, three studies [34, 39, 44] were identified as sub-studies by the same research teams and were analyzed in conjunction with their corresponding primary studies [21, 40, 43].

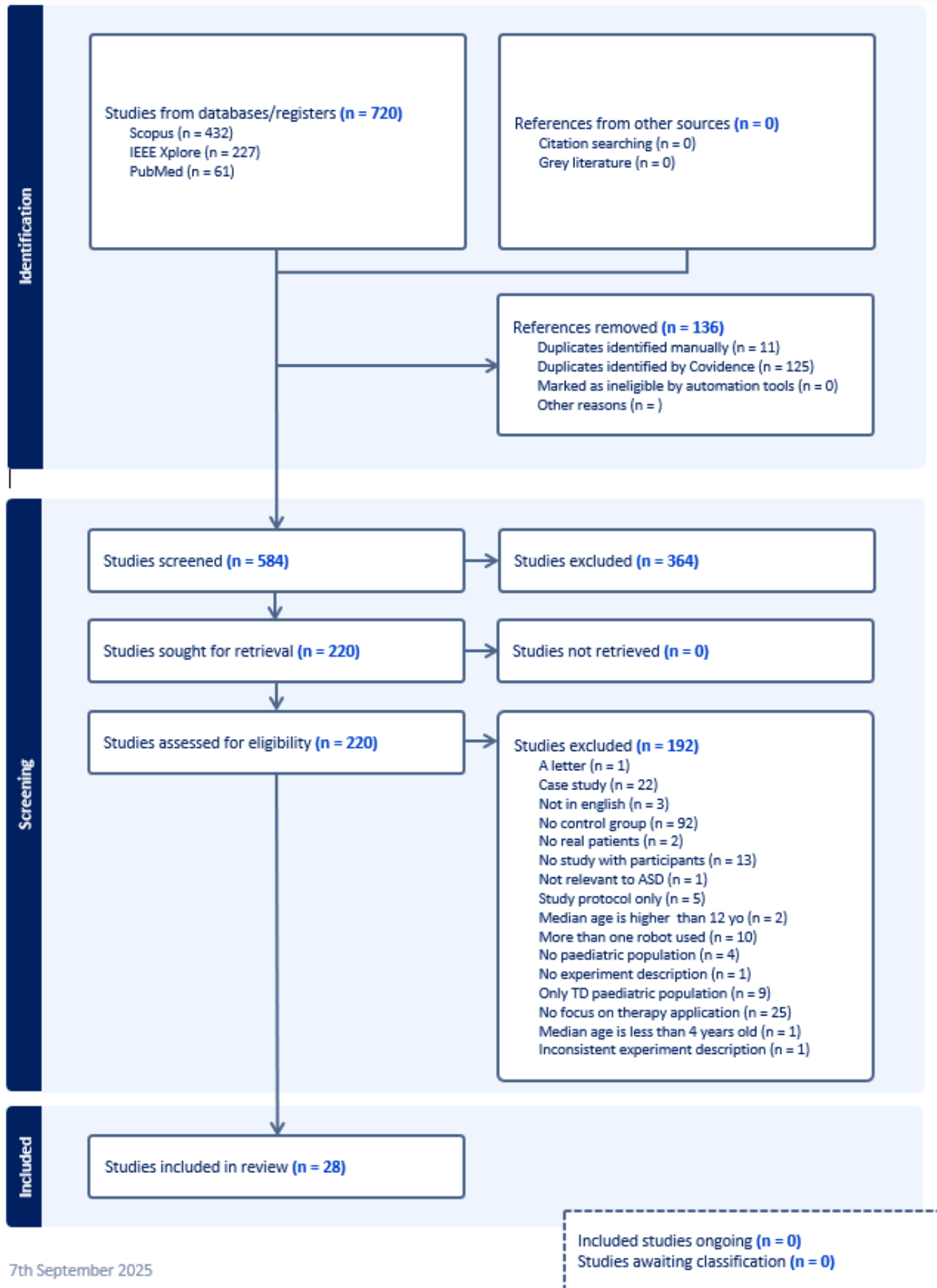


Figure 3.1: Study selection flow diagram

3.2 Findings

Twenty-eight studies were reviewed[17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44], covering 15 different social robots designed for autism therapy. The papers were analyzed by the categories: Participants, Robots Used, Objectives Addressed, Robotic Role in the Intervention, Generalization of Skills, and Outcomes.

3.2.1 Participants

The number of participants involved varied from 6 to 73, with a median of 20 children per study. Six studies involved TD participants for comparison of their interactions with the robot[20, 26, 27, 29, 35, 37], one study involved TD children for baseline comparison, but they didn't receive a robot-based intervention[43]. On average, 13.5% of TD children were engaged with a maximum of 40 TD pupils. The other studies included only autistic children as participants.

3.2.2 Robots Used

The analysis of the robots used reveals some interesting trends. Twelve different research teams[18, 22, 24, 26, 27, 28, 30, 35, 36, 40, 42, 43] used the Nao robot from Aldebaran Robotics. In contrast, the other 14 robots used were CHARLIE the Robot[32], CuDDler A*Star[31], Furhat[37], Kaspar[33], MARIA[20], iRobiQ[38], Caro[38], The Ball[41], Bee-Bot Robot[23], Cozmo[21], ONO[17], ZECA[25], Bliss[19], and Pekoppa[29]. In each of these cases, only one study reported using this type of robot.

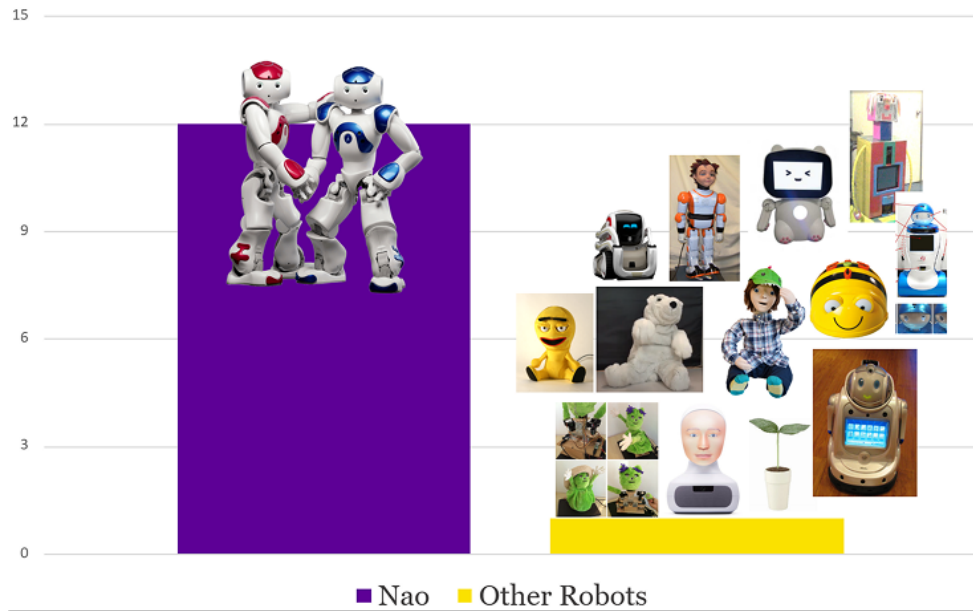


Figure 3.2: Robots Used

The appearance of the robots varies significantly, as shown in Figure 3.2, with humanoid designs being the most common. 11 robots feature faces, displaying either static or changeable expressions, with static expressions typically being neutral or smiling. Additionally, 8 out of the 14 robots have both upper and lower limbs, contributing to a generally humanoid-like form.

In contrast, some robots exhibit entirely different appearances. For example, the Bee-Bot Robot [23] resembles a honey bee, featuring a static smiling face and control buttons on its back, while Pekoppa [29] takes the form of a plant, with 2 leaves and the ability to bend its stem in response to interaction.

3.2.3 Therapy Objectives Addressed

According to Huijnen et al[50], four domains of objectives should be addressed by therapy: Communication, Play, Social, and Self-Care. This research was conducted in 2016, so it was interesting to understand if any new objectives were addressed.

Domain	Objective	Robot
Play	Cognitive, Motor and turn-taking skills	Nao
Communication	Improve VPT skills	iRobiQ , CARO, Kaspar
	Contact: eye gaze, touch	Maria
	Attention	Bee Bot
	Conversation (talk and body language)	Nao, Bee Bot
	Speech prosody	Furhat
	Gestures recognition	Nao
	Gestures imitation	Nao
	46	Nao
	Requesting	The Ball
Social	Offer Help	Nao
	Imitation (body language, emotions)	Nao, Maria, Zeca, Charlie
	Emotion identification and discrimination	Nao, Zeca, Bee Bot
	Joint attention	Nao, ONO, Cozmo, CUDDLER A*STAR, Charlie
	Turn-taking	The Ball, Charlie, Nao
	Problem-solving skills	Nao
	Coping-mode selection	iRobiQ , CARO
	Initiation of interaction	iRobiQ , CARO
Self-care	Emotional self-regulation	Nao
Mediator	Learning with parents	Bliss
	Facilitator of emotions	Pekoppa

Figure 3.3: Objectives addressed

All objectives are presented in Figure 3.3. Green shows the newly addressed objectives that haven't been marked as addressed by any robot in Huijnen et al[50]. The red colour indicates an objective that, according to the research, was addressed unsuccessfully by robotic intervention.[17, 18, 30, 31, 35]

Self-care and independent living, which includes: potty training, eating/drinking, (un)Dressing, self-care, personal hygiene, domestic skills, mobility, hobbies and leisure time; Respect/value

others; Learn a new form of communication; Develop interest in play; Variation in play, and Rules negotiation were left unaddressed by any of the analyzed studies.

3.2.4 Robotic Role in the Intervention

The robots are playing various roles, as shown in Figure 3.4. The purple colour indicates the part of the study with the Nao Robot. For easier classification of the robotic roles in interventions, all roles that explored activities fully led by the robot with only a child and a robot as actors, with no or minimal supervision, were called 'Instructor'. All roles, where a robot had a leadership role but encouraged the interaction with a child and another human actor and the activities were controlled by the human actor, were called 'Mediator'. The 'Instructor/Mediator' role also included the third human actor, but in this case, activities were led by the robot. Listener, Reinforcement agent and the Recipient of help are the specific roles that appeared in the studies.

12 out of 26 studies investigate the 'Instructor' role of the robot. [32, 31, 37, 33, 20, 44, 26, 40, 27, 42, 36, 27]

The next most popular robotic role is 'Mediator' with 6 studies researching it. 4 studies investigated the blend of two – Instructor and Mediator – roles. Such roles as 'Listener' [29], 'Reinforcement agent' [19], and the 'Recipient of help' [35] were specific to the studies and explored only once.

Most studies investigate the 'Instructor' role of the robot, where activities are led solely by the robot, with or without therapist supervision. However, multiple studies have shown that the combination of robot-assisted and traditional therapies yields better and faster results[22, 27, 38, 39, 42] in children than an intervention led solely by a robot.

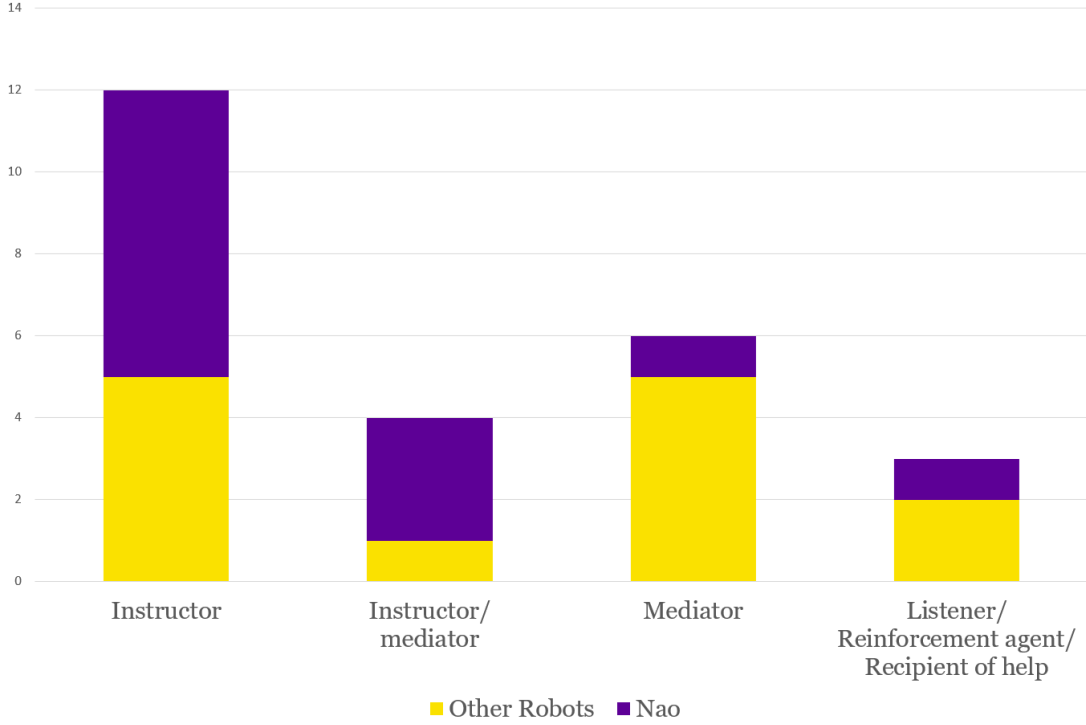


Figure 3.4: Robotic Role in the Intervention

3.2.5 Generalization of Skills

Out of four studies that assessed the generalization of learned skills, three showed successful generalization of gesture and emotion recognition skills.[17, 39, 42] Generalization of helping and social verbalization skills was not successful.[35, 41]

