Technology-Enhanced Speech Therapy for Children with Autism Spectrum Disorder: A Review of Blended Intervention Approaches

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DOI: https://doi.org/10.47772/IJRISS.2026.100700884

Received: 01 August 2026; Accepted: 06 August 2026; Published: 14 August 2026

ABSTRACT

Technology-enhanced interventions gained increased attention during the COVID-19 pandemic and have continued to reshape the delivery of speech therapy services. Children with Autism Spectrum Disorder (ASD) commonly experience challenges in speech, language, and social communication. They may benefit from technologies such as robot-assisted therapy, tablet-based applications, and virtual reality (VR). This review explores the role of technology-enhanced speech therapy for children with ASD, with particular emphasis on blended intervention approaches and their impact on social communication outcomes. These technologies have been increasingly integrated into speech therapy to support language development, social communication, and engagement by providing structured, interactive, and repeatable learning opportunities. While technology-enhanced interventions have demonstrated promising outcomes, including improved participation and communication skills, clinician-led approaches remain fundamental to intervention. Conventional methods including behavioural, developmental, augmentative and alternative communication (AAC)-based interventions, continue to provide the clinical foundation for effective therapy. Emerging evidence suggests that blended intervention models, which integrate technology-enhanced tools with traditional speech therapy, offer a balanced and effective approach by combining the strengths of both modalities. Overall, blended intervention approaches that combine technology-enhanced tools with clinician-led therapy show promising potential to support speech, language, and social communication development in children with ASD.

INTRODUCTION

Hirota and King (2023) characterized Autism Spectrum Disorder (ASD) as deficits in social communication and the presence of restricted interests and repetitive behaviours. Children or individuals who are diagnosed with ASD usually experience challenges in communication which affects the key areas of functioning (Sturrock et al., 2022). This includes education, daily living skills and social relationships. Recent studies show that ASD is prevalent worldwide and have garnered global attention. A systemic review by Issac et al. (2025) showed that 0.77% of children globally are diagnosed with ASD. Because communication and social interaction difficulties are core characteristics of ASD that affect everyday functioning across all levels of severity, early intervention is essential to improve developmental outcomes for children with ASD (Thomas et al., 2021).

Early intervention especially speech therapy, has been acknowledged to be very important intervention for children with ASD and has demonstrated favourable outcomes (Osmanet al., 2023). Speech and language intervention strengthens vocabulary acquisition, symbolic communication, narrative skills, and engagement in reciprocal interactions (Frazier et al., 2021). Traditional speech therapy utilises a range of intervention strategies that depends on the child's requirements, including the Floortime method, simulation of game situations, Applied Behavioural Analysis (ABA), multi-modal sensory approaches, and the implementation of Augmentative and Alternative Communication (AAC) systems to support each child's communication needs (Hryntsiv et al., 2025).

In recent years, technology-enhanced interventions have received growing attention in speech therapy. In this context, technological tools include computer-based, tablet, and social robotics provide a comfortable environment that promotes constant learning for ASD children (Scarcella et al., 2023). Cardy et al. (2023) found that children with ASD tend to utilise technology more than non-autistic children, as various studies have shown that technological based interventions do produce remarkable results in facilitating engagement, learning and communication (Pérez-Fuster et al., 2022; Suparjoh et al., 2020; Fernández-Batanero et al., 2024). Humanoid robots in particular, have produced positive effects on the social and communication skills of children with ASD (Kouroupa et al., 2022). This may be because children with ASD often show greater attention and engagement when interacting with robots than with humans (Chung et al., 2025; Ghiglino et al., 2025; So et al., 2023; Kewalramani et al., 2024; Ishak et al., 2023). Evidence shows that robots can elicit positive emotional responses and heightened engagement during interaction with children with ASD (Dubois-Sage et al., 2024). Studies have also reported that children with ASD showed improvements in eye contact, following instructions, and understanding social rules, which lead to better social interaction (C. Syriopoulou-Delli et al., 2021).

