disabilities

MDPI

Case Report

Therapeutic Effect of Educational Robotics on Neurocognitive and Social Skills in Two Case Studies of Children with Neurodevelopmental Difficulties

Alejandro De la Hoz [1], Ester Ceballos [2] and Javier Cubero [1,*]

[1] Health Education Lab, Department of Experimental Sciences and Mathematical Education, Faculty of Education and Psychology, University of Extremadura, 06006 Badajoz, Spain; alexdlhoz@unex.es
[2] Toc-Toc Child and Adolescent Psychology, 06004 Badajoz, Spain; ester@toctocpsicologia.com
* Correspondence: jcubero@unex.es; Tel.: +34-924289300

Abstract

In recent decades, technological advances have fostered new therapeutic approaches for children with neurodevelopmental disorders, particularly Autism Spectrum Disorder. Educational robotics has emerged as a promising resource for acquiring social skills, recognizing emotions, and developing theory of mind. However, there is still a need to understand which dimensions are most susceptible to this specific intervention and how its impact differs based on individual profiles. This study analyzes the effect of a therapeutic intervention based on Educational Robotics on Social Skills, Emotional Recognition, and Theory of Mind in two students diagnosed with Autism Spectrum Disorder. The intervention was structured in seven sessions using the ANDY® kit. Tests from the NEPSY-II battery and an observational rubric of Social Skills recorded session by session were applied. Both participants showed significant improvements in Social Skills, especially in *rules of courtesy*, *nonverbal communication*, and *conversational interaction*. Regarding Emotional Recognition, one participant improved in identifying highly affective emotions, while the other showed more modest progress. Theory of Mind showed progress in only one of the participants. Adherence was high, although a slight decrease in motivation was identified in the last sessions. These results suggest that Educational Robotics, when applied within a structured therapeutic framework, can effectively foster socioemotional development in children with Neurodevelopmental Disorders. However, variability across domains highlights the importance of tailoring interventions to individual profiles and complementing them with strategies that support the transfer of learning to natural contexts.

Keywords: educational robotics; autism spectrum disorder; neurodevelopmental disorders

Check for updates

Academic Editors: Malcolm MacLachlan and Reinie Cordier

Received: 8 September 2025
Revised: 18 December 2025
Accepted: 20 January 2026
Published: 26 January 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

1.1. Disability and Autism Spectrum Disorder (ASD): Neurocognitive Foundations

Within the framework of inclusive education, school systems face the challenge of addressing the growing diversity of the student population, which includes learners with Autism Spectrum Disorder. This condition is defined as a neurodevelopmental disorder characterized by persistent deficits in communication and social interaction, alongside restrictive and repetitive patterns of behavior, interests, or activities [1]. Autism Spectrum Disorder (ASD) affects approximately 2.8% of the child population, equivalent to 1 in every 36 children [2], and its diagnosis has progressively increased due to greater understanding and awareness of its clinical manifestations.

Individuals with Autism Spectrum Disorder exhibit significant difficulties in two major social domains: emotional reciprocity and the ability to establish and maintain satisfactory interpersonal relationships. These challenges include problems initiating and sustaining social interactions, recognizing and appropriately expressing one's own and others' emotions, adapting behavior to different contexts, interpreting non-verbal communication, understanding implicit social rules, and managing the literalness of language (Figure 1) [3–6].

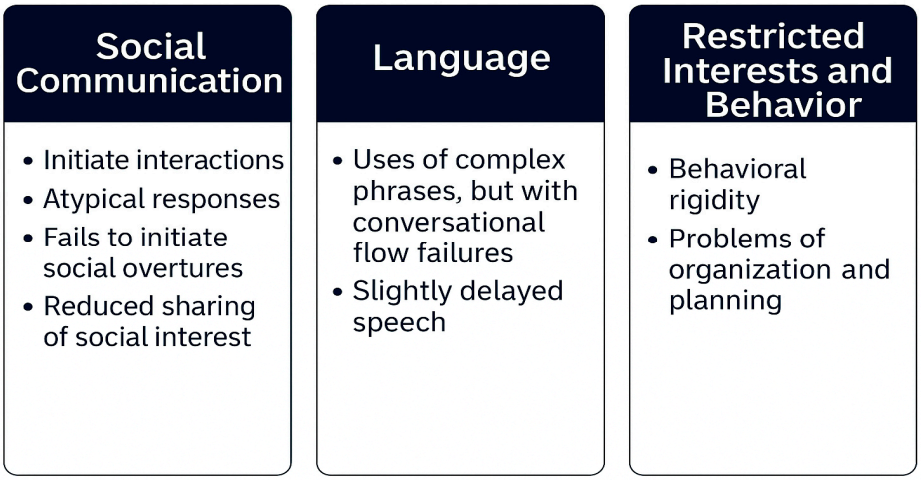


Figure 1. Descriptive traits of students with Level 1 Autism Spectrum Disorder.

Such difficulties increase the risk of social isolation, directly affecting emotional well-being and raising the incidence of comorbid disorders such as anxiety and depression [6,7]. Moreover, they negatively impact quality of life as well as personal and professional development, highlighting the need for effective interventions targeting socioemotional domains.

Cognitive-neuropsychological theories provide a framework for understanding these challenges. In particular, Theory of Mind (ToM), defined as the ability to attribute mental states to oneself and others, is a central construction in explaining the social difficulties associated with Autism Spectrum Disorder [8]. According to Baron-Cohen [9], individuals with Autism Spectrum Disorder display ToM deficits, which limit their ability to infer others' beliefs, intentions, or emotions, thus hindering effective social interaction.

These deficits are often accompanied by impairments in executive functions such as attention, a tendency to rely on visual rather than verbal thinking, and heightened systematization skills [8]. Children with Autism Spectrum Disorder typically show low tolerance for distraction but can maintain high levels of sustained attention on tasks that are of particular interest to them. Additionally, they tend to process information in a fragmented way, which impairs their ability to grasp global meaning and prioritize relevant details. These characteristics affect social development, manifesting in behaviors such as appearing not to listen because attention is directed toward other stimuli, extending conversations on a single topic beyond socially acceptable limits, or focusing on irrelevant details rather than the main thread of conversation [1].

The predominance of visual thinking and fragmented information processing also hampers the generalization of learning and behavior, thereby impacting social and communicative competence. For example, children with Autism Spectrum Disorder may appear distracted because their attention shifts to secondary stimuli, or they may engage in conversations focused solely on personal interests, which impedes social reciprocity [8].

Crucially, the persistence of these difficulties, particularly the challenge in skill generalization, underscores the continued need for interventions that are systematic, evidence-

based, and aligned with individual learning profiles. Established Comprehensive Treatment Models (CTMs) such as Applied Behavior Analysis (ABA), the Picture Exchange Communication System (PECS), the Early Start Denver Model (ESDM), and Pivotal Response Training (PRT) address these deficits through core educational principles, including the use of systematic instruction, positive reinforcement, and a focus on intrinsic motivation and functional communication [10]. The success of these consolidated curricula validates the necessity of a highly structured and individualized approach that actively targets core deficits. Therefore, interventions must seek to leverage the structured, predictable environment, which is paramount in these established principles, to maximize the acquisition and functional application of social skills and ToM abilities in the context of the identified cognitive strengths of the Autism Spectrum Disorder population. Educational robotics interventions are coherently aligned with these needs, as they capitalize on the visual and systematization strengths of students with Autism Spectrum Disorder to deliver structured, motivating, and collaborative practice that facilitates the generalization of socio-cognitive skills like ToM.