3.2.6 Outcomes

Figure 3.5 shows the comparison of positive, neutral, and negative results. Positive outcomes suggest that the improvements resulting from robotic intervention are better than those in the control group. Neutral means that the difference is not significant, but it still shows improvement from the start. Six studies showed negative results for joint attention, helping, and prosodic skills. It is an interesting result, considering that Joint Attention is the most often assessed skill from the list of objectives.[20, 22, 30, 32, 37, 40] One study didn't find any improvements in social and communication domains.[26]

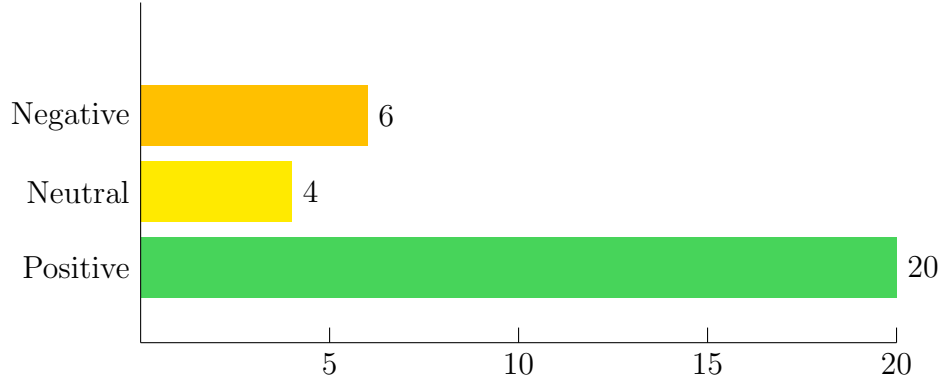


Figure 3.5: Outcomes

3.3 Data Analysis

We carefully considered the results and suggest the following considerations.

3.3.1 Choice of robot

As shown in Figure 3.2, there are 15 different robots with distinct appearances in total. The most commonly used is the Nao robot by Aldebaran Robotics, chosen by 12 out of 26 research teams, highlighting researchers’ preference for this platform in autism therapy studies.

However, this variety can be overwhelming and may complicate the selection process for therapists considering the use of social robots in interventions. Some robots, such as the QTrobot and Buddy Robot, are available for purchase. However, we did not include them in the analysis due to a lack of studies involving at least two participant groups for testing. More research on these robots would be beneficial to support evidence-based decision-making for clinicians.

A robot that is relatively accessible is the Nao robot, and there is a clear trend toward its use in interventions, as shown in Figure 3.2.

The Nao robot is an excellent choice for academic teams due to its versatility and extensive capabilities. It offers 25 [degrees of freedoms \(DOFs\)](#), enabling a wide range of natural and complex movements. Equipped with 7 touch sensors, 4 directional microphones, and speakers, Nao facilitates rich interactive experiences. It supports 20 different languages, making it suitable for diverse user groups. The robot includes 2 built-in 2D cameras for visual perception and operates on an open, fully programmable platform, allowing researchers and developers to customize and expand its functionalities to meet specific project needs [\[60\]](#).

However, for real-life application in autism therapy, using the Nao robot is neither practical nor advisable. One major concern is its cost, averaging around 11,000 USD

(depending on features and whether the unit is new or used). Other significant drawbacks include:

- The robot weighs 5.48 kg (12.08 lb), which is arguably too heavy for toys intended for children under 12 years old.
- It lacks a dedicated user interface for therapists.
- It does not have expressive facial features;
- Its advanced features and capabilities make it overly complex for simple interactions.
- The joints are easily accessible and contain sharp edges, posing a potential safety hazard during [child-robot interaction \(CRI\)](#).

Additionally, according to the Nao Robot Safety Guide published by Aldebaran Robotics [82], the robot is not intended for use as a toy and is not suitable for unsupervised interactions, as illustrated in Figure 3.6.

WARNING: Even if I look human, I am still an object. I am not intended for use by children under 14 years old, or any person with reduced physical, sensory or mental capabilities, or lack of experience and knowledge, unless:

- supervised by a person responsible for their safety and who has read and understood these instructions, or
- if they are 14 years old and above, have been given instructions concerning my use in a safe way and understand the hazards involved.

- Other children should be suitably supervised to ensure that they do not play with me.
 - Do not allow to use me as a toy.

Figure 3.6: Nao Robot Safety Guide - Usage [98]

Another concern is the robot’s non-compliance with ISO 8124-1:2022 [81], which outlines safety requirements for children’s toys. According to the safety guide, the robot has multiple joints with sharp edges that are easily accessible, as shown in Figure 3.7.

- **CAUTION:** avoid carrying and touching me when I am moving, walking or getting up, you could be severely pinched. My joints are analogous to the articulations of your own human body.
- More specifically: Do not place your hands in any of my joints as shown in Figure 3, as you could be severely pinched.

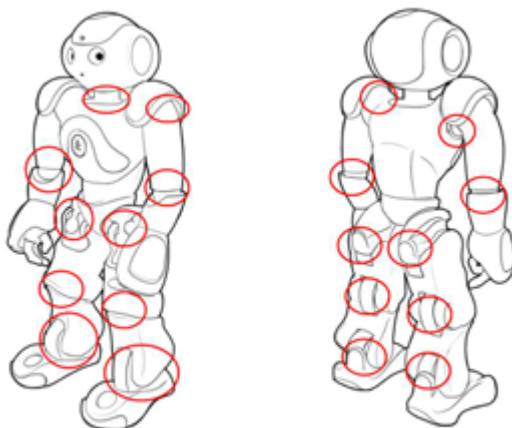


Figure 3: Keep fingers out of the joints!

Figure 3.7: Nao Robot Safety Guide - Joints [98]

Due to these mismatches between the robot’s use in research, applicable safety standards, and the manufacturer’s intended use, we conclude that the Nao robot is not an appropriate tool for autism therapy.

Although it is a convenient and powerful platform for researchers, it is impractical for real-world clinical use. It is expensive, heavy, not child-safe, and lacks a built-in therapist-friendly interface. These are critical factors when evaluating whether a robotic tool is suitable for autism interventions.

3.3.2 Role of the robot

There is a clear trend toward positioning robots as “Instructors”, as discussed in the Findings subsection 3.2.4. While this role showcases the robot’s autonomy and capability in research, it may raise concerns among clinicians, who could perceive such positioning as a threat to their professional roles or as an attempt to replace human-led therapy. This perception could potentially hinder the adoption of robotic technologies in therapeutic settings.

Furthermore, multiple studies have demonstrated that assigning robots a “Mediator” role — in which they facilitate interaction between the clinician and the child — leads to better therapeutic outcomes and supports greater generalization of skills compared to approaches involving robots as the sole providers of therapy. This mediator framework

allows robots to enhance, rather than replace, human interaction, which may improve both clinical effectiveness and acceptance among practitioners.

3.3.3 Clinically relevant outcome measures

A clinically relevant outcome measure in any intervention is the ability to generalize learned skills beyond the therapy setting. Generalization indicates whether skills acquired during sessions can be effectively applied in interactions with different individuals and across various real-life contexts. [83]

Despite its importance, only 5 out of 28 studies [17, 39, 42, 35, 41] reviewed reported outcomes related to generalization, suggesting a significant gap in evaluating this critical aspect of intervention effectiveness.

In addition, joint attention — a foundational social-communication skill often targeted in robot-based autism interventions — showed inconsistent outcomes across studies. While some research reported significant improvements, others found minimal or no measurable progress. These mixed and sometimes contradictory findings underscore the need for further research to identify the specific factors influencing the development of joint attention in robot-assisted therapy and to establish more robust, clinically relevant evaluation criteria.

3.4 Exploring Researchers’ Attitudes Toward Social Robots Through Technology Acceptance Model (TAM)

Multiple stakeholders are involved in the adoption of social robots for autism therapy, including researchers, therapists, parents, and children. Each group has distinct perspectives on what is useful and easy to use, and these differing viewpoints can significantly influence the likelihood of further adoption and actual use of the technology, as described by the TAM. Based on the tasks and objectives of the analyzed studies [17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44], we drew the following conclusions about researchers’ perceptions of usefulness and ease of use of social robots, as explicit justifications for robot choice were rarely provided.

3.4.1 Perceived usefulness

According to the literature, the key factors that make a robot useful in research contexts include its ability to make gestures, communicate effectively, be programmable, and exhibit sufficient flexibility to perform a variety of movement tasks. In these respects, the NAO robot has been widely regarded as well-suited for research purposes.

In contrast, within therapeutic contexts, the priorities may shift toward simplicity, expressiveness, safety, and durability. Here, a robot may need to be designed to operate

reliably in repeated sessions, maintain a child’s engagement without unnecessary complexity, and ensure safe interaction.

In therapy, social robots have been successfully applied to engage children in gesture and emotion recognition tasks and to increase their interest in therapy sessions. However, evidence for their ability to promote helping-related behaviours is lacking, and findings regarding their effectiveness in stimulating joint attention are mixed.

From a research perspective, the most frequently utilized—and arguably most useful—role for a social robot is that of an *Instructor*. This role is often favoured because it does not require active therapist involvement, thereby simplifying the research process and standardizing interventions. However, another role, the *Mediator*, may be more reflective of a realistic therapeutic setting, as it positions the robot as a bridge between therapist and child. Studies suggest that the ‘Mediator’ role can be more effective than interventions delivered solely by a robot or solely by a human.

Notably, no research was found on the potential of robots to facilitate the establishment of rapport with a newly met child — an ability that could be critical in therapeutic settings. Likewise, while therapists express high demand for robots that can serve as *Data Collectors* — automating the tracking and recording of child behaviour — this role remains largely underexplored in current research.

3.4.2 Perceived Ease of Use

For researchers, a robot’s ease of use is closely associated with its flexibility and programmability, as these features allow for precise customization of experimental protocols. This perspective, however, contrasts with that of therapists and parents. Among the 28 studies reviewed, 11 [29, 42, 41, 22, 33, 40, 24, 19, 38, 18, 21, 27, 36, 25] reported feedback from therapists, educational specialists, or parents. Children’s perspectives were not systematically reported; however, several studies noted children’s satisfaction with the appearance and behaviour of certain robots, as well as the development of attachment in longer interventions. Four of these studies [22, 24, 38, 40] specifically included parental feedback collected through questionnaires and/or interviews. In particular, a study [24] conducted follow-up interviews with parents, who reported the results of robot-based interventions for their children in real-life contexts.

Other studies [29, 42, 41, 19, 18, 21, 27, 36, 25] focused on collecting feedback from therapists or educational specialists, while one study [33] incorporated input from the general population to validate the explanations presented by the robot.

Therapists may require robots that are both adaptable to the unique needs of each child and equipped with a structured interface and preconfigured features. Such a design would allow therapists to prepare the robot quickly for each session, minimizing technical overhead while still enabling personalization.

Parents, on the other hand, may be generally less concerned with extensive customization, as they are likely to use the robot primarily with their child. For them, consistency in features such as the robot’s voice, personality, reinforcement type, and activity set may be

preferable. Their main requirements may be a straightforward setup, minimal supervision, particularly important given that many families with children with autism also have other children to care for, and a high degree of safety in operation.

For children, ease of use is associated with how naturally they can interact with the robot. This includes intuitive verbal or nonverbal communication, responsiveness to the child’s behaviour, and the ability to sustain engagement without requiring complex instructions or interventions.

3.4.3 External Factors

In addition to perceived usefulness and perceived ease of use, several external factors influence the adoption of social robots for autism therapy. Cost is a significant barrier, as many of the robots used in research, such as NAO, require substantial investment for purchase, maintenance, and repair. These costs are often prohibitive for individual therapy practices or families without institutional funding.

Government or institutional support can also determine adoption rates. In settings where funding, training programs, and technical assistance are available, the likelihood of adoption increases. Conversely, in contexts without such support, even highly effective technology may remain unused due to a lack of resources.

Other external considerations include the availability of local technical support, the robustness of the robot in real-world therapy environments, and compatibility with existing therapy workflows. Regulatory guidelines, ethical concerns, and data privacy requirements may also influence whether organizations choose to integrate robots into their practice.

3.4.4 Gaps to Explore

The literature suggests that the adoption of social robots for autism therapy is shaped by a combination of perceived usefulness, perceived ease of use, and external factors such as cost and institutional support.^[94] High purchase and maintenance costs, limited government or organizational funding, and a misalignment between research-oriented designs and the practical needs of therapy settings contribute to cautious attitudes among therapists and parents.

Therapists often recognize the potential of social robots but may hesitate to integrate them into practice without clear evidence of long-term therapeutic benefits, simple and reliable session preparation, and consistent performance across diverse scenarios. Parents, while intrigued by the novelty of the technology, might tend to prioritize safety, ease of setup, minimal supervision, particularly in households with multiple children, and observable improvements in their child’s outcomes. In both groups, the absence of these assurances often results in low intention to use.

The review highlights a significant research-to-practice gap: while the perceived usefulness of social robots has been well explored in controlled research contexts, far less is

known about their usefulness and usability from the perspectives of therapists and parents, who are the primary decision-makers in real-world adoption. Existing studies rarely address how these stakeholders define "usefulness" or what design features would make robots genuinely easy to integrate into daily therapy routines.