Combining technology-based tools, such as humanoid robots, with clinician-led speech therapy may provide better support for the speech, language, and social communication development of children with ASD. Current evidence suggests that blended intervention approaches may provide greater benefits than traditional speech therapy alone (Hryntsiv et al., 2025). For a better outcome in enhancing both verbal skills and communicative initiative in these children who have ASD, exploring a blended approach that integrates robotic therapy and traditional speech therapy would prove to be highly effective (Di Cara et al., 2025). However, the growing use of technology in speech therapy highlights the need for better understanding on how these tools can be effectively integrated into clinical practice. Therefore, this review aims to explore the role of technology-enhanced speech therapy in ASD, emphasizing blended intervention approaches and their impact on social communication skills.

Social Communication Challenges in Children with ASD

The main characteristic of children with ASD is difficulty in social communication, which often involves challenges in joint attention, nonverbal communication, and reciprocal social interaction (Xiao & Li, 2025). The severity of the disorder determines where a child falls on the autism spectrum and influences the level of social communication challenges they experience. These challenges can affect their adaptive functioning and participation in everyday life (Lord et al., 2022).

The various types of social communication issues include struggles to engage with others in play, not initiating any form of interaction, naturally preferring solitude, not showing interest in people, displaying socially inappropriate behaviours such as screaming or hitting especially in public and not responding to or sharing social smiles (Cerbo & Rabi, 2019; Hirota & King, 2023). Infants who were later diagnosed with ASD shows fewer communication skills such as eye gaze, facial expressions, gestures, and vocal sounds (Bradshaw et al., 2021).

When an individual is diagnosed with ASD, they often show impairments in Theory of Mind (ToM). Theory of Mind refers to the ability to understand other people's thoughts, intentions, and emotions, and to respond appropriately in social situations. Difficulties in this area contribute to the social communication and interaction challenges commonly experienced by individuals with ASD (Silarat, 2022). Research has shown that children with ASD without intellectual disability have varying ToM abilities. Those with lower ToM skills tend to show more severe autism symptoms and poorer social, pragmatic, and adaptive behaviours than children with higher ToM skills or their typically developing peers (Rosello et al., 2020). Forming close relationships can be more challenging for individuals with ASD because they often have difficulty understanding other people's reactions, facial expressions, and emotions, which may affect their ability to empathise.

Technology-Enhanced Speech Therapy Approaches

Technology-enhanced intervention refers to the use of electronic or digital devices, applications, or software designed to enhance the development of specific skills (C. K. Syriopoulou-Delli & Gkiolnta, 2022). Its successful integration into speech therapy also depends on clinicians' willingness to adopt these technologies. For example, speech therapists in Germany generally reported positive attitudes towards digital media and video

therapy, with perceived usefulness, training, and facilitating conditions strongly influencing their intention to use technology in clinical practice (Leinweber et al., 2023).

Tablet/computer-based applications

The growth of the digital society, tablet- and computer-based digital therapies have shown increased adoption to support the learning, cognition, and social communication of ASD children. Meta-analysis by Muharib et al. (2024) found that tablet-based speech-generating devices can improve how individuals with ASD communicate, with the strongest effects on requesting and conversational responses. Studies have shown that iPad-based speech-generating devices, when used together with a systematic instructional package, can help children with ASD learn to answer multi-step questions. The acquired skills were maintained over time, generalised to new settings, and were considered feasible and effective by those who implemented the intervention (Genc-Tosun et al., 2023).

Furthermore, mobile AAC applications like Proloque2Go, TouchChat, and Avaz, along with text-to-speech technology, provide interactive, customizable tools that help children with ASD communicate using symbols, pictures, or text as an alternative to speech (Hryntsiv et al., 2025). The SPEAKplay! Mobile AAC application uses gamification and serious game design to help minimally verbal children with ASD develop fine motor and communication skills, offering engaging, customizable training that enhances access to mobile AAC devices and supports language development (Wendt et al., 2020). A study by Chapin et al. (2022) showed a tablet-based video visual scene display AAC app significantly increased communicative turns in preschoolers with ASD, suggesting it is a promising tool for enhancing early social communication.