1.2. Educational Robotics and Therapeutic Impact on ASD

In recent years, advances in Information and Communication Technologies (ICTs) have enabled the incorporation of innovative therapeutic resources into educational and healthcare settings, including Therapeutic Intervention Assisted by Robots for Disability. This approach has been developed through interdisciplinary innovation and research across the fields of Education, Psychology, Engineering, and Health Sciences [11–13]. This study aims to evaluate the therapeutic effect of Educational Robotics in primary school children diagnosed with Autism Spectrum Disorder, focusing on the improvement of their social and communication skills.

Within this framework, Educational Robotics (ER) has emerged as a promising tool for intervention in neurodevelopmental disorders such as ASD [14,15]. Educational Robotics (ER) can be defined as the interdisciplinary field that integrates principles of education, engineering, and cognitive science through the design, construction, and programming of robots for learning purposes. ER involves the use of robotic platforms as mediating artifacts to promote cognitive, social, and emotional development, while fostering problem-solving, creativity, and collaborative learning among students [16–18]. The educational principles underlying ER are grounded in constructivist and constructionist theories, which emphasize active, hands-on learning and knowledge construction through meaningful experiences.

Although initially designed for technological training, ER methodologies have been successfully adapted to early childhood and primary education through practical and affective approaches, such as unplugged CT [16,19]. The structured, visual, and engaging environment provided by ER is particularly well suited to children with Autism Spectrum Disorder, who often show restricted interests in areas such as construction and computing, thereby facilitating motivation and engagement [14,15].

From a therapeutic perspective, several studies have documented improvements in emotional regulation, social skills, and executive functions in students with Autism Spectrum Disorder, as well as in the activation of basic frontal functions, achieved through computer-mediated interventions grounded in cognitive-behavioral principles [5,20].

The mounting evidence demonstrates benefits in areas such as sustained attention, imitation, verbal initiative, and cooperation, attributed to children's affinity for robots and the structured tasks and immediate feedback they provide [21,22]. Robotics also enhances socioemotional competencies such as empathy and communication [23,24]. A systematic review concluded that digital technologies, including robotics, are effective in

improving social competence in children with Autism Spectrum Disorder, particularly within collaborative environments [22].

Furthermore, studies highlight the potential of emotionally responsive social robots (e.g., the Emorobot project) in promoting self-regulation and emotional understanding [25,26]. For instance, 75% of children with Autism Spectrum Disorder maintained attention on the NAO robot during imitation and dialog tasks, reinforcing its role as a social facilitator [27]. Nevertheless, the high technological complexity and corresponding financial cost of Socially Assistive Robots (SARs) limit their widespread implementation in schools. These advanced systems depend on complex Artificial Intelligence (AI) algorithms, computer vision, and sophisticated actuators to simulate social interaction, resulting in a significant economic and management barrier. Consequently, it is imperative to implement other Educational Robotics (ER) resources that are considerably more affordable, easier to use, and adaptable to different educational stages and student characteristics. The effectiveness of these resources lies in the potential of the teaching methodology applied, rather than in the complexity of the hardware.

In this regard, some resources, such as Bee-Bot, a basic sequencing educational robot, have been explored and shown to improve emotional reciprocity and understanding of social relationships [5]. Similarly, Peribañez et al. [28] developed a therapeutic methodology combining educational robotics, gamification, and storytelling with the Ozobot robot, yielding improvements in sustained attention, frustration tolerance, and engagement in complex tasks. Complementarily, Vegni et al. [29] demonstrated that LEGO®-based therapy, in addition to improving communication and prosocial behavior, can have positive effects on cognitive functions that are not directly targeted, such as working memory and processing speed. Similarly, Kolne et al. [30] assessed the environmental qualities of a robotics program conducted in a pediatric rehabilitation hospital. Positive rehabilitation outcomes were observed, offering opportunities to engage in social interactions with peers and adults, acquiring new skills, and developing a sense of personal identity. The doctoral dissertation by Pérez-Vázquez [5], supports the positive impact of robotics on socioemotional skills, with statistically significant improvements in emotional reciprocity, communicative behaviors (both verbal and non-verbal), and understanding of social relationships.

The strength of these studies is their capacity to demonstrate that essential socioemotional and cognitive skills can be enhanced without relying on costly Artificial Intelligence systems, which validate the argument for the scalability and sustainability of the interventions. However, these works often present the limitation of lacking replicable protocols that explicitly address complex objectives such as ToM, a gap that the present study seeks to address. While studies have provided preliminary and promising evidence regarding the use of low-cost Educational Robotics (ER) in students with Autism Spectrum Disorder, the current empirical base necessitates urgent consolidation through replication and contextual expansion.

This necessity for robust consolidation is further intensified by the inherent limitations acknowledged in the literature: while some studies report significant gains in basic social behaviors such as greeting and leave-taking [31,32], others highlight constraints related to the limited expressiveness of robots [33,34]. Crucially, the current literature emphasizes that robotic interventions should not aim to replace human social interaction, but rather to enhance it through structured, predictable, and emotionally safe environments that facilitate gradual engagement and communication [35]. In this sense, robots act as mediators that support children in practicing social and emotional behaviors within controlled scenarios before transferring them to natural contexts. Moreover, Pennisi et al. [36] highlights the importance of developing intervention designs that account for interindividual differences and the personalization of learning experiences, given the heterogeneity of cognitive and

emotional profiles within the autism spectrum. In this sense, the use of low-cost ER resources, based on simple programming, responds to these requirements by offering the predictability and control necessary to act as effective and customizable mediators [28–30].

The therapeutic efficacy of ER can also be explained from cognitive neuroscience and computational perspectives, which posit that the brain processes social information through systems capable of generating meta-representations of others' mental and emotional states [3,4]. Unlike traditional clinical interventions, in which the therapist directly mediates social interaction, Educational Robotics (ER) serves as a structured mediator that reduces the emotional charge and ambiguity inherent in human communication. In this context, the robot doesn't replace the professional but rather expands the learning environment by offering a predictable, consistent, and emotionally neutral interface that facilitates social skills training in children with Autism Spectrum Disorder [35]. In addition, the use of robots allows for the recording of objective data on attention, emotional response, and nonverbal communication, providing accurate metrics to personalize the intervention and systematically evaluate its progress [36]. From this perspective, ER adds value by integrating the principles of behavioral therapy and neuroeducation with technological tools that enhance motivation and the generalization of social learning, offering a structured and controllable practice environment that complements human mediation [32–36]. Likewise, the research gap that underlies this study has been clarified, focusing on the lack of empirical evidence on which specific components of social cognition (e.g., emotional recognition and theory of mind) are most sensitive to ER-based interventions in natural educational contexts. These modifications reinforce the justification for the research presented.

In summary, further systematic research is required to examine how educational robotics can contribute to the socioemotional development of children with Autism Spectrum Disorder, particularly in early educational stages, where empirical studies remain limited. Addressing this issue is fundamental, as deficits in communication and social abilities are among the most significant challenges in ASD, directly affecting the quality of life and social integration of these children.

2. Materials and Methods

2.1. Design

This research was conducted using an exploratory, pre-experimental, individualized, and observational design, with intensive longitudinal monitoring. The study focuses on the progression of socio-emotional and cognitive skills in each participant, assessed through standardized pre- and post-intervention measures (pre-test and post-test) as well as continuous observational tracking during the intervention sessions. Given the small sample size and the absence of a control group or withdrawal phases, the results are interpreted as preliminary evidence of feasibility and individual progress, rather than as generalized causal effects. This approach allows for a detailed analysis of each participant's response to the educational robotics intervention [37–39].