While we have proposed some reasons for the gap in social robot adoption, we need to investigate:

- How therapists and parents define the usefulness of social robots in autism therapy.
- The specific features and roles they find most valuable.
- The practical barriers they face in integrating robots into therapy, including cost, preparation time, and reliability.
- How safety, ease of setup, and customization requirements vary between therapists and parents.
- The external supports (e.g., funding, technical assistance, training) necessary to increase intention to use.

The upcoming interviews and surveys with therapists and parents are designed to address these gaps, validating whether the trends observed in the literature align with real-world perceptions. The findings will help inform the development of social robots that are better aligned with the needs, expectations, and constraints of their intended users, thereby increasing both intention to use and likelihood of adoption.

Chapter 4

Interviews with Therapists

4.1 Methods

After analyzing the current research trends, we aimed to assess how they align with the expectations and needs of key stakeholders. Following careful consideration and thorough evaluation, we chose to conduct interviews with therapists, as they are likely to be among the first to adopt social robots in therapeutic settings. Moreover, therapists offer a broader perspective on autism, informed by their experience with diverse individuals, in contrast to parents who primarily focus on their own child’s unique needs.

The study design included semi-structured interviews that were conducted to gather in-depth insights from clinicians who met both of the following eligibility criteria: 1. Therapists who provide therapy to children with autism and/or other developmental disorders. 2. Therapists who focus on improving children’s social skills through therapeutic interventions.

The interviews explored clinicians’ expectations, perceived usefulness, the role of robots in therapy sessions, and the decision-making process involved in adopting social robots.

To assess coding reliability, 30% of the interviews were independently coded by a second, blinded reviewer. The inter-coder agreement, as measured by Cohen’s Kappa, was 85%. The disagreements were solved through a discussion.

This study received ethical approval from the University of Waterloo’s Office of Research Ethics (REB #46471). Written informed consent was obtained from all participants before the interviews.

The subsequent sections discuss the recruitment approach, study materials, and analysis method. Appendices [A](#) and [B](#) contain the recruitment and study materials.

4.1.1 Recruitment

Following ethics approval, recruitment was conducted from March 1, 2025, to April 1, 2025. KidsAbility Centre and the [Waterloo Regional Health Network \(WRHN\)](#) in Kitchener-Waterloo, Ontario, supported participant recruitment by distributing the research posters

and email invitations among their staff. The inclusion and exclusion criteria for the participants are presented as follows:

Therapist Inclusion Criteria:

- Must be a registered developmental therapist practicing in Canada
- or
- Must be actively providing therapeutic interventions to children with autism and/or other developmental disorders to improve their social skills.

The exclusion criteria were the inability to read and write in English, as the study was conducted in English.

Therapist recruitment was conducted through the professional networks of the research team and collaborators, including KidsAbility Centre and the Waterloo Region Health Network. Invitations were distributed via email and physical posters, with recipients encouraged to share the invitation within their networks, facilitating snowball sampling. This strategy was essential for engaging a population that is often difficult to recruit.

Snowball sampling is sometimes criticized for its limited generalizability, as it may lead to homogeneity in participants' experiences or viewpoints [80]. To mitigate this bias, we recruited across multiple independent networks, which helped capture a broad range of perspectives.

Therapists received an informational letter and a link to a screening survey designed to assess their eligibility for participation. Those who met the eligibility criteria were invited to book a time slot for an interview. Upon completion of the interview, each participant received a remuneration of CAD 150 per hour in appreciation of their time and contributions. A total of 10 clinicians completed the interviews.

4.1.2 Data Collection

Interviews were the primary method of data collection used to gain in-depth qualitative insights from therapists regarding their professional experiences, values, and perspectives. All eligible participants took part in a one-on-one interview session conducted online via MS Teams, each lasting approximately one hour. Before the interviews, therapists completed an eligibility survey (see Appendix B), which included the consent letter and requested their agreement to participate. Participants had access to all relevant information in advance and were allowed to ask questions before the start of the interview.

The interviews focused on therapists' expectations of the tool, their perception of its usefulness, the role they envisioned for the robot in therapy sessions, and their decision-making process regarding the adoption of social robots in clinical practice. If a therapist was not familiar with social robots before the study, they were shown pictures of well-known examples, like Nao and QTrobot (mechanical appearance), Kaspar (human-like),

and Paro (animal-like), along with a brief explanation, similar to this: *“A social robot can take different forms. One example is the robot shown on the screen, and in this study, we are focusing on actual physical robots. A social robot is designed to display social cues and engage in simple, structured social interactions. This makes it particularly useful for children with autism, as it can repeat social cues as many times as needed to support understanding. Research has shown that this repetition and predictability can be beneficial for supporting social learning in autism therapy.”*

A semistructured format guided the interviews using prepared questions (see Appendix B), allowing for flexibility to tailor the discussion to each participant. This structure enabled consistency across sessions and allowed participants to explore relevant themes in a participant-led manner. The interviews were recorded for transcription purposes, with participants’ informed consent. All details regarding the recording’s purpose, handling, retention period, and withdrawal process were provided in the consent materials.

4.2 Data Analysis

Data collected from clinician interviews were synthesized to provide a comprehensive understanding of stakeholder expectations, perceived usefulness, and adoption factors related to social robots in therapeutic contexts.

Interview data were transcribed and analyzed using reflective inductive thematic analysis to uncover underlying values, expectations, and concerns among clinicians. The transcription process involved both a primary coder (the author, a graduate student) and a secondary coder (a graduate student), both of whom were trained in qualitative data analysis. Interview recordings and auto-generated transcripts from Microsoft Teams were manually reviewed and edited to ensure accuracy and readability. Transcriptions were not verbatim; filler words, false starts, and repetitive speech were removed to enhance clarity and support efficient coding.

To begin the thematic analysis, the coders independently familiarized themselves with the data and generated preliminary codes for a subset of the transcripts. These initial codes were compared and aligned through discussion, after which the primary coder completed the coding for the full dataset. Similar codes were grouped into clusters, from which broader themes and subthemes were derived. Coding was conducted using NVIVO 14 for the primary and secondary coders, respectively.

The reflective inductive approach allowed for themes to emerge directly from the data without imposing a pre-existing framework. This was critical given the exploratory nature of the study and the goal of capturing authentic user perspectives on a relatively novel therapeutic technology. Subthemes were developed as needed to clarify specific areas of concern or emphasis and to ensure alignment with the study objectives. The secondary coder reviewed the revised structure for consistency and coherence, serving as a check on potential bias or misinterpretation.

Findings from this analysis are presented in section 4.3.

4.3 Findings

The interviews followed a consistent structure, using a set of predefined questions aimed at assessing participants’ existing knowledge of social robots in therapy and their expectations regarding their use. Based on the responses, seven primary themes were identified: Perceived Usefulness, Robotic Role, Robotic Appearance, Customization, Concerns, Decision-Making, and Implementation.

4.3.1 Participants

We conducted one-hour online interviews with ten registered therapists or clinicians actively providing social skills interventions for children. All participants who expressed interest in the study identified as female, consistent with existing research suggesting that approximately 97% of developmental therapists are women [51].

Demographic information was provided by six participants, as submission of this information was voluntary. These respondents were aged 25–40, with one participant over 45. Participants’ professional work settings are shown in Figure 4.1. All participants reported having two or more work environments.

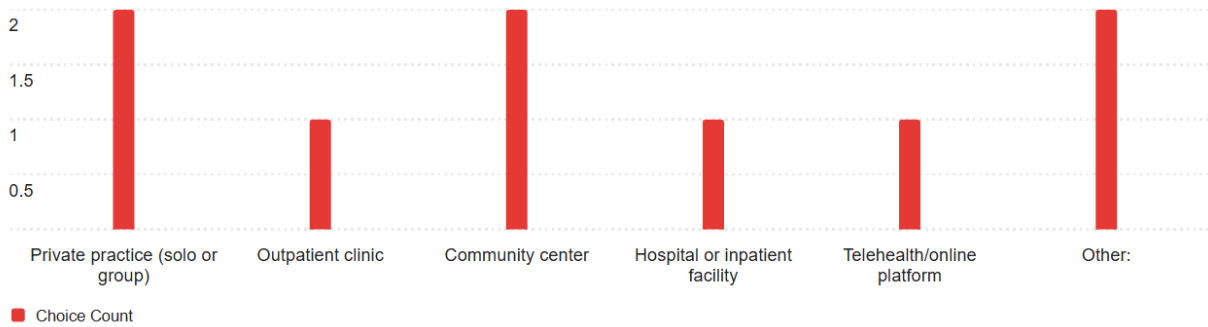


Figure 4.1: Participants’ primary work settings

Most of the participants reported limited or no knowledge of robotics or related technologies. One participant indicated that they did not use any digital devices in their therapeutic practice.

Overall, participants held a positive view of social robots in therapeutic contexts. Participant 2 (P2) expressed a negative perception, while P10 initially held reservations but shifted to a more favourable opinion after engaging with the topic.

4.3.2 Perceived Usefulness

Therapists expected the robot to be valuable for several reasons, including its accuracy and consistency, its novelty and ability to capture children’s interest, and its potential to serve

as a “stepping stone” toward real-life social interactions. One participant expressed interest in using the robot for games and to train turn-taking skills, while another suggested it could be particularly helpful for children who are newly diagnosed and not yet comfortable with human interaction.

More than half of the participants expressed interest in using the robot for data collection and analysis, highlighting its potential to support clinical decision-making. An additional expectation was the robot’s potential to reduce caregiver burnout and alleviate frustration experienced by both children and those involved in ongoing skill-based therapy. All participants agreed that the robot could be beneficial for emotional support, building rapport, and offering a sense of companionship for children.

For at-home use, participants envisioned the robot as a source of parental support, capable of analyzing children’s behavioural cues during short interactions and assisting in everyday communication. This included reminding parents or caregivers of therapist recommendations based on observed behaviours and helping navigate challenging social situations.

4.3.3 Expected Robotic Role

One participant emphasized that the robot should operate autonomously, stating: “I don’t know what it(robot) is targeted to do — it’s supposed to know, so it should be autonomous.” In contrast, the remaining nine therapists expressed hesitation about the use of a fully autonomous robot. Eight participants preferred a model where the robot is pre-programmed or configured before the session, while one participant preferred to be able to fully control a robot during interactions.

All participants, except P2, envisioned the robot acting as a mediator, facilitating interactions without leading the activity. P2 viewed the robot as an undesirable tool for use in therapy. Three participants expressed interest in using the robot as a peer for their patients in both individual and group therapy settings, noting the variability in children’s social skill levels: *“There aren’t always kids with similar social skills. So if there’s one child who has a lot more social skills than the others, they don’t get the opportunity to practice those skills as much. Being able to pair with one kid one-on-one in a group setting might be beneficial. I could also see it being used in one-on-one sessions—maybe to model and teach certain social skills at a peer-to-peer level as well.”* Two therapists highlighted that the robot could be particularly beneficial for children with severe autism, as it offers a novel and alternative mode of communication, and that they are actively exploring ways to incorporate such tools to support these children better.

All participants clearly stated that they did not want the robot to lead a session, nor did they expect it to be more than a complementary tool used to target specific skills. The robot was consistently described as an assistant, rather than a replacement for human-led therapy. Participant 1 (P1) stated that they want the robot to have the lowest involvement possible. *“It’s important that the robot is an assistant and never more than that.”*, *“I imagine it would be something used in conjunction with a clinician.”*, *“I could see that being kind of a fun and interesting thing for a kid to do. I certainly wouldn’t want that*

to be the only way we were targeting that skill for a child.” P4 envisioned the robot as a member of the therapy team, suggesting it should be present during morning rounds to collect updated information about patients. This participant expected the robot to adapt its interactions or suggest new activities based on the most recent observations.

Data Collector

A distinct role emphasized by more than half of the participants was the robot’s potential as a data collection or observation tool.

“I think it would be beneficial if the social robot could track, depending on what kind of program it’s working on. It would be beneficial to track that data because, as humans, there’s only so much we can monitor while still being fully engaged. But I think a robot could remain just as engaged and still collect much more data than we could as humans.”

Therapists expressed interest in the robot’s ability to track:

- The type and effectiveness of reinforcements used during activities;
- Preceding triggers to emotional dis-regulation or meltdowns;
- A child’s attempts to initiate interactions;
- The accuracy of responses and the correctness of task performance;
- The latency between a given cue and the child’s response;
- The database for the guidelines, providing therapists with the newest practices and structured recommendations;

4.3.4 Robotic Appearance

Participants expressed diverse opinions regarding the ideal appearance of the robot. Many emphasized that its design should be purpose-driven and adaptable to the individual preferences of each child. The majority of therapists preferred robots that do not resemble humans too closely, instead favouring designs with mechanical features or a more neutral appearance.

In contrast, [Participant 3 \(P3\)](#) believed that a human-like (android) appearance could be more beneficial for practicing social skills, as it would better simulate real-life interactions.

Several participants also suggested that animal-like designs or robots resembling relatable characters could be especially helpful for younger children, promoting emotional comfort and helping to build rapport.

All therapists, except P2, expressed a desire for the robot to have some level of mobility, noting that many of their patients struggle with remaining seated for extended periods. They emphasized that a mobile robot would be better suited to follow the child and adapt

to their movements. P4 mentioned that a robot should not try to mimic behaviours that involve physical touch to offer comfort, like hugging. *"It would be strange to me if I had a robot tapping me on the shoulder or trying to make me feel better by touch."*

4.3.5 Customization

Participants expressed a strong desire for the robot to be highly customizable to meet the individual needs of each child. Key areas of customization included the type of reinforcement strategies the robot could provide, its adaptation to the age of the patient, and the range of motion it demonstrated during interactions.