A study by MAMAT et al. (2024) introduces a Malay-language Virtual Speech Therapy System (VSTS) that can be installed on a tablet or phone that employs "Applied Behaviour Analysis (ABA)" and "Discrete Trial Training (DTT)" that uses speech recognition and text-to-speech to provide accessible therapy for children with ASD, achieving high recognition accuracy and supporting verbal development. Kalantarian et al. (2020) presented a mobile application called "Guess What" which is designed to be a shared experience between a child and their parent. The child will express the word displayed on the screen using gestures and facial expressions, while parents can attempt to guess correct word within a 90-second time limit. This game is available on Android and iOS, making it widely accessible for parents to utilise for their children.

Virtual Reality technology

Incorporating VR into therapy or training programs has been shown to effectively improve social functioning, emotion recognition, and speech and language among individuals with ASD. This emphasises VR technologies as a tool that has potential in elevating the educational journey for young students with ASD (Zhang et al., 2022). A systematic review by Yang et al. (2025) revealed that "VR technology interventions have a positive effect on social skills in children and adolescents with ASD". Immersive VR is particularly useful when dealing with individuals with "high functioning autism" (HFA) as it is able to enhance their complex social skills. Children and adolescents with low functioning autism (LFA) mainly showed improvements in basic skills.

In a comparison between virtual reality (VR) emotional training and traditional therapist-led training in ASD children, both were recognised that it can address recognising primary emotions, however VR enabled quicker mastery of both primary and secondary emotions, highlighting its potential as an effective tool for developing basic and complex social skills Frolli et al. (2022). A study by Manju et al. (2023) explores a Virtual Reality Intervention (VRI) that uses eye-tracking to improve learning, and visual perception in ASD children, demonstrating that repeated virtual therapy can progressively reduce inattention.

López-Belmonte et al. (2022) showed that gender affects the use of AR and VR ASD children, affecting motivation, attention, and communication, while autonomy and learning outcomes remain unaffected, highlighting the need to consider gender when designing AR and VR educational interventions for ASD students. VR interventions show potential in addressing challenges and supporting skill generalization in ASD children in speech and language therapy, however, most studies focus primarily on social skills (Mills & Duffy, 2025).

Robot-assisted therapy

Innovative technologies are increasingly being incorporated into the field of Speech and Language Therapy. Technological advancements have shown promise in aiding children with ASD, particularly through robotics and "socially assistive robots" (SARs) (Dubois-Sage et al., 2024). Robots have attracted relevant concern and awareness in autism therapy due to their motivating qualities, predictable behavior, and simplified design (Dubois-Sage et al., 2024). The selection of robot types and forms for individuals with ASD has been thoughtfully evaluated to ensure they are appropriate, effective, and engaging within therapeutic settings.

Humanoid robots

Studies have shown that children are more attentive, enthusiastic, and responsive during sessions that incorporated the "NAO" robot (Yousif, 2021). Technology-based interventions, that incorporate "Socially Assistive Robots" (SARs), have been associated with notable gains in social engagement, emotional self-regulation, and communication skills in ASD children. This is due to the robot's simple, toy-like design which is able to capture children's attention and make learning activities more enjoyable. Robots such as LEGO Mindstorms and Kaspar effectively improving eye contact, cooperation, and emotion recognition (Sumra & Sumra, 2024).

The "17th ACM/IEEE International Conference on Human-Robot Interaction" (2022) has examined variations in autistic traits alongside socio-demographic factors. The intervention outcomes with the "NAO" robot varied based on the different characteristics of a child including age and verbal abilities. Generally; older, more verbal and high-functioning children would show greater engagement, positive behaviour and communication. On the other hand, younger children would display more affection, curiosity and different interaction patterns. A study by Lin et al., (2025) demonstrated that the "NAO-RBI" system, integrating an "NAO" robot with Kinext-based body movement recognition, effectively improves body language skills and capability of these ASD children expressing themselves, highlighting the potential of robot-assisted practice in special education.