2.2. Participants

The study sample consisted of two boys, aged 6 and 7, both diagnosed with Autism Spectrum Disorder (DSM-5) [1]. The results of their diagnostic test, performed by two Psychologists with the General Health Professional specialization, indicated the presence of an Autism Spectrum Disorder, Level 1, characterized by functional language, intelligence within the average range, and a need for mild support in the social and communicative domains. The clinical diagnosis of the participants was confirmed in accordance with the criteria of the DSM-5-TR (APA, 2022).

These two case studies of Children with Neurodevelopmental Difficulties were selected through convenience sampling, based on the researchers' judgment of accessibility, the children's behavioral characteristics relevant to the study, and the precedent set by previous research. All participants, as well as their parents and/or legal guardians, were informed and provided with consent to take part in the evaluation. The study compiled with all ethical standards for research involving human subjects as outlined in the Declaration of Helsinki and subsequent updates. Ethical approval was granted by the Ethics Committee of the University of Extremadura on 15 December 2023.

2.3. Materials

The study employed ANDY® of Extrem-Bots®, a programmable robot that incorporates proximity sensors, traction motors for precise movement, visual feedback via LED lights, and auditory feedback via preprogrammed sounds.

Its intuitive interface and visually accessible design allow for the establishment of clear and predictable routines, which are essential in structured learning environments. Through programmed responses and visual and auditory stimuli, ANDY® functions as a mediator with the student, promoting active participation and meaningful learning.

The robot's flexible programming enables the adaptation of intervention objectives to each student's individual profile, supporting personalized work and the gradual development of cognitive, social, and emotional skills. To facilitate this, a visual methodology was implemented, consisting of robotic panels placed on the classroom floor that combined words and pictograms sourced from Aragonese Portal of Augmentative and Alternative Communication (ARASAAC) [40] (Figures 2 and 3).

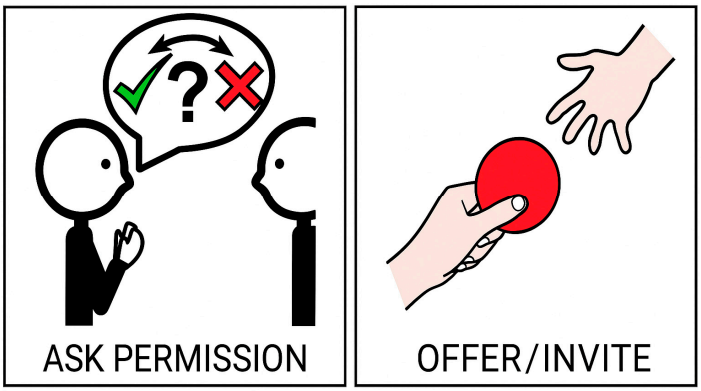


Figure 2. Example of pictograms used in the intervention.

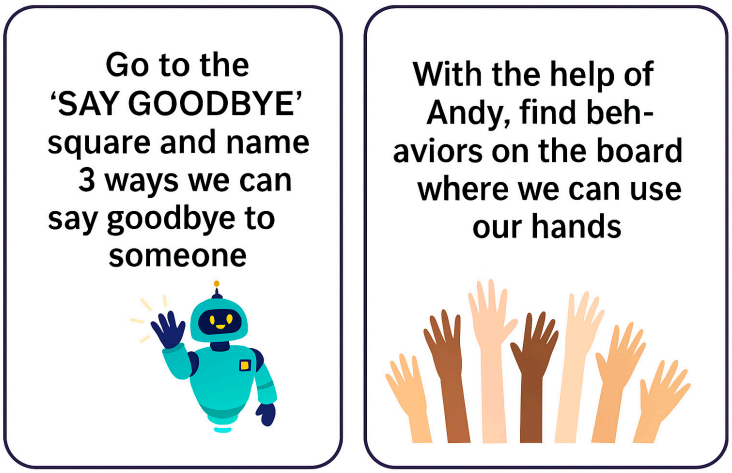


Figure 3. Example of cards used with ANDY®.

These panels were progressively adapted across sessions to match the participants' varying levels of knowledge. Activities included matching pairs, selecting the correct answer, completing blanks, and cognitive speed exercises ("racing tasks"), allowing for the reinforcement of conceptual understanding and the practice of social and cognitive skills within a structured and motivating context.

2.4. Procedure

The intervention was conducted through seven biweekly group sessions over a period of four months, with each session lasting approximately 50 min. Each session was designed with specific objectives aimed at developing social, communicative, and cognitive skills in children with Autism Spectrum Disorder:

- Session 1: Initial assessment of participants' social, communicative, and cognitive skills, using standardized instruments and direct observation.
- Session 2: Training in basic operation and programming of the ANDY® robot, familiarizing children with its controls, routines, and general functioning.
- Session 3: Instruction in courtesy norms and appropriate social behaviors across contexts.
- Session 4: Development of non-verbal communication, including eye contact, gestures, and body orientation.
- Session 5: Practice in initiating and maintaining peer interactions, reinforcing conversational turns and reciprocity.
- Session 6: Comprehension and use of literal and figurative language, promoting accurate interpretation of messages in social contexts.
- Session 7: Final assessment, evaluating progress in social skills, emotion recognition, and theory of mind.

Each session was attended by two clinical therapists and was structured in two distinct phases. The first phase involved children sharing their weekly experiences, fostering verbal expression, adaptation to the session context, and narrative skills. This phase aimed to prepare participants cognitively and emotionally for interaction with the robot.

In the second phase, the ANDY® robot was activated, its controls were reviewed, and the planned activities began. During the activities, children were required to identify the correct solution and move the robot to retrieve the corresponding card. The children interacted directly with ANDY® by programming its movements and activities using visual panels. The robot responded immediately to their instructions, reinforcing correct actions with auditory and visual signals, promoting active participation and motivation.

The activities were designed to promote both active participation and meaningful learning, integrating cognitive and socio-emotional components. During the sessions, the therapist supervised the activity, guided the understanding of instructions, reinforced correct behaviors, corrected mistakes, and ensured the safety and fluidity of the session. The progression of tasks, immediate feedback from the robot, and the predictable session structure helped maintain motivation and facilitate the generalization of acquired skills in a safe and controlled environment. This methodological design ensures that children receive a personalized and adaptive intervention, allowing repeated practice of key social and cognitive behaviors.

2.5. Instruments

Pre- and post-intervention assessment results were collected using standardized and validated questionnaires, administered by a professional psychologist. The Developmental Neuropsychological Assessment, Second Edition (NEPSY-II) Child Neuropsychological Battery [41] was employed, including the *Emotion Recognition* and *Theory of Mind* subtests,

which evaluate emotional reciprocity, joint attention, emotional intelligence, and mentalistic concepts of empathy, among other skills.

The NEPSY-II Child Neuropsychological Battery provides standardized scaled scores and percentiles to compare the child's performance with the normative sample for their age. As is standard practice in Psychology and Disability Research, the scaled scores are interpreted using a normative mean of 10 and a standard deviation of 3. Scores between 8 and 12 are considered average. Values below 7 reflect below-expected performance, and those 4 suggest clinically significant difficulties. Percentiles between 25 and 75 indicate typical performance, while scores below 25 reflect low performance, and scores above 75 reflect elevated performance.

2.6. Data Analysis

During each session, the children's progress in the targeted areas was recorded using rubric. The rubric included dimensions such as courtesy norms (greetings, farewells, giving and receiving compliments, asking permission, saying thank you, respecting turns), joint attention, and initiating and maintaining conversations appropriately.