Therapists emphasized that the responsibility for customization should be shared among three stakeholders: the therapist, the child's parents, and a technician or developer. As Participant [Participant 4 \(P4\)](#) noted, "I think if you left all of that up to the therapist, that would be too much pressure."

4.3.6 Decision-Making on the tool utilization

Participants noted that when considering the use of a robot in therapy, they would take into account several factors, including cost, the strength of the evidence base, the availability of training resources, and the child's interest and engagement with the robot. However, the most critical considerations were the robot's safety and its practical usefulness, particularly whether the skills learned through interaction with the robot could be generalized to real-life situations: *"It needs to be considered whether the robot is actually useful, because if the child is only responding in a certain way and only succeeding when interacting with the robot, that may not translate into real-life benefits. Another drawback is potential safety concerns, such as the robot's awareness of people around it. For example, a child could touch it, get their fingers caught, or even damage the robot. This is particularly relevant since some children may engage in aggressive behaviours, which could not only harm the robot but also pose safety risks to the child. Cost is another important drawback. These robots appear to be quite expensive to use effectively across different settings, especially when factoring in the need for therapists to become comfortable with them. Additional expenses could arise from replacing parts, reprogramming, or involving technical support staff, further increasing the financial burden."*

Interestingly, participants indicated that they would initially rely on case studies to inform their decision-making. They would then explore controlled trials to evaluate whether the tool demonstrates effectiveness across a broader population.

4.3.7 Implementation

Participants emphasized that for successful implementation in broader therapeutic practice, the robot must first be tested and validated in clinical settings. All participants expressed a preference for personally trialling the robot before adopting it in their work.

Regarding home use, participants expressed several concerns. While all therapists, except P2, recognized the robot’s potential value in home settings, they emphasized the need to be fully confident in its capabilities and safety before recommending it. Therapists noted that expectations for a robot used at home would be significantly higher than in clinical settings. [Participant 7 \(P7\)](#) anticipated that the social work field would likely be the first to adopt therapeutic robots, ahead of other clinical disciplines. They stated, *“I have a feeling that the first field where it’s going to be incorporated faster than in our field is the social worker field. Just 100% sure it’s going to be there first, and then—it’s kind of a related area. And I think we’re going to take a lot from them. But I see it will be developing.”*

4.3.8 Concerns

Therapists’ primary concerns centred around the robot’s safety and its ability to appropriately respond to challenging or potentially dangerous situations, such as detecting a child’s meltdown or aggressive behaviour and safely removing itself from the environment. *“I feel like there are so many things—especially when we work with kids with autism—like, what if they were to elope? What would a robot do? Or if they’re engaging in self-injurious behaviour? You know, I just feel like there are some situations where you need that human interaction.”*

Additional concerns included the robot’s cost and durability, whether it would genuinely promote interaction with humans, its cultural acceptance, and the generalization of skills learned through its use.

As one participant explained: *“We have to be careful of that ourselves as humans, and so if we’re entrusting any piece of that to tech—where things could go wrong or not work right or whatever—we just would have to be confident it was doing what it needs to do, and doing it safely, ethically, and all of that.”*

Furthermore, four therapists expressed concern that the use of a robot could potentially lead to a reduction in realistic social interactions, fostering an overreliance on technology instead of supporting long-term interpersonal development. One participant remarked: *“I just don’t feel like it. It’s very natural. I think we want to be promoting social interactions, and I just feel like it’s hard enough to learn social skills and understand them. I would just want to make things more natural. Especially in my sessions—I try to avoid technology.”*

Therapists also raised concerns about data privacy, noting that any robot used in therapy should be operated and monitored by the therapy center or the child’s parents. While one therapist mentioned a concern about the possibility of a robot replacing a therapist, two other participants were confident that a robot could not and should not take over their professional role.

4.4 Exploring therapists’ attitudes toward social robots through **Technology Acceptance Model (TAM)**

Looking at the findings from the **TAM** perspective, in the case of therapists, adoption is held back not by a lack of interest but by the gap between what research prototypes offer and what therapy practice demands.

4.4.1 Perceived usefulness

From the therapists’ perspective, a social robot is useful when it can help keep children engaged, hold their attention through repetitive or less exciting tasks, and support specific learning goals such as self-care skills, distinguishing between safe and unsafe behaviours, or turn-taking. All therapists saw the robot’s best role as a “Mediator,” helping to connect them with the child rather than replacing human interaction. They also envisioned significant potential in robots that could automatically collect data on a child’s progress. Therapists expected a robot to provide useful statistics on factors such as triggers for meltdowns, when a child initiates interaction, or which types of reinforcement are most effective. Such data could help guide and improve therapy outcomes.

Perceived usefulness drops quickly if the robot’s capabilities fail to meet therapy goals, cannot adapt to a child’s unique needs, or do not produce visible, lasting improvements beyond the novelty phase. Some therapists also suggested that such robots could be more useful in short-term or “express” interventions, or in contexts such as social work, where building rapport quickly with a child is essential. They could also serve specialists like lawyers, police officers, and other professionals who need to interact with children but lack specialized training in child communication.

4.4.2 Perceived ease of use

When it comes to ease of use, therapists want a robot with a straightforward, structured interface, preset activities, and a variety of reinforcement options that can be quickly adjusted. Reliability is essential—they want confidence that the robot will work from one session to the next without unexpected issues. Safety and durability are also recurring priorities, particularly given the unpredictable nature of therapy environments. Therapists expressed willingness to learn how to operate a robot, to participate in training workshops, and to give an assessment of whether the technology fits their therapy styles.

However, therapists represent only one-half of the adoption story. Parents, who would be asked to give their consent for new therapy methods, have their expectations, concerns, and definitions of usefulness. The next chapter of this thesis will focus on the parental perspectives.

Chapter 5

Surveys with Parents

5.1 Methods

A survey was developed to capture caregivers’ perspectives on using robots as therapeutic tools for their children.

The survey was distributed via social media platforms (Instagram, LinkedIn, Reddit) and through physical posters placed at Waterloo Regional Health Network Hospital and various University of Waterloo locations, such as the Engineering 7 (E7) building and United College Graduate building. E7 was selected due to its on-site daycare program. The residential building was chosen because it houses many graduate students, many of whom are parents.

This study was approved by the University of Waterloo’s Office of Research Ethics (REB #46471) (see Appendix A). Before beginning the survey, participants were provided with a consent letter and asked to confirm their consent. Only those who gave informed consent were able to proceed with the survey. Informed consent was obtained from all participants.

Surveys were employed to gather both quantitative and qualitative insights from a diverse group of caregivers. Remote, self-administered surveys were chosen due to their low burden on participants, enabling them to participate at their convenience and without the pressure of researcher presence. This approach was essential to reach a broader population, including those who may not be available or comfortable participating in interviews. All responses were collected anonymously through Qualtrics. Questions were designed to be accessible while still gathering meaningful perspectives on the use of social robots in therapy. The survey contained a mix of closed- and open-ended questions and followed the structure outlined below. All sections concluded with open-ended prompts to allow participants to elaborate on their thoughts, values, and concerns. If participants reported that they were not familiar with social robots, they were shown a brief description: *“Social robots are robots specifically designed to interact with people in a human-like way, using speech, gestures, and facial expressions. In autism therapy, these robots are often used to help children practice key social skills, such as making eye contact, taking turns, and recognizing emotions.”* For a complete list of questions, see the Appendix B.

5.1.1 Recruitment

Following ethics approval, recruitment for the caregiver survey was conducted from March 1, 2025, to June 24, 2025. The inclusion and exclusion criteria for participation were as follows:

Caregiver Inclusion Criteria:

- Parents/guardians of children who require therapy to improve their social skills

and/or

- Parents/guardians of children diagnosed with autism

The exclusion criteria included the inability to read and write in English, as the survey was administered in English.

Recruitment was conducted through multiple public channels to ensure broad outreach. These included social media platforms such as Facebook, Instagram, LinkedIn, and Reddit. On Facebook and Reddit, surveys were shared within specific autism-focused groups and threads. For Facebook, these included 'Ontario Autism Coalition' and 'Autism Therapy Ontario'. On Reddit, we posted in communities such as 'r/autism' and 'r/Autism_Parenting'. On Instagram and LinkedIn, the study was promoted via public posts, which were further shared by individual accounts as well as the official 'Engineering Outreach, University of Waterloo' pages on both platforms. The respective group or channel administrators approved all posts before publication.

Physical posters were placed in high-traffic locations at Grand River Hospital and across the University of Waterloo campus.

This public, open-call approach was chosen to maximize participation from diverse caregiver populations, including those outside formal clinical or academic networks. Although open recruitment limits control over participant demographics and may introduce variability in response quality, it increases accessibility and supports a more representative understanding of caregiver perspectives. Most of the participants were recruited through online sources, while only 7 scanned the physical QR code.

Interested individuals accessed the study through a Qualtrics survey link embedded in all recruitment materials. Before beginning the survey, participants were presented with a consent form [A](#) and eligibility screening questions [B](#). Only those who met the criteria and provided informed consent were able to proceed to the full survey. Participation was voluntary, anonymous, and uncompensated. However, participants had the option to enter a draw for a \$50 gift card of their choice. The survey took approximately 15 minutes to complete. A total of 186 participants completed the survey.

5.1.2 Data Analysis

Surveys consisting of both multiple-choice and open-ended questions served as the primary method of data collection. Quantitative data from the parent surveys were analyzed using

descriptive statistical methods in Microsoft Excel. Measures of central tendency (mean) and response distributions were used to identify general patterns in caregiver perspectives. Open-ended responses, though limited in volume, were also processed in Excel to provide context and nuance to the numerical findings. These qualitative responses were reviewed and thematically coded using an inductive, reflective approach to uncover underlying themes and sentiments.

Connections between the interview and survey findings are presented to triangulate insights and enhance the validity of the conclusions. Future directions for research and practice, grounded in the emergent themes and identified gaps, are further explored in Chapter 6.

5.1.3 Bot Removal Process

Qualtrics uses multiple layers of protection to detect and remove bot responses. Its Fraud Detection feature leverages Google’s reCAPTCHA v3 algorithm to assign a score (Q_RecaptchaScore) to each respondent, flagging likely bots (scores below 0.5), which can be automatically excluded through survey logic. [84] According to Bonett et al. (2024), this method is efficient and accurate for bot detection [85]. We used the Q_RecaptchaScore to manually review and filter out low-quality responses by deleting all submissions with a score below 0.5, which were identified as bots. This process helped ensure the reliability and validity of the analyzed data.

5.1.4 Survey Summary

1. **Introduction and Consent:** The survey began with an informational letter outlining the study’s purpose, goals, and procedures. Participants were informed about the voluntary nature of the study, data confidentiality, and their right to withdraw at any point before submitting the survey. Participants were required to confirm their understanding and provide informed consent before continuing. The option to enter a gift card draw was also introduced in this section, along with the opportunity to opt into anonymous quote sharing.
2. **General Beliefs About Social Robots (5 questions):** Participants were asked about their prior experience with therapeutic technologies such as tablets, sensory devices, or social robots. Follow-up questions explored their awareness of and familiarity with social robots specifically, as well as their beliefs regarding the potential usefulness of these tools in supporting their child’s social and communication development. The questions were developed in alignment with the objectives of the study to ensure relevance and focus. This section helped contextualize baseline knowledge and attitudes before diving into more detailed topics.
3. **General Attitude Towards Robots in Education (2 questions):** This section examined caregivers’ openness to using robots as educational tools for children with autism. Participants were asked whether they would consider using a robot

and what factors—such as clinical recommendation, cost-effectiveness, or customization—would influence their decision. The goal was to capture a broad picture of motivational drivers that could impact adoption.

4. **Perceived Benefits and Concerns (2 questions):** Participants rated the importance of various potential benefits of social robots (e.g., increased engagement, reduced anxiety, individualized content) using a Likert scale. They were also asked to select from a list of potential concerns, including issues related to affordability, emotional connection, integration with other therapies, and long-term effectiveness. Open-ended questions followed, prompting participants to share additional factors influencing their ratings.
5. **Necessity of Social Robots (1 question):** Participants responded to a series of statements measuring the perceived necessity of social robots in their child’s therapy journey. These statements focused on the robots’ ability to improve communication, replace or complement existing therapies, and enhance the accessibility and consistency of interventions. Responses were recorded on a 5-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree.”
6. **Concerns About Social Robots (1 question):** Building on previous sections, this portion of the survey focused on deeper emotional and ethical concerns. Participants were asked to rate their agreement with statements regarding customization limits, dependency risks, safety, privacy, and affordability. Follow-up open-ended prompts encouraged participants to explain the reasoning behind their answers.
7. **Use of Social Robots at Home (8 questions):** This section explored practical considerations of home-based robot use. Participants indicated their preferences for receiving therapy at home versus a center, the perceived benefits of reducing travel time, and how likely they would be to adopt a robot if prescribed by a professional. They were also asked about their desire to involve their child in the robot selection process, preferences for content customization, comfort with automated tracking and reporting, and expectations for involvement from therapists or educators. Additional open-ended questions were included to gather suggestions on desired robot features and the kind of support needed to adopt the technology at home confidently.
8. **Demographic Information (4 questions):** To ensure a diverse and representative sample, the final section collected basic demographic information, including the participant’s relationship to the child, number of children, and the child’s age and gender. This data was used to analyze trends across different caregiver profiles while maintaining participant anonymity.
9. **Submission and Optional Gift Card Entry:** Participants were reminded to review their answers before submitting the survey. Those who wished to enter the gift card draw were invited to provide their email address and select a preferred gift card type. This final step was optional and separate from the main dataset to preserve the anonymity of survey responses.