Kinney et al. (2021) suggests that using a "NAO" robot in social skills interventions can gradually enhance the complexity and initiation of speech in children with ASD. However, this was only observed when the children interact with the robot, though speech toward peers showed no change, suggesting that ASD children may need repeated exposure to truly reap the full benefits of robot-assisted interventions. This study found that Sacino et al. (2022),ASD children's spontaneous interactions with a humanoid robot and an adult were influenced by individual characteristics particularly language ability and social functioning, suggesting that tailoring robot behaviour and giving children more control can enhance engagement and learning.

Animaloid robot

Study by Bharatharaj et al. (2017), this study suggests that a "parrot-inspired robot using the adapted model-rival method" (AMRM) can engage children with ASD, showing positive emotional responses and potential to support how ASD children interact socially. Puehn et al. (2022) introduces Philos, a low-cost animal-insoored (penguin-like) social robot designed to relieve personalized human-robot interaction through adaptive personalities, gesture expression, and touch and vision-based responses, highlighting it's potential for therapeutic and assistive applications.

Animal-inspired robots aim to improve engagement and emotional connection in children with ASD by using familiar, friendly animal-like features that support social interaction and therapeutic participation (Kumazaki et al., 2020). Study by Chandra. (2022) found that neurodivergent university students preferred robot dogs that combined Aibo's friendly appearance with A1's responsive behavior, valued their use for companionship, emotional support and practical tasks.

A study by Burns et al. (2021) designed HERA, a NAO robot dressed in a soft koala suit equipped with fabric-based tactile sensors to respond to affective touch. This aims to enhance how ASD children communicate and interacts with people around them. Study by Niderla & Maciejewski. (2021), presents a rabbit-shaped

zoomorphic robot designed for children with ASD that uses movable joints, sensors, a touchscreen face, and AI-driven control to facilitate communication, convey emotions, and support therapeutic interactions, with positive responses observed during clinical trials.

Toy robots

The study by Laurie et al. (2022) found that tangible and digital robot toys can enhance joint attention and social engagement in autistic children, though individual differences in social motivation and responses to digital features influence their interactions. The study by Leoste et al. (2021) found that using a simple Bee-Bot robot in an emotion's memory game improved verbal communication and engagement in children with ASD, demonstrating that even toy robots can support social interaction similarly to more complex humanoid robots.
The study by Bethere et al. (2023) qualitatively explored expert views on AI-powered plush robots for children with ASD and found they can be beneficial in educational and rehabilitation settings when designed with appropriate features and customization, though effectiveness depends on individual needs and specialist-guided use.

Traditional Speech Therapy Interventions

Speech therapy aims to improve communication, social interaction, and quality of life by targeting verbal, non-verbal, and functional skills. Floortime method, "Picture Exchange Communication System" (PECS), games, imitation techniques, and behavioral techniques which are Applied Behavioural Analysis (ABA) are some of the approaches used in speech therapy with ASD children (Hryntsiv et al., 2025).

a) DIR/ Floortime

DIR/Floortime is an "evidence-based cost-effective, completely child-led approach" and helps the improvement of a child's social and emotional development (Divya et al., 2023). In DIR/Floortime, a parent or adult engages with the child by carefully observing the behaviours exhibited by the child, interpreting their emotions and intentions, valuing their ideas and as such respond effectively. Through ongoing two-way interactions, the adult and child build shared understanding and meaning together (Cullinane, 2025).
A longitudinal study of DIR/Floortime-based speech therapy for young ASD children found statistically significant gains after 24 sessions, including increased communicative acts, greater use of communicative space, stronger intentional two-way communication, and reduced gesture use, showing overall improvement in communication (Ferreira et al., 2025). Sinyanyuri et al. (2024) found that elementary school teachers who use the DIR/Floortime play-based floor approach managed to improve communication, engagement, self-confidence and social inclusion in ASD children.