Observed action was scored using a four-level ordinal system:

- 3: Perform the action independently and spontaneously.
- 2: Performs the action with minimal assistance (e.g., gestures or guiding glance).
- 1: Perform the action with full assistance (e.g., verbal direction or physical guidance).
- 0: Do not perform the action.

Rubric data were collected session by session to track the individual progression of each skill, evaluating both frequency and consistency of the observed behaviors. The data was obtained by recording the sessions and subsequently evaluating them by a therapist, in accordance with the ordinal system mentioned above.

Quantitative data was managed and visualized using Microsoft Excel 365© and JAMOVI©, enabling a descriptive follow-up of participants' evolution throughout the intervention.

3. Results

The following section presents the results for the different variables analyzed, reported individually for each of the two study participants.

3.1. Participant 1

The assessment of Participant 1 (Table 1), conducted using the NEPSY-II Social Battery [41], analyzed performance on Emotion Recognition and Theory of Mind subtests, both before and after a technology-based educational intervention (Educational Robotics).

Table 1. Participant 1 results on Emotion Recognition and Theory of Mind.

Test/Item	Pre-Test	Post-Test
Emotion Recognition Test		
Scaled Score	5	2
Joy (P)	51–75	>75
Sadness (P)	26–50	11–25
Neutral (P)	>75	11–25
Fear (P)	51–75	>75
Anger (P)	6–10	>75
Disgust (P)	11–25	>75
Theory of Mind Test		
Score	15	15
Verbal ToM (P)	26–50	26–50

Note: P = percentile according to the NEPSY-II normative scale.

In the Emotion Recognition test, the total scaled score decreased from 5 (pre-test) to 2 (post-test), suggesting a reduction in overall performance according to normative standards. However, relevant changes were observed in the recognition of specific emotions. At baseline, the participant demonstrated adequate recognition of emotions such as joy (P 51–75), fear (P 51–75), and particularly neutral expressions (>75), while showing low performance in emotions such as anger (P 6–10) and disgust (P 11–25). In the post-test, improvements were observed in the recognition of more complex and negatively valanced emotions, such as anger and disgust, both reaching the 75th percentile. High performance was maintained in fear recognition (>75), and recognition of joy also improved to a superior level (>75). Nevertheless, there was a decrease in the identification of neutral expressions, which dropped from >75 to 11–25, and a reduction in sadness recognition, falling from the 26–50 percentile range to 11–25.

In the Theory of Mind test, no changes were observed. The Participant 1 maintained a raw score of 15 in both assessments, corresponding to the 26–50th percentile for items of a verbal nature.

Participant 1 demonstrated generalized improvement across nearly all observed dimensions (Table 2), with particularly marked progress in conversational skills and peer interaction. The overall average for Courtesy Norms increased from 1.3 in Session 3 to 2.6 in Session 6, although notable differences were observed between items. For instance, while "asks permission" and "responds to requests" were consistently performed spontaneously in almost all sessions, "greets" showed a fluctuating pattern: after achieving high scores in Session 5, it declined again in Session 6. The item "asks for help" was assessed only once, with no evidence of progress observed.

Table 2. Participant 1 results on social and communication skills.

Dimension/Item	Session 3	Session 4	Session 5	Session 6
Courtesy Norms				
Greets	0, 1	0	2, 3	0, 1
Says goodbye	0, 1	0	3	2, 3
Asks for help	0	–	–	–
Asks permission	3	–	3	3
Responds to requests	3, 3, 3	0, 3, 3, 3	–	3, 3
Dimension average	1, 3	0, 6	2, 6	2, 6
Non-Verbal Communication				
Orients body	3, 2, 3, 2, 3, 3, 3	3, 3, 3, 3, 3	3, 3, 3, 3, 3, 3, 3, 3	0, 1, 1, 2, 3, 3, 3, 3, 3
Looks directly	3, 3, 3, 3	3, 3, 3, 3, 3, 3, 3	2, 2, 3, 3, 3, 3, 3, 3, 3	0, 0, 0, 1, 3, 3, 3, 3, 3, 3, 3, 3
Dimension average	2, 6	3, 0	3, 0	2, 9
Conversational Skills				
Initiates conversation spontaneously	3, 3	3, 3	3, 3	3
Closes conversation	2	2	3, 3	3, 3, 3, 3
Asks about topics of interest	2, 1	3	3, 3, 3	3
Dimension average	2, 3	2, 5	3, 0	3, 0
Emotional Expression				
Emotional contagion	3, 3	3, 3	3, 3, 3	–
Dimension average	2, 5	3, 0	3, 0	–
Social Interaction				
Interaction with peers	0, 1, 1, 2	3, 0, 3, 3, 3, 3, 3	3, 3, 3, 3, 3	3, 3, 3, 3
Dimension average	1, 0	2, 6	3, 0	3, 0

In the Non-verbal Communication dimension, the participant scored highly from the outset on "orients body" and "looks directly." However, Session 6 reflected a slight regression in eye contact, with several instances requiring assistance or absence. Despite this

temporary decline, both skills maintained averages near the maximum competency level, suggesting acquired abilities that remain sensitive to contextual or emotional conditions.

Conversational Skills represented one of the areas of greatest growth. "Initiates conversation spontaneously," "closes conversation," and "asks about topics of interest" demonstrated clear progression, reaching fully autonomous performance (scores of 3) by Session 5. The average for this dimension increased from 2.3 to 3.0, reflecting consistent and sustained improvement across all items.

Regarding the Emotional Expression dimension, the item "emotional contagion" was scored consistently at 3 during the first three sessions, although it was not recorded in the final session. This pattern suggests an observable and potentially consolidated emotional response, although its maintenance cannot be fully confirmed due to the lack of data in the last session.

Social Interaction with peers, considered one of the most challenging skills for children with Autism Spectrum Disorder, showed particularly significant progress. The participant progressed from assisted or absent responses to spontaneous and sustained execution in the last two sessions, reaching an average of 3.0. This change suggests not only acquisition but also a certain stabilization of behavior in structured contexts.

3.2. Participant 2

For Participant 2, in the Emotion Recognition test (Table 3), the total scaled score remained unchanged between the pre-test and post-test, maintaining a value of 1, which falls within the lower performance range ($\leq$2nd percentile).

Table 3. Participant 2 results on Emotion Recognition and Theory of Mind.

Test/Item	Pre-Test	Post-Test
Emotion Recognition Test		
Scaled Score	1	1
Joy (P)	2–5	6–10
Sadness (P)	6–10	6–10
Neutral (P)	>75	>75
Fear (P)	26–50	>75
Anger (P)	51–75	26–50
Disgust (P)	11–25	26–50
Theory of Mind Test		
Score	6	12
Verbal ToM (P)	>2	11–25

Note: P = percentile according to the NEPSY-II normative scale.

However, a more detailed analysis by type of emotion revealed some relevant changes. For joy, the participant showed a slight improvement, moving from a very low percentile range (2–5) to a still low, but slightly higher range (6–10). Sadness remained largely unchanged, staying within the 6–10th percentile in both assessments. A notable improvement was observed for fear, with recognition increasing from the 26–50th percentile at baseline to above the 75th percentile at post-test. In contrast, accuracy in identifying anger declined, decreasing from the 51–75th percentile to the 26–50th percentile after the intervention. Finally, disgust recognition improved from the 11–25th percentile to a moderate range (26–50).