5.2 Findings

The surveys included both quantitative and qualitative open-ended questions. The parents mostly replied to the quantitative (multiple-choice) questions, so analysis of qualitative data was limited.

5.2.1 Participants

The total number of respondents was 186. According to the Qualtrix built-in system, 127 of them were recognized as bots, and that data was removed from the analysis. Also, some of the respondents didn't finish the survey, so those with less than 50% of completion were removed from the analysis as well. Thus, the number of participants included in the analysis was **40 individuals**. Among the respondents, 60% identified as mothers and 37% as fathers. The children of respondents were primarily aged 3–5 years. Of these children, 59% were male and 40% female. Additionally, 68% of respondents had two or more children.

5.2.2 General Beliefs About Social Robots (5 questions)

85% of participants have previously used devices for therapy purposes. Among those devices, three participants reported using Virtual Reality, seven — Tablets/Mobile Phones/Smart Assistant devices, sixteen — Sensory Devices, and two participants used robotic toys.

In contrast to the therapists, none of whom had heard of social robots before, 72.5% of parents had heard about social robots for autism therapy. Among them, 22.5% were not familiar at all, 25% — slightly familiar, 17.5% — moderately familiar, and 35% reported being very familiar with the use of social robots in therapy.

85% believed that a social robot could help their child improve social and communication skills, 10% were not sure, and only 2.5% did not believe in it.

5.2.3 General Attitude Towards Robots in Education (2 questions)

The parents stayed consistent with their previous answers. 87.5% reported that they would try using a social robot for their child's therapy, while 7.5% were unsure, and 2.5% did not want to use a robot.

The reasons that would encourage them to utilize a robot are presented in Figure [5.1](#).

5.2.4 Perceived Benefits and Concerns (2 questions)

Figure [5.2](#) presents the perceived therapy outcomes associated with the use of a social robot, based on the percentage of respondents who rated each as 'Important' (4) or 'Very

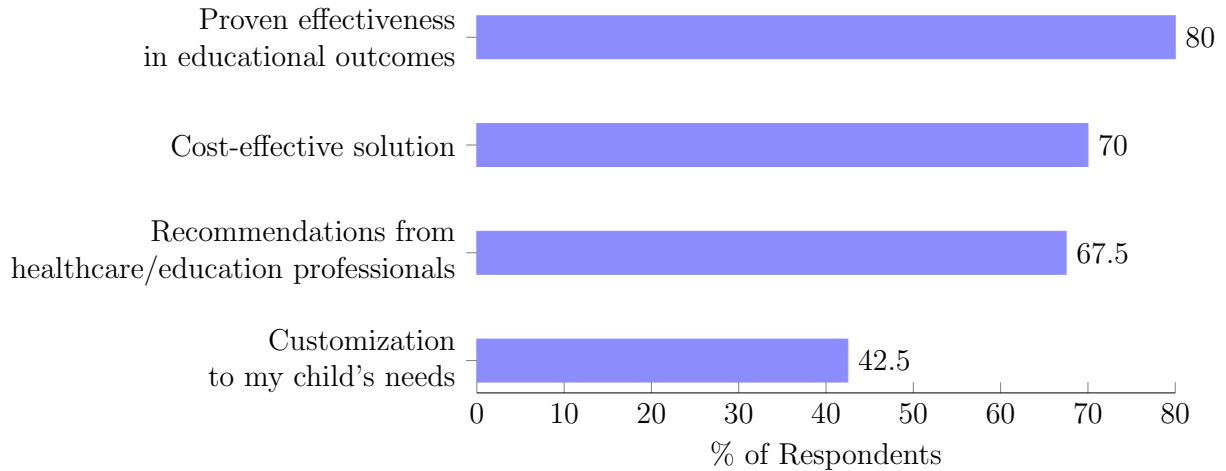


Figure 5.1: Would any of those reasons encourage you to use a robot to improve your child's social skills?

Important' (5) on the Likert scale. The remaining respondents rated each item as 'Neutral' (3).

The top three concerns identified by parents were:

- Cost and affordability
- Dependence on technology
- Lack of personal connection or empathy

These concerns were prioritized by 80% of participants. Additionally, two participants noted in open-ended responses that they could not prioritize a single concern. Other commonly mentioned concerns included:

- Safety and data privacy
- Difficulty integrating the robot with existing therapies
- Limited effectiveness in supporting long-term learning

Only 2.5% of participants reported having no concerns.

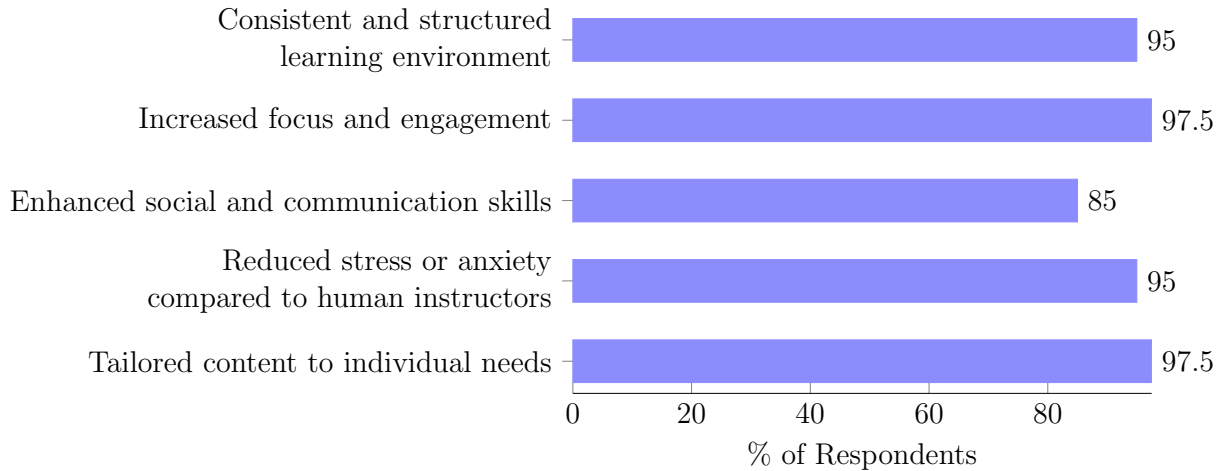


Figure 5.2: How important is each of those criteria as an outcome from the use of the robot you choose?

5.2.5 Necessity and Concerns about Social Robots (2 questions)

Table 5.1 displays the percentage of parents who agreed or disagreed with various statements regarding the necessity of social robots in therapy. Participants were asked to rate each statement, even if they had no direct experience with the technology. Overall, most participants agreed or strongly agreed with the statements, indicating a clear trend toward perceiving robots as essential for therapy, despite no or limited experience with them.

Statement	1	2	3	4	5
	<i>Strongly</i>				<i>Strongly</i>
	<i>Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Agree</i>
A social robot is essential for improving my child's social interactions.	2.5	0	2.5	70	20
A social robot is necessary for my child's communication development.	2.5	0	15	55	20
Using a social robot could complement or replace some therapy center sessions.	0	2.5	5	62.5	25
A social robot could make therapy more consistent and accessible for my child.	0	0	2.5	65	25

Table 5.1: Parent perceptions of the necessity of social robots in therapy

Table 5.2 presents the percentages of parents who agreed or disagreed with statements regarding their concerns about using social robots in therapy.

Statement	1	2	3	4	5
	<i>Strongly</i>				<i>Strongly</i>
	<i>Disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Agree</i>
I am concerned that a robot might not address my child’s specific needs	10	7.5	7.5	60	2.5
I worry about my child becoming overly dependent on the robot	0	5	7.5	60	12.5
I feel unsure about the safety and reliability of using a robot at home	7.5	7.5	10	52.5	10
I am concerned that a robot might reduce my child’s interaction with human therapists	5	12.5	5	62.5	5
I am worried about the cost of purchasing and maintaining a social robot	2.5	0	5	55	30

Table 5.2: Parent anticipated concerns regarding social robots in therapy

5.2.6 Use of Social Robots at Home (8 questions)

72.5% and 77.5% of parents preferred a robot to be used at home rather than travelling to a therapy center, and believed it would reduce the time and effort involved. 87.5% of parents were ‘Likely’ or ‘Very Likely’ to use a robot if prescribed by a therapist. 80% would involve their child in selecting the robot, 10% were unsure, and 2.5% would not involve their child.

When asked who should handle the customization of the robot, 35% of parents chose themselves, and another 35% preferred the therapist to do so. 15% selected an automated setup by the robot, while 10% were unsure or needed more details. Participants could only choose one option.

87.5% were comfortable with the robot tracking their child’s progress, and 72.5% wanted reports sent to the therapist. 15% were unsure, and 7.5% did not want the robot to track progress or chose not to answer.

80% of parents were willing to learn how to use and support the robot-based teaching system at home. 70% expected high therapist involvement, 17.5% moderate, 2.5% low, 2.5% no involvement, and 2.5% preferred not to say.

Although a limited number of participants answered open-ended questions, the responses still revealed clear preferences.

Parents emphasized that a teaching robot should be engaging, emotionally aware, and supportive of their child’s learning journey. Key expectations included the ability to teach in multiple languages, adapt lessons to the child’s pace and style, and recognize emotions to build a positive and encouraging learning environment. Interactive features like games, multimedia, and personalized feedback were seen as necessary for maintaining interest. Parents also valued tools that promote social skills, empathy, and emotional regulation. Importantly, they stressed that while a robot can assist in learning and development, it should never replace the empathy and understanding of a human.

Features like progress tracking, context-awareness, and mental check-ins were noted as essential for creating a safe and effective educational experience.

To feel comfortable using a teaching robot for their child, parents expressed the need for clear information about data privacy, including how their child’s information is collected, stored, and accessed. They emphasized the importance of the robot meeting safety standards, functioning offline, and demonstrating proven benefits through research or testimonials. Some parents preferred the robot to be used as a supportive tool alongside a human therapist. Additional needs included training, access to technical support, engaging and fun activities, language accessibility, and the ability to adapt to the child’s individual needs.

5.3 Exploring parents’ attitudes toward social robots through **Technology Acceptance Model (TAM)**

Circling back to the Technology Acceptance Model, we analyzed findings from parental interviews through the lenses of perceived usefulness, perceived ease of use, and attitudes toward using social robots.

5.3.1 Perceived usefulness

Parents generally view social robots as valuable tools to support their child’s therapy. A strong majority (87.5%) expressed willingness to try a robot. They see these robots as useful devices that can deliver personalized, adaptive lessons tailored to their child’s pace and style, with features like progress tracking, emotional awareness, and context sensitivity. However, they emphasize that robots should complement—not replace—human therapists, who provide irreplaceable empathy and understanding. Notably, 87% of parents also believe that robots could play an essential role in improving their child’s social interactions and communication skills.

5.3.2 Perceived ease of use

When it comes to perceived ease of use, 80% of parents are ready to learn how to operate robot-based systems at home. Preferences vary: some parents want to handle robot setup

themselves, others prefer therapists to manage it, and a smaller group is comfortable with automated setup. Most parents see robots as helpful home therapy tools that could save time on travel and improve accessibility. They also express a strong desire for the robot to integrate smoothly into daily life. Clear guidance on data privacy, safety, and practical features—such as waterproofing and durability to withstand everyday use—is particularly important to them.

5.3.3 Parental attitude and external influences on adoption

Parents’ attitudes toward using social robots are primarily positive. They believe a teaching robot should be engaging, emotionally aware, and adaptable to their child’s individual needs, fostering a supportive and encouraging learning environment. Trust and acceptance depend heavily on transparent information about data handling, strict adherence to safety standards, and clear evidence of the robot’s benefits through research or testimonials. Additionally, parents expect significant therapist involvement alongside robot use. That aligns with the therapist’s perception that robots should serve as supportive tools rather than standalone solutions.

External factors also strongly influence parental acceptance. The most common concerns were cost, dependence on technology, and a perceived lack of personal connection or empathy. Other concerns include safety, data privacy, challenges integrating the robot into existing routines, and its long-term effectiveness. To feel comfortable adopting social robots, parents want them to offer offline functionality, ensure safety, and provide access to training and technical support. Interestingly, compared to therapists, fewer parents expressed concerns about data privacy policies.

Chapter 6

Discussion

6.1 Comparing Interviews and Surveys

There was a notable misalignment between therapists and parents regarding their awareness of social robots for autism therapy. While parents reported being highly aware and comfortable with the technology, many therapists indicated they were hearing about it for the first time. Several factors may explain this discrepancy:

- Parents may be more exposed to emerging technologies as they actively seek alternative support options, while therapists may remain focused on established, evidence-based practices.
- Subject bias — Parents may have provided responses they believed were more favourable or aligned with what the researchers expected, influenced by the incentive of the gift card draw. They might have assumed that giving the "correct" answers could increase their chances of winning. In contrast, every therapist received fixed remuneration for their participation, with no perceived incentive to provide "correct" answers or compete for researcher approval.

The survey data on the perceived necessity of social robots was also unexpected. Many parents rated robots as highly necessary for supporting their child's social development and therapy, even if they had not previously used one. This contrasts with therapists' responses and with several open-ended comments, where participants emphasized that robots should not be the sole form of intervention. Instead, they should be interchangeable with other methods and used to promote real-life social interactions.