II. AAC

Augmentative and Alternative Communication (AAC) helps individuals with complex communication needs by making up for functional communication challenges and lack of language skills. AAC comprises of various communication methods and systems such as speech, image output devices and manual signs and "picture exchange communication systems" (PECS). In the case of non-verbal children, PECS is most used globally.
PECS has proven to show improvement in verbal, non-verbal and social communication skills in younger autistic individuals (Jamal et al., 2024). Younger children tend to benefit the most, which signifies the importance of early intervention as it leads to generalisation of skills in different settings (Jamal et al., 2024). Implementing PECS within the special education curricula as an evidence-based intervention enables for better communication and related developmental skills among ASD children (Hassanzadeh & Shaweisi, 2025).
Nkhoma, W. (2025) demonstrates that PECS training significantly improves children's ability to make independent requests, while also reducing frustration and increasing classroom participation. This strongly indicates that PECS is very effective approach to enhance communication among individuals with ASD. It is also an affordable option which is beneficial in resource-limited education settings.
Impairment severity, intervention intensity, socioeconomic status, and caregiver involvement are some of the factors that would affect the success of PECS, highlighting the importance of tailored strategies to optimize communication outcomes for children with ASD (Wannapaschaiyong et al., 2025).

iii. PROMPT and Hanen's 'More Than Words' (HMTW)

PROMPT (Restructuring Oral Muscular Phonetic Targets) is a motor-based intervention that uses tactile–kinesthetic input to facilitate accurate speech movement patterns, targeting the place, manner, and timing of

articulatory gestures. Rather than focusing solely on auditory modeling, the approach provides structured physical cues to support motor planning and execution. Evidence suggests that, in children with ASD, PROMPT may contribute to measurable improvements in phonatory stability, mandibular and lip-facial control, lingual coordination, overall speech intelligibility, consonant accuracy, and word-level precision (Donadio et al., 2024). Hanen's 'More Than Words' developed by Sussman is a parent training program that helps parents learn practical way to enhance communication in children with ASD. It is run by a speech therapist and includes group and family sessions that teach parents how to create more playful interactions, adjust daily routines to their child's level, and respond to their child using both verbal and nonverbal strategies. A study by Noyan Erbaş et al. (2021) showed positive effects of the HMTW programme on parents' self-efficacy, anxiety, stress levels, and interaction behaviours, as well as on the verbal language and social interaction skills of children with ASD.

Blended Intervention Approaches

There has been an increase in the range of intervention approaches used to support ASD children. Blended intervention approaches in healthcare and education have significantly risen and revolutionized service delivery, particularly in speech therapy. Research suggest that combining multiple modalities can enhance engagement, reinforce learning across environments, and promote generalization of communication skills.

A study by Ponthier (2021) found that a blend of teletherapy and physical early intervention caused some skill improvements in ASD children, but outcomes were stronger in children without ASD. This suggests that ASD children would require additional individualized blended intervention to achieve significant communication gains. Another study by Hryntsiv et al. (2025) concluded that children with ASD who were treated with both traditional and innovative speech intervention methods showed greater improvement than those receiving only traditional therapy, indicating that a blended approach was more effective.

Lorah et al. (2024) found in their systematic review that mobile AAC interventions for ASD children are effective when it is done with multiple evidence- based practices (e.g., prompting, reinforcement, DTT and modelling), and highlights the need for broader research across ages, settings, and communicative functions. Also, a study found that integrating Applied Behavior Analysis with robot-assisted training using the humanoid robot iCub had enhanced the social skills in ASD children (Ghiglino et al., 2025).

