International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

https://gssrr.org/index.php/JournalOfBasicAndApplied/index

The Use and Future of Social Humanoid Robots in Special Education: A Systematic Review

Bahadır İnan [a]*, Birkan Güldenoğlu [b]

[a] *Yozgat Bozok University, Faculty of Education, Yozgat, 66000, Turkey*

[b] *Ankara University, Faculty of Educational Sciences, Ankara, 06590, Turkey*

[a] *Email: bahadirr.inan@gmail.com*, [b] *Email: birkanguldenoglu@yahoo.com*

Abstract

The rapid advancement of technology enables the development of innovative approaches in education. In the field of special education in particular, technological tools aimed at meeting students' individual needs have gained significant importance. Within this context, social humanoid robots emerge as innovative tools that can support students' learning processes, enhance their social interactions, and foster the development of their individual abilities. However, questions such as how social humanoid robots can be effectively used in special education, the educational value of these robots, and the types of future developments that may occur remain largely unanswered in the literature. This research employs a systematic review approach to critically examine studies on the use of social humanoid robots in the education of children with special needs, assessing the concrete field experiences, adaptability to inclusive education, and outcomes of these studies. To achieve this, twelve studies were analyzed in detail using the PRISMA reporting guidelines. Inclusion criteria for this review included studies conducted with individuals diagnosed with special needs aged 2-15, published between 2014 and 2023, involving at least one case or participant group regardless of qualitative or quantitative research methodologies, and published in a peer-reviewed journal. A majority of these studies focused on children with autism spectrum disorder (ASD). Findings from studies conducted with social humanoid robots (such as NAO, ZENO, QTROBOT, PROBO, KASPAR) with ASD children indicate improvements over time in eye contact and joint attention skills, significant increases in interaction initiation abilities, support for verbal and non-verbal communication skills, though with limited gains in imitation skills.

Received: 10/25/2024
Accepted: 12/25/2024
Published: 1/3/2025

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* Corresponding author.

These studies reveal certain limitations, particularly related to small sample sizes, low female participation, and lack of control groups. Furthermore, it can be suggested that one of the most critical areas researchers need to focus on is conducting large-scale studies to assess the effects of social humanoid robots on special education across diverse child populations. In conclusion, the use of social humanoid robots in special education holds substantial potential to enrich these students' educational experiences. However, effective utilization of this potential requires careful planning, ongoing research, and providing educators with necessary guidance.

Keywords: Educational Robotics; Children with Special Needs; Social Humanoid Robots; Child Robot Interaction; Inclusion.

1. Introduction

The rapid advancement of technology enables the development of innovative approaches in education. In special education, technological tools used to address the individual needs of students have gained significant importance [1]. In this context, educational robots stand out as innovative tools that can be used to support students' learning processes, enhance their social interactions, and develop their individual abilities. However, questions about how to effectively use educational robots in special education, the pedagogical value of these robots, and what kinds of advancements may occur in the future remain largely unanswered in the literature Reference [2,3].

Educational robots are seen as potentially powerful tools to support students with special educational needs, such as autism spectrum disorder [4], intellectual disabilities and motor impairments [5], Down syndrome [1], and learning disabilities [6]. These robots can help children improve their social skills, increase their attention spans, and engage with learning materials in a more interactive way. Another important aspect here is how the use of educational robots in special education may evolve in the future. Current technological advancements are making these robots smarter, more accessible, and more adaptable. However, critical questions still need to be addressed, such as whether the infrastructure is sufficient for the widespread use of these technologies, how educators can access these technologies, and whether such technology use might risk exacerbating inequalities in education [7].

2. Theoretical Framework

2.1. Educational Robotics in the Context of Inclusive Education

Inclusive education refers to the arrangement of schools and social settings that facilitate the collective learning of all students alongside their peers, allowing them to engage in educational activities across all facets of school life. This entails designing schools, classrooms, programs, and activities to ensure that every student has access to quality education. Consequently, it is essential to investigate strategies for transforming educational systems and other learning environments to address the needs of all learners [8].According to [9], inclusive education has several key objectives. These include providing high-quality education based on individualized instruction tailored to students’ potential, fostering interpersonal relationships through a rich and supportive social environment, and utilizing assistive supports and technology in teaching processes to contribute to the academic skills of all children. The literature suggests that to achieve these goals, it is beneficial to ensure access and participation of both children with special needs and typically developing children in robot-based games and activities. Positive classroom experiences with robots are reported to improve academic achievement, which in turn broadens students' future educational and employment opportunities [10, 11].