Another divergence emerged around concerns about data privacy and storage. Only 5% of parents highlighted it as a primary concern, whereas all interviewed therapists emphasized it as a key issue. This contrast may be explained by the differing responsibilities: therapists are legally obligated to protect patient data under professional and regulatory standards, while parents bear only personal responsibility for their child's information.

These misalignments—particularly the strong openness parents demonstrated toward adopting new technology—highlight the need for further validation of the survey data and suggest opportunities for deeper exploration in future studies.

6.2 Comparing expectations and existing research

Our research into robot-assisted therapy for [Autism Spectrum Disorder \(ASD\)](#) reveals a significant disconnect between the expectations of therapists and the focus of existing studies. To foster wider adoption and maximize the impact of these tools, several key areas require greater attention.

A primary concern is the applicability of the robots themselves. While the Nao robot is a popular choice for researchers due to its accessibility, it presents considerable challenges for real-world implementation. Its high cost, substantial weight, lack of child-safety features, and absence of a built-in user interface [82] make it impractical for everyday use in therapy settings. Therapists require tools that are not only effective but also safe, user-friendly, and cost-efficient. The limited research on commercially available robots like the QTRobot and Buddy Robot [101], which could offer more practical solutions, further exacerbates this issue. More studies on these robots, particularly those with controlled participant groups, would significantly aid therapists in their decision-making.

From the parents’ perspective, however, there is a surprising openness to integrating robots into therapy, particularly in home settings. A majority of parents expressed strong willingness to use a robot if prescribed by a therapist, and many even perceived a robot as essential for their child’s social development, despite limited direct experience.

Parents emphasized the importance of robots being engaging, emotionally aware, customizable to their child’s needs, and equipped with features such as multi-language capabilities, adaptive learning styles, and emotional recognition. They also placed significant value on progress tracking, data transparency, and safety, but were generally less concerned about privacy and data storage than therapists were.

A critical factor highlighted by therapists is the generalization of learned skills. The ability for skills acquired during therapy sessions to transfer to different individuals and situations is paramount for successful intervention. However, current research rarely assesses this crucial aspect, with only 5 out of 28 studies [17, 39, 42, 35, 41] presenting results on generalization. This omission leaves a significant gap in understanding the true long-term benefits of robot-assisted interventions.

Many studies position robots as instructors, which therapists perceive as undesirable and even a potential threat to their professional roles. In contrast, therapists prefer robots that act as helpful assistants to themselves or even parents for at-home usage. This aligns with parental feedback, where many emphasized that robots could never replace human empathy and should be used alongside a human therapist. Several parents envisioned robots as motivational companions or learning tools, similar to books or games, that reinforce therapy but do not take full responsibility for it. Research suggests that a “mediator”

role for the robot, rather than solely robotic therapy, yields better results and promotes generalization. A clear statement and justification of the robot’s purpose, setting, and duration of use are essential for promoting its adoption.

Furthermore, the novelty effect of robots needs careful consideration. While robots may initially engage children, therapists voiced concerns about increased workload and the seamless integration of robots into their daily routines. For successful implementation, strategies must be developed to ensure the robot remains a helpful and useful tool without adding undue burden to the therapist. At the same time, parents expect robots to be easy to operate, engaging, and capable of functioning offline, which would make them more accessible and less disruptive at home.

Finally, both groups of participants, therapists and parents, expressed a strong interest in robots as data collection tools to assist with assessments. This application remains largely underexplored in current research, which tends to focus more on direct robotic interaction with the child. Leveraging robots for objective data collection could significantly enhance the assessment process and provide stakeholders with valuable insights, especially if the progress reports are shared with both therapists and parents, as many parents indicated they would prefer.

6.3 Bridging Stakeholder Expectations and Adoption Needs

There are several key stakeholders involved in the acceptance of social robots for autism therapy: researchers, therapists, parents, and children. Each group holds distinct views on what defines the usefulness and ease of use of these robots, which significantly influence their acceptance and likelihood of adoption, as explained by the [Technology Acceptance Model \(TAM\)](#).^[94]

Perceived usefulness varies across these groups. Researchers emphasize technical features such as programmability, flexibility, and the ability to perform diverse movements, qualities that make robots like NAO well-suited for research and experimentation. In therapeutic settings, however, priorities shift toward simplicity, safety, durability, and expressiveness to ensure reliable, engaging sessions tailored to each child’s needs. Therapists often see robots functioning as “Mediators” between a therapist and a child or as “Data collectors” to support monitoring a child’s progress. These roles can enhance therapy without replacing human empathy. Parents similarly value personalized, adaptive lessons and emotional awareness of the tool, recognizing a robot’s potential role in supporting social and communication skills development.

Perceived ease of use also differs by stakeholder. Researchers require high programmability and customization to control experiments precisely. Therapists prefer structured interfaces with pre-set activities and easy-to-adjust to minimize technical demands during sessions. Therapists also have a strong emphasis on reliability and safety. Parents prioritize straightforward setup, minimal supervision, and consistent performance since they

primarily use robots at home with their child. They also desire seamless integration into daily life. For children, ease of use relates to intuitive, natural interaction that maintains engagement without complicated instructions.

External factors also play a significant role in adoption. High costs remain a barrier for families and smaller therapy practices, whereas access to funding, local technical support, and compatibility with existing therapies can facilitate uptake. Additionally, the development of clear safety standards, regulatory guidelines, and ethical application frameworks is crucial to support broader adoption of the technology.

In summary, although all stakeholders acknowledge the potential benefits of social robots, their perceptions of usefulness and ease of use vary depending on their roles and contexts. Successful adoption would depend on how well these diverse needs and concerns are addressed. Bridging the gap between research prototypes and practical therapeutic use is required to fully realize the promise of social robots in autism therapy.

6.4 Ethical Considerations

Using robots in autism therapy raises several critical ethical questions. The most crucial points are safety and reliability. Since these robots will work with kids, we have to be sure they're safe and always work as expected.

Another big worry is how robot interactions might affect real-life social skills. A child might get used to how a robot acts, which is often very simple and consistent. This could make it harder for them to deal with the complex and often unpredictable ways real people interact. We need to make sure robots help kids improve their social skills in the real world, not make the gap wider. These findings align with the study by L. Hung et al. [98]. In order to mitigate this concern, the study [98] suggests that robots should never be used as a replacement for human care, but rather a complementary tool to enhance therapy.

Furthermore, the increasing sophistication of technologies brings forth new ethical challenges related to data storage and the incorporation of advanced technologies like [Artificial Intelligence \(AI\)](#). [AI](#) has begun to be utilized as a scribe tool for [Electronic Medical Records \(EMRs\)](#), demonstrating high levels of satisfaction among therapists and significantly reducing the time spent on documentation [99]. However, the collection of sensitive data during therapy sessions requires robust security protocols and clear guidelines for data privacy and usage. The inherent unpredictability and lack of complete transparency often associated with [AI](#) models raise serious questions about their suitability for a therapeutic context where reliability and clear causal links are crucial. Researchers must carefully evaluate the risks associated with integrating [AI](#), ensuring that its unpredictable nature does not compromise the therapeutic process or the well-being of the child. Additionally, they must verify that private data is collected only during the intended therapeutic period and that the robot does not gather any personal information outside of its advertised scope of use.

The novelty of this field necessitates the development of new medical regulations to govern the use of the robot, restricting its application solely to therapy-related environments

under the supervision of qualified professionals or caregivers.

Lastly, a significant practical and ethical consideration for widespread adoption is affordability and accessibility. If robots are proven to be a necessary and effective therapeutic tool, prescribed by therapists, then government funding or insurance coverage for these devices should be explored. Without financial support, many families who could benefit most may be unable to access this valuable technology.

The potential issues are not limited to those listed here and may extend far beyond them. It is crucial to thoroughly investigate possible problems to ensure that the new technology does not cause harm to its users.

6.5 Limitations

The primary limitation of this research is that a single reviewer and analyst conducted it. While all structural and methodological requirements of a systematic literature review were followed, the absence of multiple reviewers means it cannot be classified as a fully rigorous systematic review. To ensure transparency and reproducibility, all findings and claims were carefully linked to the relevant source articles. However, the results should be independently reviewed by at least one additional reviewer to confirm their validity. Guidance from a University of Waterloo librarian was sought, and the quality of the work was deemed satisfactory for academic presentations and potential publications. Additionally, we did not specifically search for articles on the adoption of social robots in this review, given the limited number of studies in this area. Instead, the focus was on studies examining the therapeutic benefits of these robots when implemented in therapy sessions and comparing them to other therapeutic approaches.

A second limitation is the inclusion criterion that restricted the analysis to studies involving at least two participant groups, including a control group. While such studies tend to produce clearer and less biased results compared to case studies or single-group interventions, this approach may have excluded valuable insights. Case studies, although methodologically less robust, often provide richer, in-depth information about individual experiences and nuanced interactions that were not captured in the selected studies.

A notable limitation lies in the recruitment process. Parents were recruited through open platforms such as Reddit and Facebook, which are difficult to control. Although the survey was explicitly shared within autism-related forums and threads targeting the intended population, a significant portion of responses appeared to come from bots. Consequently, there is no reliable way to verify that the analyzed survey data was exclusively submitted by parents of autistic children. The procedures used for filtering responses and identifying bots are detailed in Section 5.1.3.

Additionally, insights from therapists were gathered exclusively from female professionals based in Canada. This narrow demographic scope may limit the generalizability of the findings. Perspectives from male therapists or those practicing in other geographical, cultural, or institutional contexts could provide diverse and potentially contrasting views on the integration and perceived usefulness of social robots in therapy.

Finally, both surveys and interviews capture participants' intentions rather than their actual adoption behaviour, which may not accurately reflect real-world implementation or long-term use of robotic technologies in clinical practice.

Chapter 7

Conclusions

In this thesis, we explored how social robots are being used in autism interventions — and, more importantly, why their promise in research has not translated into widespread adoption in practice. To bridge this gap and gain insights into the real-world adoption of social robots, we combined three different approaches: a review of nine years of published research, in-depth semi-structured interviews with therapists, and both qualitative and quantitative surveys with parents.

The literature review revealed a fragmented research landscape. The robots used in studies varied widely — from small tabletop companions to full humanoid models like Nao. Most were integrated into therapy as Instructors, taking on the role of a therapist, while others were explored as Mediators. The majority of studies reported positive outcomes, yet the lack of standardization in methods, outcome measures, and reporting made it difficult to draw strong, comparable conclusions. This fragmentation is more than just an academic inconvenience — it means that therapists and parents have little consolidated evidence to guide their decisions.

Once we understood what researchers tend to develop and test in social robots for autism therapy, we turned to another group of key stakeholders: therapists. In interviews, many expressed genuine enthusiasm for the potential of robots to engage children, especially in repetitive or structured tasks that might otherwise be tedious, and to support targeted learning goals such as self-care, safety awareness, or turn-taking. However, their enthusiasm was tempered by practical realities: high costs, limited availability, steep learning curves, and a persistent mismatch between research prototypes and the everyday demands of therapy.

To further understand the gap between academic innovation and practical application, we gathered parental perspectives through surveys. Parents expressed cautious optimism. They acknowledged the novelty and potential appeal of robots for their children and reported a willingness to try them even without a therapist’s recommendation — but only if the benefits and long-term improvements were proven, clearly justified, and affordable. For many, their support hinged on seeing measurable gains in real-world skills — improvements that make daily life smoother, foster independence, and bring tangible benefits to their child’s well-being.

Taken together, these three perspectives make the message clear: advancing the use of social robots in autism therapy is not simply about building smarter or more lifelike machines. It requires research that is grounded in practical needs, conducted in real-world settings, and shaped by the voices of end-users — children, therapists, and parents — from the moment a study is conceived to the final stages of user trials. This means setting clear therapeutic goals, carefully matching the right robot to the right task, and measuring success in ways that matter most to families and practitioners. As one therapist put it, *“If it helps one kid get more fluent and navigate their environment in a better way, in my opinion, it’s worth it a million percent.”*

This research journey also brought an unexpected reminder of how quickly the technology landscape can shift. When the writing began, it was reasonable to assume that cornerstone platforms like Nao would remain available. Yet, in June 2025, Aldebaran Robotics, the manufacturer of the Nao robot, announced that it was permanently closing. [100] While the company pledged ongoing support for existing Nao robots and expressed hope for new investors to continue production, the news underscores the fragility of relying on commercial availability for long-term adoption. For therapists and families, this highlights the need for flexibility and forward planning — ensuring that valuable skills and intervention strategies can transfer to alternative tools if necessary.

In the end, the path from research innovation to everyday adoption is long, winding, and often unpredictable. But with stronger connections between academic work and lived experience, social robots hold the potential to become truly transformative partners in the lives of children with autism and the people who support them.

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APPENDICES

Appendix A

Recruitment Materials

A.1 Ethical Clearance

UNIVERSITY OF WATERLOO

Notification of Ethics Clearance to Conduct Research with Human Participants

Principal Investigator: Catherine Burns (Systems Design Engineering)

Student investigator: Sabrina Saiko (Systems Design Engineering)

File #: 46471

Title: Investigating the attitude towards Robot-Based Home therapy for navigating Autism Spectrum Disorder (ASD) Traits in Children

The Human Research Ethics Board is pleased to inform you this study has been reviewed and given ethics clearance.