Regarding the Theory of Mind test, Participant 2 demonstrated significant improvement. The total score increased from 6 points at baseline to 12 points at post-test. In the Verbal Theory of Mind subtest, the participant progressed from below the 2nd percentile at baseline to the 11–25th percentile at the end of the intervention.

Participant 2 exhibited more pronounced progression during the initial sessions (Table 4), particularly between Sessions 3 and 5, with a slight regression in Session 6 across some dimensions. Courtesy Norms showed overall improvement (from 1.0 to 2.8), although not all skills evolved linearly. For instance, "asks for help" quickly reached the maximum performance level (3) and remained there, whereas "greets" displayed instability: after achieving high scores in Sessions 4 and 5, it declined again in Session 6, mirroring a fluctuating pattern like that observed in Participant 1. "Responds to requests" also exhibited this type of fluctuation.

Table 4. Participant 2 results on social and communication skills.

Dimension/Item	Session 3	Session 4	Session 5	Session 6
Courtesy Norms				
Greets	0, 0	3, 3	3, 3	0, 1, 2
Says goodbye	1, 1	0, 1, 3	3, 3	3, 3
Asks for help	2, 2, 3	3	3	3
Asks permission	3	–	2	–
Responds to requests	1, 0, 1	3, 3, 2, 3, 2	3, 3, 3	0, 1, 2
Dimension average	1, 0	2, 3	2, 8	2, 2
Non-Verbal Communication				
Orients body	0	0, 1, 0, 1, 3, 3	2, 2, 3, 3, 3, 3	3, 3, 3, 2, 3
Looks directly	0	0, 2, 0, 1, 2	2, 2, 3, 3, 3	0, 0, 2, 2, 3, 3
Dimension average	0, 0	1, 6	2, 7	2, 6
Conversational Skills				
Initiates conversation spontaneously	0	3, 3	3	3
Closes conversation	0	1, 2, 3	3, 3	3, 3, 3
Asks about topics of interest	3, 3, 3	3, 3, 3	3, 3, 3, 3, 3	3, 3
Dimension average	0, 75	2, 4	3, 0	3, 0
Emotional Expression				
Emotional contagion	0	2, 1, 3, 3, 3	3, 3, 3	–
Dimension average	0, 0	2, 6	3, 0	–
Social Interaction				
Interaction with peers	3, 1, 1, 1	2, 1, 2, 3, 0, 1	3, 3, 3, 3, 3	0, 0, 1, 2
Dimension average	1, 5	1, 7	3, 0	0, 75

Regarding Non-verbal Communication, a dramatic change was observed. In Session 3, both skills ("orients body" and "looks directly") scored zero. From Session 4 onward, gradual improvement was noted, reaching medium-high levels and approaching maximum scores in Sessions 5 and 6. This progression indicates effective acquisition of behaviors initially absent, albeit with some variability in eye contact.

Conversational Skills demonstrated robust development. From very low scores in Session 3 (average of 0.75), the participant progressed to fully spontaneous performance across all evaluated items, maintaining this level in the final two sessions. In particular, the skill of "asks about topics of interest" was consistently performed from Session 4 onward, with multiple opportunities showing autonomous responses.

Concerning the Emotional Expression dimension, the item "emotional contagion" showed marked improvement. From non-existent performance in Session 3, maximum scores were achieved in the intermediate sessions. However, the lack of assessment in the final session limits longitudinal interpretation of this dimension and raises questions about the consolidation of the skill.

Finally, interaction with peers exhibited an oscillating pattern. Despite significant improvement in Session 5, a considerable decline in both frequency and quality of behavior was observed in Session 6, with predominance of assisted or absent scores. This drop

suggests fragility in the stability of social reciprocity, possibly influenced by the emotional demands of the environment or participant fatigue.

4. Discussion

4.1. Participant 1

The analysis of Participant 1's results reveals a complex pattern of development in socioemotional and cognitive competencies following an Educational Robotics (ER) intervention. Overall, the intervention promoted substantial improvements in conversational skills and social interaction, while outcomes in emotion recognition and Theory of Mind (ToM) were more heterogeneous.

In the Emotion Recognition test, notable improvements were observed specifically in the recognition of anger, disgust, fear, and joy, all reaching or exceeding the 75th percentile at post-test. These findings are consistent with previous studies [42] showing enhanced capacity in children with Autism Spectrum Disorder to identify basic emotions such as sadness and happiness following ER-based interventions, particularly interventions using floor robots in unplugged formats [32]. According to Pérez-Vázquez et al. [32], these results may be attributed to the design of activities tailored to the characteristics and needs of students with Autism Spectrum Disorder, using visual supports and simple, engaging tasks [43]. Visual supports facilitate information processing in students with Autism Spectrum Disorder, who tend to think in images. This improvement aligns with studies by Cabibihan et al. [44] and Costescu et al. [20], which suggest that robotized environments, by providing less ambiguous and more structured stimuli, enhance processing of intense and prototypical emotions.

However, the observed decline in recognition of neutral and sad expressions (falling to the 11–25th percentile) may indicate attentional bias or difficulty interpreting subtler emotions with lower expressive intensity. This limitation has also been reported in previous studies as a common challenge for children with Autism Spectrum Disorder, even after successful interventions [36,45].

In the Theory of Mind test, no changes were detected in total or verbal subscale scores. This stagnation may be due to the more abstract, metarepresentational nature of ToM, which requires prolonged or more explicit interventions focused on mentalistic reasoning, false-belief inference, or understanding mental states [18,46]. Although ER is effective in structuring social interactions, it does not appear to include stimuli explicitly designed to address complex mentalistic processes, such as false-belief reasoning or understanding double intentions, aspects deemed essential for improvement in this domain [36,46].

Regarding social skills observed during sessions, Participant 1 showed clear progress. The dimensions of peer interaction and conversational skills (initiating conversation, closing, and asking questions) reached maximum average scores in the final sessions. These results are consistent with recent studies highlighting the capacity of robots to act as mediators of social interaction by providing structured, motivating, and less sensory-demanding contexts [20,28]. Specifically, these findings align with Pérez-Vázquez et al. [32], whose intervention using robots with characteristics like this study improved social skills in students with Autism Spectrum Disorder, such as greeting and saying goodbye. Non-verbal communication also showed positive trends, although with minor regressions, possibly attributable to emotional state or fatigue. These fluctuations support the need for continuous, adaptive interventions, as Espinosa-Garmendi et al. [20] emphasize, highlighting that learning stability in children with Autism Spectrum Disorder is highly dependent on contextual consistency and explicit reinforcement.

Overall, ER functioned as an effective facilitator for practical dimensions of social behavior, particularly those related to pragmatic language and direct interaction. However, its

impact on higher-order skills, such as emotional inference or Theory of Mind, requires more specific methodological adjustments and possibly integration with pedagogical strategies centered on social reasoning.

4.2. Participant 2

For Participant 2, the ER-based intervention also showed positive effects, although with a different pattern of development. The most prominent improvement was in Theory of Mind, with a substantial increase in total score. This progress is especially notable, as verbal ToM is typically resistant to change in children with Autism Spectrum Disorder without specific support [9,46].

This improvement may be linked to the sequential logic and predictability provided by ER, characteristics that, according to Weintrop et al. [18] help structure the cause-and-effect reasoning necessary for mentalistic inference. Unlike Participant 1, this child appears to have used robotic scaffolding to better organize understanding of others' intentions and mental states, even in the absence of activities specifically targeting explicit mentalism. Recent studies have emphasized the value of robots in developing intention-reading and action anticipation skills, even when mentalistic abilities are not directly addressed [47,48].