Another review study highlighted the use of PECS (low-tech) and iPad-based AAC (high-tech) interventions in enhancing ASD children's communication and related skills, with each offering distinct benefits, and recommends combining both approaches for better outcomes (Ariwijaya, 2020). Study by Benway & Preston (2024) showed that an AI-assisted speech therapy program combining clinician led pre-practice with automated motor-based practice (ChainingAI) led to significant improvements and generalization of /r/ sound production in participants with residual speech sound disorder, showing that AI-supported hybrid therapy as a promising way to increase treatment intensity and access.

DISCUSSION

The findings of this review highlight the increasing role of technology-enhanced speech therapy for children with ASD, particularly the potential of blended intervention approaches to enhance speech, language, and social communication outcomes. Lately, technology in health care service is given attention to especially in speech therapy. On the other hand, rapid technological progress has led to studies about assistive technology or technological approaches for children with ASD, integrating technology into interventions with ASD children has shown notable positive changes in their day-to-day social interactions, and are more receptive and expressive with their language. Technology offers a promising service delivery avenue for autistic children because it supports neurodiversity-affirming approaches through safe, controlled practice environments and personalized content tailored to each child's interests, cognitive level, and communication preferences (Cardy et al., 2023).

Efficacy of technology-based interventions

Technology-enhanced tools, including tablets, computers, virtual reality (VR), and robots, have been

increasingly integrated into traditional speech therapy and have shown promising outcomes for children with ASD. Across the reviewed studies, children with ASD were generally more engaged during technology-enhanced interventions and showed improvements in requesting, conversational skills, emotion recognition, and social interaction. These approaches are usually structured and consistent, plus it is an engaging learning environment that suits the of ASD children's learning styles. However, the outcomes of technology-based interventions differ depending on each child's characteristic and diagnosis, the intensity of intervention, the therapist's level of training, and available resources. Therefore, evidence suggest that technology combined with evidence-based interventions and clinician led therapy can lead to better results than using technology-based interventions alone.

Implications of blended intervention in speech therapy practice

Blended intervention in speech therapy combine technology with traditional methods, evidence -based approaches and clinician-led has proven to improve ASD children's communication skills. Compared with traditional therapy, blended intervention approaches appear to provide greater improvements in communication outcomes for children with ASD. These findings highlight the practical value of blended interventions for service delivery, treatment outcomes, and accessibility. Rather than replacing traditional therapy, technology such as tablet-based programmes, virtual reality (VR), and robot-assisted interventions can be integrated into clinician-led practice to provide additional opportunities for learning, practice, and skill generalisation.

Technology has become a more efficient alternative as it is able to provide immediate feedback, motivating formats and personalised structures tailored to the needs of a specific child. Speech therapists can then execute their roles in correct target selection, cueing, generalisation and functional communication cues. A proper combination would allow children with ASD to reap the full benefits from this customised intervention.

While there is growing evidence supporting blended interventions in speech therapy for children with ASD, several limitations should be considered. The studies included in this review differed in the types of technology used, intervention duration, intensity, participant characteristics, and outcome measures. These differences make it difficult to directly compare findings or determine which approaches are most effective. In addition, many studies involved small sample sizes or short intervention periods, highlighting the need for more robust evidence. Another limitation is the cost and availability of technology, particularly in low-resource settings, as well as the need for speech therapists to receive appropriate training to integrate these tools effectively into clinical practice.

CONCLUSION

Technology-enhanced speech therapy, particularly in blended intervention models, has shown increasing evidence and potential in supporting children with ASD by enhancing speech, language and social communication development. Tools such as AAC-based applications, tablet-based learning platforms, virtual reality environments, and robot-assisted interventions can promote sustained engagement while offering structured, consistent opportunities for practice. Overall, blended intervention approaches offer a promising direction for speech therapy by combining the benefits of technology with the expertise of clinicians.

Further research involving larger participant groups and longer follow-up is needed to better understand the long-term effectiveness of blended interventions. Future studies should also explore how these technologies can be implemented across different clinical and educational settings while remaining accessible and practical for children with ASD and their families.

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