Initial Approval Date: 03/03/25 (m/d/y)

University of Waterloo Research Ethics Boards are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS2 2022), the Ontario Personal Health Information Protection Act (PHIPA), and all laws and regulations of the province of Ontario (as applicable). Additionally, CREB operates in a manner consistent with the International Conference for Harmonization of Technical Requirements for Pharmaceuticals for Human Use (ICH) Guidance E6(R2): Good Clinical Practice, the International Organization for Standardization of Good Clinical Practices (GCP) as set out by ISO 14155 - Clinical investigation of medical devices for human subjects, Part C, Division 5 of the Food and Drug Regulations, Part 4 of the Natural Health Products Regulations, Part 3 of the Medical Devices Regulations. Both Boards are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREB) and IRB00007409 (CREB).

Expiry Date: 03/04/26 (m/d/y)

Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.

Level of review: Delegated Review

Signed on behalf of the Human Research Ethics Board



Heather Dekker, Ethics Advisor, hdekker@uwaterloo.ca, 519-888-4567, ext. 41506

This above-named study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Documents reviewed and received ethics clearance for use in the study and/or received for information:

file: Standard Operating Procedure (SOP) for NAO Robot.pdf

file: Eligibility form_version3_20250202.pdf

file: Flyer_version3_20250202.pdf

file: Social media description_version2_20250202.pdf

file: Email_Recruiting_clinicians_version2_20250227.pdf

file: Consent Letter_parents_version3_20250227.pdf

file: Consent Letter_clinicians_version3_20250228.pdf

file: Interview Appreciation (1).pdf

file: Questionnaire for parents_version3_20250227.pdf

file: Interview for clinicians_version1_20250202.pdf

Approved Protocol Version 6 in Research Ethics System

This is an official document. Retain for your files.

You are responsible for obtaining any additional institutional approvals that might be required to complete this study.

A.2 Participants group - Parents

A.2.1 Flyer for Parents

PARTICIPANTS NEEDED

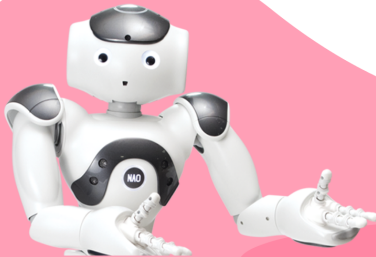
Calling for PARENTS!

If your child/children require therapy to improve their social skills
OR
your child/children are diagnosed with Autism

Participate in a 15-minutes survey about robot-assisted therapy for children.

As a thank-you, you'll be entered into a draw **to win a \$50 gift card** of your choice!

For more information or to volunteer for this study scan the QR code below
or send an email to: ssaiko@uwaterloo.ca



We are looking for parents to participate in a user experience study who fall under ONE or more of the following categories:

- Parents/guardians of children who require therapy to improve their social skills
- Parents/guardians of children diagnosed with autism

*THIS STUDY HAS BEEN REVIEWED AND RECEIVED ETHICS CLEARANCE THROUGH A UNIVERSITY OF WATERLOO RESEARCH ETHICS BOARD

A.2.2 Social Media Description for Parents

Calling all parents and caregivers! We're on an exciting mission to explore the revolutionary potential of robot-assisted home therapy for children diagnosed with autism. Your unique insights can directly influence the development of cutting-edge, accessible therapy solutions!

Why Participate?

-  Contribute to groundbreaking research in autism therapy
-  Share your valuable insights and experiences
-  Help us design tools that better serve families

What's Involved?

- ✓ A short 15-minutes survey about your thoughts on using robots for therapy
- ✓ All participation is voluntary and confidential
- ✓ A chance to win 50\$ gift card of your choice!

Who Can Join?

Parents or caregivers of children, who require therapy for improvement of their social skills. You DON'T have to have any previous experience with the robots to participate!

Interested?

Follow the link to the survey below or
Contact us at ssaiko@uwaterloo.ca for more details.

Thank you for helping us create a brighter future for children diagnosed with autism and their families! ❤️

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board REB#46471

<https://lnkd.in/eqP3jPxZ>

A.2.3 Consent Letter for Parents

Project Title: Investigating the attitude towards Robot-Based Home therapy for navigating Autism Spectrum Disorder (ASD) Traits in Children

Faculty Supervisor: Catherine Burns, System Design Engineering, 519-888-4567 x33903, c4burns@uwaterloo.ca

Student Investigator(s): Sabrina Saiko, System Design Engineering, ssaiko@uwaterloo.ca

This letter explains what the study is about, what participation involves, possible risks and benefits, and your rights as a research participant. You may print or save a copy for your records. If you do not understand something in the letter, please ask one of the investigators before consenting to participate.

This study aims to explore parents' and clinicians' attitudes toward robot-based home therapy for children with Autism Spectrum Disorder (ASD) and create a standard for designing social robots for home therapy.

This research addresses the critical need for standardized robotic therapy methods, potentially enhancing early interventions, mitigating barriers, which many parents are facing and improving outcomes for children with ASD. It also contributes to advancing ASD assessment and intervention practices while exploring innovative technological solutions.

Eligible participants are those who are involved in supporting growth, development, and well-being of children, who require therapy to improve their social skills (parents, caregivers, legal guardians, etc.)

Participation in this study is voluntary and there may not be any direct benefits for the participants. It will involve an online anonymous questionnaire of approximately **15 minutes** in length. You may decline to answer any of the survey questions.

This anonymous questionnaire will not ask for your name or other identifying information. Removing your responses later is not possible because the researchers will have no way of identifying which responses are yours.

Upon completing the survey, you will have the option to provide an email address if you wish to enter the draw for a **\$50 gift card**. Providing your email is voluntary. It will be securely stored until the draw is completed. The winner will be notified immediately and will receive a \$50 gift card of their choice. After the draw, all email addresses will be permanently deleted from the database.

This survey is hosted by University of Waterloo, which has multiple safeguards in place, although no Internet transmission is ever fully secure. Collected data will be securely stored on password-protected computers for at least 3 years.

With your permission, the data that you provide in this study may be shared publicly without any names or other identifying information. The purpose of sharing this data is to ensure research transparency, reproducibility, and to allow other researchers to verify findings, as

well as to contribute to future research on robot-assisted therapy for ASD. If you agree to the public sharing of anonymous data, please indicate your consent below.

This study will inform future research on robot-assisted therapy for Autism Spectrum Disorder (ASD). It will guide the design of user-friendly and engaging robots, enhance understanding of trust and acceptance in human-robot interaction, and support the development of therapeutic tools for broader applications. The findings will also serve as a foundation for longitudinal studies and interdisciplinary collaboration, advancing innovation in robotic-assisted therapy.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board REB#46471. If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please contact me by email at ssaiko@uwaterloo.ca. You can also contact my supervisor, Professor Catherine Burns at 519-888-4567 ext. 33903 or email c4burns@uwaterloo.ca.

I hope that the results of my study will be of benefit to those directly involved, as well as to the broader research community and families of children with ASD traits.

Thank you in advance for your assistance in this project.

Yours sincerely,
Sabrina Saiko
Graduate Student in
System Design Engineering Department
University of Waterloo

A.3 Participants group - Therapists

A.3.1 Flyer for Therapists

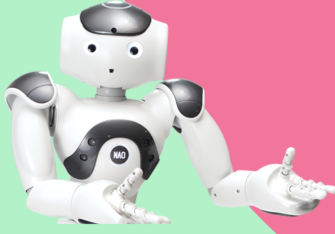


The flyer has a pink background with a green curved bottom section. It features yellow lightning bolts in the top corners and an orange lightning bolt in the bottom right. The main title 'SEEKING THERAPISTS FOR INTERVIEW' is in large, bold, white letters with black outlines. Below it, text describes the study's purpose and compensation. A QR code is provided for more information, along with contact details. A small robot illustration is on the left, and the University of Waterloo logo is on the right. A circular badge highlights the compensation of 150\$ per hour. The bottom section, on a green background, lists eligibility criteria under the heading 'Who can participate?'. A small disclaimer is at the very bottom.

SEEKING THERAPISTS FOR INTERVIEW

We are looking to hear your thoughts on the application of robot-based therapy for social skills improvement.

Your participation will involve online 1-hour interview.
As a thank you receive 150\$ for your time



Scan the QR
or email: ssaiko@uwaterloo.ca
for more information

**150\$
per hour**

Who can participate?

Licensed clinicians and therapists who:

- Provide therapy to children with autism and/or other developmental disorders
- Focus on improving children's social skills through therapeutic interventions

*THIS STUDY HAS BEEN REVIEWED AND RECEIVED ETHICS CLEARANCE THROUGH A UNIVERSITY OF WATERLOO RESEARCH ETHICS BOARD

A.3.2 Email for Therapists

Dear clinicians,

My name is Sabrina Saiko, and I am a master's student in the Department of Systems Design Engineering at the University of Waterloo, working under the supervision of Dr. Catherine Burns. As part of my research, I am conducting a study on the application of robot-based home therapy for managing Autism Spectrum Disorder (ASD) traits in children.

We are currently inviting clinicians and therapists to participate in a research study that explores attitudes toward robot-based therapy for children with ASD (or other social skill challenges). Your perspective would provide valuable insights.

Participation in this study involves an approximately one hour online interview where we will discuss your views on using robots as a therapeutic tool. **You will receive \$150 per hour for your time.**

This study has received ethics clearance from the University of Waterloo Research Ethics Board, and the participant identities will be kept confidential.

If you are interested in participating or would like more details about the study, please reply to this email or contact me directly at ssaiko@uwaterloo.ca.

Thank you for considering this opportunity to contribute to the advancement of research in this important field.

Best regards,
Sabrina Saiko
Graduate Student, Department of Systems Design Engineering
University of Waterloo

A.3.3 Consent Letter for Therapists

Project Title: Investigating the attitude towards Robot-Based Home therapy for navigating Autism Spectrum Disorder (ASD) Traits in Children

Faculty Supervisor: Catherine Burns, System Design Engineering, 519-888-4567 x33903, c4burns@uwaterloo.ca

Student Investigator(s): Sabrina Saiko, System Design Engineering, ssaike@uwaterloo.ca

This letter explains what the study is about, what participation involves, possible risks and benefits, and your rights as a research participant. You may print or save a copy for your records. If you do not understand something in the letter, please ask one of the investigators before consenting to participate.

This study aims to explore clinicians' attitudes toward robot-based therapy for children with Autism Spectrum Disorder (ASD) and create a standard for designing social robots for home therapy.

This research addresses the critical need for standardized robotic therapy methods, potentially enhancing early interventions, mitigating barriers, which many parents are facing and improving outcomes for children with ASD. It also contributes to advancing ASD assessment and intervention practices while exploring innovative technological solutions.

Eligible participants include clinicians who provide therapy to children for enhancing social skills.

Participation in this study is voluntary. It will involve an on-site one-on-one interview of approximately length. You may decline to answer any of the interview questions. As appreciation for your time you will be offered **150\$ per hour**.

Participation in this study is voluntary. It will involve an interview of approximately **1 hour** in length to take place in a mutually agreed upon location. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. If you wish to withdraw your study data after participating, please contact the researchers. You can request your data be removed from the study up until **30th of April 2025** as it is not possible to withdraw your data once papers and publications have been submitted to publishers.

With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish.

Your identity will be confidential. Your name will not appear in any thesis or report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be retained for at least **3 years** to which only researchers

associated with this project will have access. There are no known or anticipated risks to you as a participant in this study.

The data from this study will inform future research on robot-assisted therapy for Autism Spectrum Disorder (ASD). It will guide the design of user-friendly and engaging robots, enhance understanding of trust and acceptance in human-robot interaction, and support the development of therapeutic tools for broader applications. The findings will also serve as a foundation for longitudinal studies and interdisciplinary collaboration, advancing innovation in robotic-assisted therapy.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board REB#46471. If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

For all other questions or if you would like additional information to assist you in reaching a decision about participation, please contact me by email at ssaiko@uwaterloo.ca. You can also contact my supervisor, Professor Catherine Burns at 519-888-4567 ext. 33903 or email c4burns@uwaterloo.ca.

I hope that the results of my study will be of benefit to those directly involved, as well as to the broader research community and families of children with ASD traits.

Thank you in advance for your assistance in this project.

Yours sincerely,
Sabrina Saiko
Graduate Student in
System Design Engineering Department
University of Waterloo

A.3.4 Interview Appreciation Letter for Therapists

Participation Appreciation

Project Title: Investigating the attitude towards Robot-Based Home therapy for navigating Autism Spectrum Disorder (ASD) Traits in Children

Student Investigator:

Sabrina Saiko
University of Waterloo,
ssaiko@uwaterloo.ca

Faculty Supervisors:

Dr. Catherine Burns
University of Waterloo, Canada
c4burns@uwaterloo.ca

Thank you for participating in the study on robot-based home therapy for navigating Autism Spectrum Disorder (ASD) traits. Your engagement and the valuable insights you shared about your experience interacting with the robot have been invaluable to our research.

The goal of this study was to gain a deeper understanding of perspectives, apprehensions, and needs surrounding robot-based approaches in ASD training. Your expertise and experiences will greatly contribute to identifying areas for improvement and inform the development of more effective, user-friendly robot-based systems for enhancing ASD therapy.

If you expressed interest in receiving a copy of the study results, we will ensure that they are forwarded to the email address you provided as soon as the findings are compiled. Should you have any further questions or wish to provide additional feedback, please do not hesitate to reach out to any member of our research team.