In the Emotion Recognition test, the overall scaled score remained in the lower range. Nevertheless, improvements were observed in specific emotions, such as joy, fear, and disgust. Although partial, these changes indicate better discrimination of positive and negatively valanced emotions, an achievement noted in studies using robots to repeatedly model basic emotions with explicit feedback [28,49]. Similarly to Participant 1, these results align with prior research showing increased emotion recognition capacity in children with Autism Spectrum Disorder after ER interventions, particularly those using unplugged floor robots [32].

Social skills also showed solid advancement up to Session 5, particularly in conversational skills, courtesy norms, and non-verbal communication. Unlike Participant 1, this child started with virtually absent eye contact and body orientation, which gradually improved to medium-high levels. This can be explained by habituation effects to robot-mediated social stimuli, which act as a bridge to human interaction [44,50]. ER facilitates this transition by providing predictable sequences, visual interfaces, and consistent reinforcement key elements for children with social sensitivity or behavioral inhibition. However, a regression was observed in Session 6, especially in peer interaction, where scores declined. This drop could be associated with fatigue, emotional demands of the environment, or lack of novelty in the activities. As noted by Peribañez et al. [28] intrinsic motivation toward ER in children with Autism Spectrum Disorder must be sustained through progressive variability and complexity to avoid habituation or disengagement. Additionally, reinforcement of skills in natural contexts through human support (therapists, educators) may be necessary.

Overall, Participant 2's results suggest a particularly positive impact on cognitive dimensions of social cognition, as well as basic interaction skills. Although behavioral effects showed some instability, the initial improvements indicate that robotic intervention can serve as an effective environment for activating socioemotional development processes in children with Autism Spectrum Disorder who start from a low baseline. Incorporating adaptive, personalized elements in programming and establishing explicit bridges to non-mediated interpersonal environments will be key for sustaining and generalizing these gains.

Taken together, the findings from both participants underscore the potential of Educational Robotics (ER) as a valuable tool for fostering socioemotional development in children with Autism Spectrum Disorder, particularly in enhancing pragmatic language

and direct social interaction. While the nature and extent of progress varied according to each child's initial profile, notable gains were observed in conversational abilities, basic emotion recognition, and—especially for Participant 2—in Theory of Mind. These outcomes align with broader research emphasizing ER's capacity to structure predictable, motivating environments conducive to social learning [51]. However, the limitations identified—such as difficulties in interpreting subtle emotional cues and the instability of behavioral gains—highlight the need for ER to be integrated with more explicit, personalized pedagogical strategies and contextual supports. In this regard, the role of adult mediation, particularly parental involvement, emerges as a critical factor in sustaining and generalizing therapeutic effects, as demonstrated by Amirova et al. [52], who found that family engagement significantly enhanced the outcomes of robot-assisted interventions. These insights reinforce the notion that ER should not be viewed as a standalone solution, but rather as a structured, engaging, and adaptable medium that, when combined with human support and targeted methodologies, can effectively catalyze socioemotional growth in children with Autism Spectrum Disorder.

Finally, this applied research, focused on interventions for autism spectrum disorder (ASD) as a syndrome, demonstrates its versatility. It also shows that it can be applied to other interventions to help children with specific difficulties, some of which may be related to autism, but others not necessarily. This individualized intervention trial can be adapted not only to autism spectrum disorder but also to other neurodevelopmental difficulties.

5. Conclusions

The Educational Robotics (ER) intervention applied in this study proved to be an effective tool for promoting the development of observable social skills, such as courtesy norms, non-verbal communication, and conversational interaction, in children with Level 1 Autism Spectrum Disorder. Improvements were evident in both participants, although differences in specific areas of progress, confirming the intrinsic heterogeneity of this profile and highlighting the need to consider individual characteristics when designing and implementing interventions.

ER was shown to function as a motivating facilitator that promotes active participation and enhances basic social behaviors. However, gains in more complex inferential skills, such as recognition of subtle emotions and Theory of Mind, were variable and dependent on each child's initial profile. This indicates that these competencies require more specific, prolonged, and complementary interventions for effective development.

Moreover, the slight decline in motivation observed during the final sessions suggests that sustaining interest in ER requires the incorporation of adaptive and dynamic elements into the intervention, which help maintain engagement and learning over time.

Overall, these findings support the inclusion of ER as a useful and motivating resource within psychoeducational programs for children with Autism Spectrum Disorder. They also underscore the importance of continuing research on its implementation from a multidimensional and longitudinal perspective. Future studies should consider larger samples, medium- and long-term follow-ups, and the integration of ER with complementary pedagogical and therapeutic methodologies, to enhance the generalization of learning to natural and functional contexts.

6. Study Limitations and Future Research Directions

Despite the promising results, this study has several limitations that must be considered. First, the sample size is extremely small (two participants), which limits the generalizability of the findings to other children with Autism Spectrum Disorder of similar characteristics. Second, the intervention was relatively short and applied on a biweekly

basis, which may have affected the stability and consolidation of certain skills, particularly inferential abilities and Theory of Mind.

Future studies should consider larger and more heterogeneous samples of children with Autism Spectrum Disorder, allowing for a more representative analysis of diversity within the spectrum. Extending the duration of the intervention and increasing session frequency, as well as incorporating additional objective measures such as coded video recordings or complementary standardized assessments, would also be valuable. Another important line of research would be studying the integration of educational robotics with complementary pedagogical and therapeutic methodologies, evaluating the transfer of skills to school and home environments. Lastly, longitudinal studies could provide insights into the stability and generalization of the effects of educational robotics on socioemotional and cognitive competencies over time.

Methodologically, efficacy was tested by evaluating the participants individually, without incorporating a control or comparison group. While this approach is adequate for validating the initial effects of an intervention using accessible resources, it imposes a limitation on the capacity to establish a robust causal inference and to attribute the results solely to robotic intervention. Therefore, future lines of research must migrate toward experimental designs with control groups or systematic single-case replications. This is essential to consolidate the empirical base on the efficacy of low-cost ER and to strengthen the internal validity of the findings.

Author Contributions: Conceptualization, A.D.l.H., E.C. and J.C.; methodology, A.D.l.H., E.C. and J.C.; software, A.D.l.H., E.C. and J.C.; validation, A.D.l.H., E.C. and J.C.; formal analysis, A.D.l.H., E.C. and J.C.; investigation, A.D.l.H., E.C. and J.C.; resources, A.D.l.H., E.C. and J.C.; data curation, A.D.l.H., E.C. and J.C.; writing—original draft preparation, A.D.l.H., E.C. and J.C.; writing—review and editing, A.D.l.H., E.C. and J.C.; visualization, A.D.l.H., E.C. and J.C.; supervision, A.D.l.H., E.C. and J.C.; project administration, J.C.; funding acquisition, J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Regional Government of Extremadura. Department of Education and Employment. Innovation and talent plus program (PIT+) project name: Training in Active Research Skills and Active Teaching for Innovation, File No.: 06/ITP/073/23y.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of University of Extremadura (194/2023, 15 December 2023).

Informed Consent Statement: Informed consent was obtained from all parents or legal custodians of study participants.

Data Availability Statement: Data is contained within the article.

Acknowledgments: The authors would like to thank the Ministry of Science, Innovation, and Universities for the predoctoral contract (FPU20/04959), as well as the company Toc-Toc Child and Adolescent Psychology scp for its participation in the research project.

Conflicts of Interest: Ester Ceballos is an employee of the company, Toc-Toc Child and Adolescent Psychology scp. The authors declare no conflicts of interest.