Your confidentiality is of utmost importance to us. While the interview was recorded for transcription and analysis purposes, please rest assured that the recording will be deleted immediately upon completion of the transcription process. Your identity and any potentially identifying details will remain strictly confidential, secured, and accessible only to the research team. All findings will be reported in an aggregated format to ensure complete anonymity.

Thank you again for your valuable contribution to our study.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #46471). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca

Appendix B

Study Materials

B.1 Survey for Parents

28.07.25, 15:08

Qualtrics Survey Software

Question Tour Block 1

Thank you for your interest in participating in our study!

This questionnaire is designed to assess your eligibility. Please answer all questions truthfully. Your responses will determine whether you qualify to take part in this study.

Do you have a child(children) who requires therapy to improve their social skills?

- ☐ Yes
- ☐ No

Are there any restrictions or concerns that would prevent you from participating in this study?

- ☐ Yes
- ☐ No

By submitting this form, you confirm that the information provided is accurate to the best of your knowledge and that you understand this is a screening questionnaire to assess your eligibility for the study.

- ☐ Yes
- ☐ No

Your consent

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Thank you for your time and willingness to contribute to this research.

Based on your responses to the eligibility assessment, you are eligible to participate in the study.

This study aims to explore parents' attitudes toward robot-based therapy for children with autism and get insights for creating a standard for designing social robots for therapy.

Your honest and comprehensive answers will significantly enhance our understanding of your perception of the Social Robots for therapy. Please respond to the following questions with sincerity and to the best of your ability.

Before beginning the survey, please take a moment to review the following document:

[Consent Letter](#)

By continuing, **you acknowledge** that you have reviewed the consent information and agree to participate voluntarily.

*At the end of the survey, **you will be redirected to a separate form** where you can **optionally** submit your email address if you wish to **enter the draw for a 50\$ gift card**. This redirection process ensures that your survey responses remain anonymous and cannot be linked back to your identity.*

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board REB#46471.

By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

NOTE: *If you select 'I do not agree...' option, your response will not be recorded.*

- ☐ I **AGREE** to participate in this study
- ☐ I **DO NOT** agree to participate in this study

I agree to the use of anonymous quotations in any paper or publication that comes from this research

- ☐ Yes

☐ No

I agree to share my anonymous data for research transparency, reproducibility, and future studies as established in the consent letter

☐ Yes

☐ No

Block 1

Have you ever used any tech devices for therapeutic purposes for your children (for example: Ipads / Android tablets, Wearable Devices, Sensory Devices, Robots/Robotic Toys, Virtual Reality (VR) Therapy Tools, Smart Assistive Devices, etc.)?

☐ Yes

☐ No

☐ Prefer not to say

If answered "Yes" on previous question, please list what devices you used for therapeutic purposes for your children:

Have you heard about using robots for therapeutic purposes for your children?

☐ Yes

☐ No

☐ Prefer not to say

Social robots are specially designed robots that can interact with people in a human-like way using speech, gestures, and facial expressions. In autism therapy, these robots are

often used to help children practice social skills, such as making eye contact, taking turns, or recognizing emotions.

How familiar are you with the use of robots in autism therapy?

- ☐ Not familiar at all
- ☐ Slightly familiar
- ☐ Moderately familiar
- ☐ Very familiar
- ☐ Prefer not to say

Do you believe a robot could help your child improve their social and communication skills?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

Would you consider using a robot as a teaching tool for your child with autism?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

Would any of those reasons encourage you to use a robot to improve your child's social skills? (Select all that apply)

- ☐ Proven effectiveness in educational outcomes
- ☐ Positive feedback from other parents
- ☐ Recommendations from healthcare/education professionals
- ☐ Cost-effective solution

- ☐ Customization to my child's needs
- ☐ Other (please specify):
- ☐ Prefer not to say

How important is every of those criteria as an outcome from the use of the robot you choose?

(select a number between 1-5 for each line, where 1 is **Not Important** and 5 is **Very Important**)

	Not Important			Very Important		Prefer not to say
	1	2	3	4	5	
Consistent and structured learning environment						☐
Increased focus and engagement						☐
Enhanced social and communication skills						☐
Reduced stress or anxiety compared to human instructors						☐
Tailored content to individual needs						☐
Other (please specify):						☐

If there are any other important to you outcomes, not listed in the question above, please list them here and put a number from 1 to 5 to reflect its importance

Do you have any concerns about using a robot as a teaching tool? (Select all that apply)

- ☐ Cost and affordability
- ☐ Dependence on technology
- ☐ Lack of personal connection/empathy
- ☐ Safety and data privacy issues
- ☐ Difficulty in integrating with other therapies
- ☐ Effectiveness in long-term learning
- ☐ I have no concerns
- ☐ Other (please specify):
- ☐ Prefer not to say

Even if you haven't personally used a social robot, how strongly would you agree with the following statements?

(Use the scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer not to say
	1	2	3	4	5	
A social robot is essential for improving my child's social interactions.						☐

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Qualtrics Survey Software

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer not to say
	1	2	3	4	5	
A social robot is necessary for my child's communication development.						☐
Using a social robot could complement or replace some therapy center sessions.						☐
A social robot could make therapy more consistent and accessible for my child.						☐

How strongly do you agree with the following statements?

(Use the scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer not to say
	1	2	3	4	5	
I am concerned that a robot might not address my child's specific needs						☐
I worry about my child becoming overly dependent on the robot						☐
I feel unsure about the safety and reliability of using a robot at home						☐

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Qualtrics Survey Software

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer not to say
	1	2	3	4	5	
I am concerned that a robot might reduce my child's interaction with human therapists						☐
I am worried about the cost of purchasing and maintaining a social robot						☐

Would you prefer a robot to provide therapy sessions at home rather than going to a therapy center?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

Do you think a robot could reduce the time and effort required to travel to therapy centers?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

How likely would you be to use a robot if it were prescribed by a therapist?

- ☐ Very likely
- ☐ Likely
- ☐ Neutral

- ☐ Unlikely
- ☐ Very unlikely
- ☐ Prefer not to say

Would you involve your kid into the process of choosing a robot (like choosing appearance, voice, behavior, etc)?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

Would you prefer the robot program to be customized to your child's specific learning needs and pace? If so, who should handle the customization?

- ☐ A therapist
- ☐ Me (the parent/caregiver)
- ☐ Automatically by the robot program
- ☐ No preference
- ☐ Unsure, need more details
- ☐ I don't think the customization is required
- ☐ Prefer not to say

How comfortable would you be if the robot tracked your child's progress and provided reports on their learning and development?

- ☐ Very comfortable
- ☐ Somewhat comfortable
- ☐ Neutral
- ☐ Somewhat uncomfortable
- ☐ Very uncomfortable
- ☐ Prefer not to say

Would you like the reports from the robot to be delivered to your therapist?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ I am uncomfortable with the robot tracking my child's progress
- ☐ Prefer not to say

Would you be willing to learn how to use and support the robot-based teaching system at home?

- ☐ Yes
- ☐ No
- ☐ Maybe
- ☐ Prefer not to say

Would you expect involvement from teachers, therapists, or other professionals when using a robot to teach your child? If so, what level of involvement would you expect?

- ☐ High involvement (e.g., ongoing supervision, training sessions)
- ☐ Moderate involvement (e.g., periodic check-ins, adjustments)
- ☐ Minimal involvement (e.g., basic setup and occasional reviews)
- ☐ No involvement necessary
- ☐ Prefer not to say

In your opinion, what features or functions should a teaching robot have to meet your child's needs?

(Please describe):



What additional support or information would you need to feel comfortable using a teaching robot for your child? (Please describe):



Demographic

Please provide some information about yourself to help us better understand your background.

What is your relationship to the child?

- ☐ Mother
- ☐ Father
- ☐ Guardian
- ☐ Other (please specify):
- ☐ Prefer not to say

What is your child's age?

- ☐ 0–2 years
- ☐ 3–5 years
- ☐ 6–8 years
- ☐ 9–12 years
- ☐ 13+ years
- ☐ Prefer not to say

What is your child's gender identity?

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to say

How many children do you have?

- ☐ 1
- ☐ 2
- ☐ 3 or more
- ☐ Prefer not to say

Thank you for your participation!

After submitting your response, you will be redirected to a form where you can submit your email address **to enter the draw for a 50\$ gift card.**

*This redirection process ensures that **your survey responses remain anonymous** and cannot be linked back to your identity.*

Providing your email is entirely optional and will only be used for the purpose of contacting draw winners.

Powered by Qualtrics

B.2 Eligibility Survey for Therapists

28.07.25, 15:19

Qualtrics Survey Software



Eligibility questions

Are you a registered specialist, who provides therapy or interventions aimed at improving social skills in children with autism or other developmental disorders?

☐ Yes

☐ No

Do you provide therapy or interventions aimed at improving social skills in children with autism or other developmental disorders?

☐ Yes

☐ No

Please specify your current role or position in the field:

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Default Question Block

How long have you been practicing as a therapist?

- ☐ 0-1 years
- ☐ 2-4 years
- ☐ 5-10 years
- ☐ More than 10 years

Approximately how many hours of therapy sessions focused on improving children's social skills have you provided?

- ☐ Less than 50 hours
- ☐ 50-199 hours
- ☐ 200 hours or more

What is the typical age range of the children you work with?

*(Please select **up to two** age groups that best represent your primary client base)*

- ☐ 0-3 years (infants and toddlers)
- ☐ 4-6 years (preschool age)
- ☐ 7-12 years (school-age children)

☐ 13–17 years (adolescents)

What type(s) of therapy do you primarily use in your practice (e.g., ABA, play therapy, cognitive-behavioral therapy)?

- ☐ Applied Behavior Analysis (ABA)
- ☐ Play therapy
- ☐ Cognitive Behavioral Therapy (CBT)
- ☐ Speech and language therapy
- ☐ Occupational therapy
- ☐ Social skills training groups
- ☐ Other (please specify):

Please **read the Consent Letter** carefully before proceeding. After reading it, use the space below to write any questions or concerns you may have about the study.

If you have no concerns and agree to participate, please write: *"I give my consent"*

B.3 Interview with Therapists

Clinician Interview: Perceptions of Social Robots in Therapy

Introduction:

Thank you for taking the time to speak with me today. This conversation is part of a study exploring the role of social robots in therapy, particularly for children with Autism Spectrum Disorder (ASD) or social communication challenges. I'd love to hear about your experiences, perspectives, and any thoughts you have on the potential benefits and concerns regarding these technologies.

Section 1: Experience with Technology in Therapy

1. Could you start by sharing a bit about your background? What is your role, and how long have you been working with children with ASD or social communication challenges?
2. Have you used technology-based tools, such as apps, devices, or AI-assisted programs, in your therapy sessions? If so, could you describe which ones and how they've been helpful (or not)?
3. Have you heard about social robots being used in therapy? What are your initial thoughts on this concept?
4. How familiar are you with the specific ways social robots are currently used in therapy? Have you had any direct experience with them?

Section 2: Practical Implementation

5. If social robots became widely available for therapy, would you consider integrating them into your sessions? Why or why not?
6. What would make you more likely to use a social robot in therapy? Would things like strong research evidence, recommendations from experts, or training support make a difference?
7. In your opinion, what should be the role of a social robot in therapy? Should it be a **supplementary tool**, something that **partially replaces certain therapy tasks**, or something that could **fully replace specific interventions**?
8. When using a social robot, who do you think should handle customization (creating a program for the patient, making tasks/milestones, adjusting it in the future) — therapists, parents, or should the robot adapt automatically? What level of personalization do you think is necessary?
9. Would you find it valuable if a robot could track a child's progress and generate reports on their development? If so, how would you like to see that information used?
10. Do you think a social robot would be more effective when used in a therapy center under professional supervision, or as a tool for at-home reinforcement? Why?
11. In your opinion, could using a social robot at home complement clinic-based therapy sessions? If so, in what ways?

12. Do you think a social robot could help reduce the need for frequent in-person therapy sessions, or would it be best used as a supplement rather than a replacement?
13. Could social robots play a role in expanding access to therapy, for example, by allowing children in remote areas or with mobility challenges to receive more consistent support?
14. Would the use of a social robot influence how therapy is delivered—for instance, by allowing therapists to conduct more remote or hybrid sessions?

Section 3: Perceived Benefits and Challenges

15. In your opinion, what are some of the biggest challenges in engaging children with ASD in therapy? Do you think a social robot could help address any of these challenges?
16. Do you see any potential benefits or concerns in using social robots in therapy? For example, do you think they could help with engagement, social interactions, or consistency in learning? Are there any aspects you think might be problematic, such as cost, ethical considerations, or effectiveness compared to traditional methods?

Optional question: Some clinicians worry that robots could reduce human interaction or lead to over-reliance on technology. Do you share this concern? Why or why not?

17. If you were to consider using a social robot in your practice, what factors would be most important for you? (For example, ease of use, integration with existing therapy methods, cost, customization options, etc.)
18. Would you prefer to

Section 4: Future Adoption and Support

16. If social robots became a regular part of therapy, what kind of training or support would you need to feel confident using them?
17. In your opinion, what features or capabilities would make a social robot most useful for therapy?
18. What do you think are the biggest barriers to adopting social robots in clinical settings? Do you see these challenges being addressed in the future?
19. Looking ahead, do you think social robots will become a common part of therapy for children with ASD? Why or why not?

Conclusion:

20. Is there anything else you'd like to share about your thoughts on social robots in therapy? Any concerns, expectations, or additional insights?

21. Would you be open to a follow-up conversation in the future if we need more insights?