Disability Language/Terminology Positionality Statement: The authorship team comprises health researchers and educators with both prior and ongoing research interests in collaboration with the neurodiversity community. This study uses person-first language ("individuals with Autism Spectrum Disorder") in accordance with common conventions in public health, psychology and medical research, which prioritize acknowledging the individual before their disability. This approach aligns with entities such as the WHO. Consequently, we have decided to employ person-first language consistently throughout the manuscript.

References

1. American Psychiatric Association (APA). *Diagnostic and Statistical Manual of Mental Disorders*, 5th ed.; American Psychiatric Publishing: Arlington, VA, USA, 2013.
2. Huijnen, C.A.G.J.; Lexis, M.A.S.; De Witte, L.P. Robots as new tools in therapy and education for children with autism. *Int. J. Neurorehabilit.* **2017**, *4*, 278. [CrossRef]
3. Gómez, I. Ciencia cognitiva, teoría de la mente y autismo. *Pensam. Psicológico* **2010**, *8*, 113–124. Available online: https://dialnet.unirioja.es/servlet/articulo?codigo=3339348 (accessed on 19 January 2026). (In Spanish)
4. Ibáñez, A. Autismo, funciones ejecutivas y mentalismo: Reconsiderando la heurística de la descomposición modular. *Rev. Argent. Neuropsicol.* **2005**, *6*, 25–49. Available online: https://www.academia.edu/download/56263327/Ibanez_FE_ToM_Autisom2005_RNA.pdf (accessed on 19 January 2026). (In Spanish)
5. Pérez-Vázquez, E. La Aplicación del Robot Bee-Bot Para el Desarrollo de las Habilidades de Comunicación e Interacción Social del Alumnado con Trastorno del Espectro Autista (TEA). Doctoral Dissertation, University of Alicante, San Vicente del Raspeig, Spain, 2021. Available online: http://hdl.handle.net/10045/121241 (accessed on 19 January 2026). (In Spanish)
6. Takata, K.; Yoshikawa, Y.; Muramatsu, T.; Matsumoto, Y.; Ishiguro, H.; Mimura, M.; Kumazaki, H. Social skills training using multiple humanoid robots for individuals with autism spectrum conditions. *Front. Psychiatry* **2023**, *14*, 1168837. [CrossRef]
7. Holeva, V.; Nikopoulou, V.A.; Lytridis, C.; Bazinas, C.; Kechayas, P.; Sidiropoulos, G.; Papadopoulou, M.; Kerasidou, M.D.; Karatsioras, C.; Geronikola, N.; et al. Effectiveness of a robot-assisted psychological intervention for children with autism spectrum disorder. *J. Autism Dev. Disord.* **2024**, *54*, 577–593. [CrossRef] [PubMed]
8. Trapu-Ustarroz, J.; Pérez, G.; Erekatxo-Bilbao, M.; Pelegrín, C. ¿Qué es la teoría de la Mente? *Rev. Neurol.* **2007**, *44*, 479–489. Available online: https://www.academia.edu/download/58589625/1.-_QUE_ES_LA_TEORIA_DE_LA_MENTE_1.pdf (accessed on 19 January 2026). (In Spanish) [CrossRef]
9. Baron-Cohen, S. Theory of mind and autism: A review. *Int. Rev. Res. Ment. Retard.* **2000**, *23*, 169–184. [CrossRef]
10. Odom, S.L.; Boyd, B.A.; Hall, L.J.; Hume, K. Evaluation of comprehensive treatment models for individuals with Autism Spectrum Disorders. *J. Autism Dev. Disord.* **2010**, *40*, 425–436. [CrossRef] [PubMed]
11. Alhmiedat, T.; Alotaibi, M. Design and evaluation of a personal Robot playing a self-management for Children with obesity. *Electronics* **2022**, *11*, 4000. [CrossRef]
12. Bharatharaj, J.; Huang, L.; Al-Jumaily, A.; Mohan, R.E.; Krägeloh, C. Sociopsychological and physiological effects of a robot-assisted therapy for children with autism. *Int. J. Adv. Robot. Syst.* **2017**, *14*, 1729881417736895. [CrossRef]
13. Kert, S.B.; Yeni, S.; Fatih Erkoç, M. Enhancing computational thinking skills of students with disabilities. *Instr. Sci.* **2022**, *50*, 625–651. [CrossRef]
14. Chung, E.Y. Robot-Mediated Social Skill Intervention Programme for Children with Autism Spectrum Disorder: An ABA Time-Series Study. *Int. J. Soc. Robot.* **2021**, *13*, 1095–1107. [CrossRef]
15. Loor, M.A.D.; Manobanda, A.P.J.; Baque, J.C.S.; Villacís, M.I.V. Estrategias educativas en la asignatura robótica para la inclusión de estudiantes con necesidades educativas especiales. *Polo Conoc.* **2024**, *9*, 688–705. Available online: https://polodelconocimiento.com/ojs/index.php/es/article/view/8139/html (accessed on 19 January 2026). (In Spanish)
16. Bers, M.; Strawhacker, A.; Sullivan, A. *The State of the Field of Computational Thinking in Early Childhood Education*; No. 274; OECD Publishing: Paris, France, 2022. [CrossRef]
17. Pellas, N. Enhancing computational thinking, Spatial reasoning, and executive function skills: The impact of tangible programming tools in early childhood and across different learner stages. *J. Educ. Comput. Res.* **2025**, *63*, 3–32. [CrossRef]
18. Weintrop, D.; Beheshti, E.; Horn, M.; Orton, K.; Jona, K.; Trouille, L.; Wilensky, U. Defining computational thinking for mathematics and science classrooms. *J. Sci. Educ. Technol.* **2016**, *25*, 127–147. [CrossRef]
19. Herrero, J.F.Á.; Bautista, C.V.; Herrero, J.F.Á.; Bautista, C.V. Didáctica de las ciencias, ¿de dónde venimos y hacia dónde vamos? *Rev. Ciències L'Educació* **2019**, *1*, 5–19. Available online: https://rua.ua.es/entities/publication/1067e3a2-42de-4de9-81eb-4db6bd910916 (accessed on 19 January 2026). (In Spanish)
20. Espinosa-Garamendi, E.; Labra-Ruiz, N.A.; Naranjo, L.; Chávez-Mejía, C.A.; Valenzuela-Alarcón, E.; Mendoza-Torreblanca, J.G. Habilitation of executive functions in pediatric congenital heart disease patients through LEGO®-based therapy: A quasi-experimental study. *Healthcare* **2022**, *1*, 2348. [CrossRef] [PubMed]
21. Costescu, C.A.; Vanderborght, B.; David, D.O. Reversal learning task in children with autism spectrum disorder: A robot-based approach. *J. Autism Dev. Disord.* **2015**, *45*, 3715–3725. [CrossRef] [PubMed]
22. Gómez-León, M. Desarrollo de la comprensión emocional.¿ Qué tipo de tecnología para qué alumno con trastorno del espectro autista? Revisión sistemática. *Siglo Cero* **2023**, *54*, 65–83. (In Spanish) [CrossRef]
23. Kim, E.S.; Berkovits, L.D.; Bernier, E.P.; Leyzberg, D.; Shic, F.; Paul, R.; Scassellati, B. Social robots as embedded reinforcers of social behavior in children with autism. *J. Autism Dev. Disord.* **2013**, *43*, 1038–1049. [CrossRef]

24. Calderón, O. Educational Robotics: Enhancing Mathematical Thinking and Social Skills in Learning. *Emerg. Trends Educ.* **2024**, *7*, 129–142. [CrossRef]
25. Schiavo, F.; Campitiello, L.; Todino, M.D.; Di Tore, P.A. Educational robots, emotion recognition and ASD: New horizon in special education. *Educ. Sci.* **2024**, *14*, 258. [CrossRef]
26. Doğan, S.; Çolak, A. Social robots in the instruction of social skills in autism: A comprehensive descriptive analysis of single-case experimental designs. *Disabil. Rehabil. Assist. Technol.* **2022**, *19*, 325–344. [CrossRef]
27. Lorenzo-Lledó, G.; Lorenzo-Lledó, A.; Gilabert-Cerdá, A. Application of robotics in autistic students: A pilot study on attention in communication and social interaction. *Technol. Knowl. Learn.* **2024**, *29*, 757–780. [CrossRef]
28. Peribañez, E.; Bayona, S.; San Martin, J.; Verde, A.; Garre, C.; Leoste, J.; Pastor, L. An Experimental Methodology for Introducing Educational Robotics and Storytelling in Therapeutical Activities for Children with Neurodevelopmental Disorders. *Machines* **2023**, *11*, 629. [CrossRef]
29. Vegni, N.; D'Ardia, C.; Di Filippo, G.; Melchiori, F.M. The impact of Lego® Therapy on cognitive skills in Autism Spectrum Disorders: A brief discussion. *AIMS Neurosci.* **2023**, *10*, 190. [CrossRef]
30. Kolne, K.; Bui, S.; Lindsay, S. Assessing the environmental quality of an adapted, play-based LEGO® robotics program to achieve optimal outcomes for children with disabilities. *Disabil. Rehabil.* **2021**, *43*, 3613–3622. [CrossRef]
31. Chung, E.Y.H. Robotic intervention program for enhancement of social engagement among children with autism spectrum disorder. *J. Dev. Phys. Disabil.* **2019**, *31*, 419–434. [CrossRef]
32. Pérez-Vázquez, E.; Lorenzo, G.; Lorenzo-Lledó, A.; Lledó, A. Analysis of the Application of the Bee-Bot Robot for the Development of Social Reciprocity Skills in Students with Autism Spectrum Disorder. *Int. J. Soc. Robot.* **2025**, *17*, 845–870. [CrossRef]
33. Cano, S.; González, C.S.; Gil-Iranzo, R.M.; Albiol-Pérez, S. Affective communication for socially assistive robots (sars) for children with autism spectrum disorder: A systematic review. *Sensors* **2021**, *21*, 5166. [CrossRef] [PubMed]
34. Syriopoulou-Delli, C.K.; Gkiolnta, E. Review of assistive technology in the training of children with autism spectrum disorders. *Int. J. Dev. Disabil.* **2022**, *68*, 73–85. [CrossRef]
35. Begum, M.; Serna, R.W.; Yanco, H.A. Are Robots Ready to Deliver Autism Interventions? A Comprehensive Review. *Int. J. Soc. Robot.* **2016**, *8*, 2. [CrossRef]
36. Pennisi, P.; Tonacci, A.; Tartarisco, G.; Billeci, L.; Ruta, L.; Gangemi, S.; Pioggia, G. Autism and social robotics: A systematic review. *Autism Res.* **2016**, *9*, 165–183. [CrossRef]
37. Creswell, J.W. *A Concise Introduction to Mixed Methods Research*; SAGE Publications: Los Angeles, CA, USA, 2021.
38. Lobo, M.A.; Moeyaert, M.; Baraldi, A.; Babik, I. Single-Case Design, Analysis, and Quality Assessment for Intervention Research. *J. Neurol. Phys. Ther.* **2017**, *41*, 187–197. [CrossRef]
39. Ledford, J.R.; Lambert, J.M.; Pustejovsky, J.E.; Zimmerman, K.N.; Hollins, N.; Barton, E.E. Single-Case-Design Research in Special Education: Next-Generation Guidelines and Considerations. *Except. Child.* **2023**, *89*, 379–396. [CrossRef]
40. Luque, F.C.; Morillas, C.M. Iconicidad y facilidad de aprendizaje de los símbolos pictográficos ARASAAC. *Rev. Logop. Foniatría Audiol.* **2018**, *38*, 95–104. (In Spanish) [CrossRef]
41. Korkman, M.; Kirk, U.; Kemp, S. *NEPSY-II. Evaluacion Neuropsicologica Infantil*; Pearson Publications: Madrid, Spain, 2014.
42. Pop, C.A.; Simut, R.; Pintea, S.; Saldien, J.; Rusu, A.; David, D.; Vanderborght, B. Can the social robot Probo help children with autism to identify situation-based emotions? A series of single case experiments. *Int. J. Humanoid Robot.* **2013**, *10*, 1350025. [CrossRef]
43. Lorenzo, G.; Gómez-Puerta, M.; Arráez-Vera, G.; Lorenzo-Lledó, A. Preliminary study of augmented reality as an instrument for improvement of social skills in children with autism spectrum disorder. *Educ. Inf. Technol.* **2019**, *24*, 181–204. [CrossRef]
44. Cabibihan, J.J.; Javed, H.; Ang, M.; Aljunied, S.M. Why robots? A survey on the roles and benefits of social robots in the therapy of children with autism. *Int. J. Soc. Robot.* **2013**, *5*, 593–618. [CrossRef]
45. Grossard, C.; Palestra, G.; Xavier, J.; Chetouani, M.; Grynszpan, O.; Cohen, D. ICT and autism care: State of the art. *Curr. Opin. Psychiatry* **2018**, *31*, 474–483. [CrossRef]
46. Davis, J.L.; Matthews, R.N. NEPSY-II Review: Korkman, M., Kirk, U., & Kemp, S. (2007). NEPSY—Second Edition (NEPSY-II). San Antonio, TX: Harcourt Assessment. *J. Psychoeduc. Assess.* **2010**, *28*, 175–182. [CrossRef]
47. Soares, F.O.; Costa, S.C.; Santos, C.P.; Pereira, A.P.S.; Hiolle, A.R.; Silva, V. Socio-emotional development in high functioning children with Autism Spectrum Disorders using a humanoid robot. *Interact. Stud.* **2019**, *20*, 205–233. [CrossRef]
48. Puglisi, A.; Caprì, T.; Pignolo, L.; Gismondo, S.; Chilà, P.; Minutoli, R.; Pioggia, G. Social humanoid robots for children with autism spectrum disorders: A review of modalities, indications, and pitfalls. *Children* **2022**, *9*, 953. [CrossRef]
49. Gómez-Espinosa, A.; Moreno, J.C.; Pérez-de la Cruz, S. Assisted Robots in Therapies for Children with Autism in Early Childhood. *Sensors* **2024**, *24*, 1503. [CrossRef] [PubMed]
50. Castillo, T.A.; de Celis, C.P.; Lara, C.; Somodevilla, M.J.; Pineda, I.H.; de Alba, K.F.; Romero, E. Authic: Computational tool for children with autistic spectrum disorder. In Proceedings of the International Symposium on Computers in Education (SIIE), Salamanca, Spain, 15 September 2016; pp. 1–6.

51. Sannicandro, K.; De Santis, A.; Bellini, C.; Minerva, T. A scoping review on the relationship between robotics in educational contexts and e-health. *Front. Educ.* **2022**, *7*, 955572. [CrossRef]
52. Amirova, A.; Rakhymbayeva, N.; Zhanatkyzy, A.; Telisheva, Z.; Sandygulova, A. Effects of parental involvement in robot-assisted autism therapy. *J. Autism Dev. Disord.* **2023**, *53*, 438–455. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.