Educational robots are used as learning tools worldwide [12, 13, 7] however, studies on their integration into the context of inclusive education have emerged only recently [14]. Although there is research on "social robots" for children with special needs, more investigation is needed into the potential of these robots as teaching tools in inclusive classrooms to identify effective robot-based practices for all students [15]. Social humanoid robots, a type of next-generation educational robot, are designed to participate in daily human activities, such as education. The benefits of using social humanoid robots in the learning process mainly stem from their physical appearance, making them appealing and intriguing to children, which creates various educational advantages. Firstly, robots can be utilized in curricula or groups that require greater engagement [16]. Secondly, the use of robots encourages students to explicitly develop social behaviors that are beneficial for learning. Furthermore, robots can work tirelessly as long as their energy and power demands are met, and their teaching performance does not deteriorate over time. They can also be programmed to present different subjects without years of training [17]. Additionally, educational robots do not discriminate, do not cause frustration, and are typically small, which helps children feel more comfortable and boosts their confidence [18].

2.2. Social Humanoid Robots for Children with Special Needs

The physical resemblance of social humanoid robots to humans and their ability to interact in social environments is a key element in interactive robotics. These robots are primarily designed to communicate with people, thereby becoming part of society [19]. Initially developed as assistants, robots are now used in a wide range of fields, from industry to the military. Similarly, the number of social robots used in education is rapidly increasing. Studies in various areas of education, especially in social interaction, communication, skills training, and the education of children with special needs, are being conducted. In the field of education, humanoid robots are used to assist teachers and provide additional services. Research suggests that robots enhance positive impacts and are effective when used in education. The idea of using robots in education emerged in the early 1980s [20]. As research in robotics grows, so does its application in the classroom. Robots are frequently employed in roles that assist teachers in education. In this capacity, they are significant as they help students better understand their lessons, develop problem-solving skills, and use technology in meaningful ways [21].

In recent years, several strategies have been suggested for incorporating social robots into adult education. In this context, robots have assumed multiple roles in the educational process, including those of host, teaching assistant, teacher, peer, or trainer [16]. Recent studies highlight that social robots are widely accepted by children and their parents [22, 23]. Children are highly motivated to interact with social robots for several reasons: (1) children perceive robots not only as simple machines but also as adorable toys; (2) robots capture children’s attention with their childlike appearance and possess various interactive abilities (movements, sounds, colorful lights, etc.); (3) social robots have the patience to teach children through numerous repetitions without tiring; and (4) social robots maintain emotional and behavioral consistency during interactions with children.

The previously mentioned benefits of integrating social robots into education become even more pronounced when the children interacting with these robots have special needs. In these instances, the educational experience is customized to address the unique requirements of the children, making social robots central elements of engagement. For example, with children who have autism spectrum disorder (ASD), a critical factor for an effective educational process is student engagement, as children with ASD often face challenges in concentrating and focusing. Thus, it is important to maximize their participation during lessons and explore ways for social robots to capture their attention [24]. An increasing number of studies highlight the potential of social humanoid robots in education. These robots are used to provide students with motivation, engagement, and individualized support [25, 26]. Moreover, social robots can create an interactive and engaging learning experience for students [27, 28]. The physical presence of a robot, compared to virtual alternatives, can lead to positive perceptions and improvements in student performance [29]. A study by [30] found that instructions provided by a social robot during a cognitive puzzle task were more effective than those given through video-based or virtual two-dimensional agents. This study demonstrates that incorporating social robots into the learning process enhances children's motivation and extends their attention spans. This is particularly important because students in areas such as learning disabilities often experience a lack of motivation and tend not to actively participate in the learning process [31].

2.3. Examples of Social Humanoid Robots

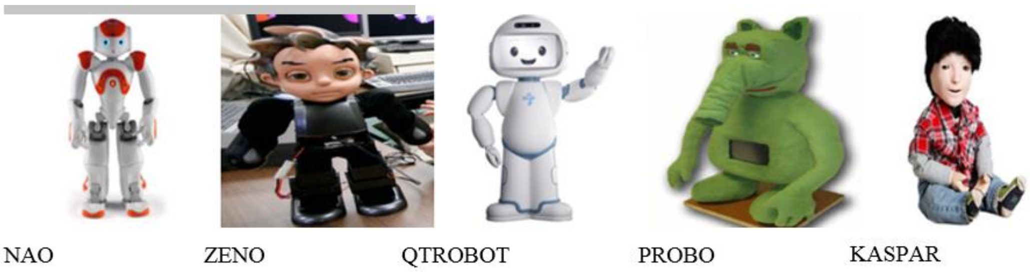

Figure1

2.3.1. Nao

NAO is perceived as a sympathetic humanoid robot from the perspective of children, as its physical appearance resembles that of a small child, and it demonstrates a gentle demeanor [32]. NAO serves as an effective tool in the education of students in special needs groups, such as those with autism spectrum disorder or emotional and behavioral disorders, through the implementation of Individualized Education Programs (IEPs). This robot helps children reduce their shyness, reluctance, and frustration, while also enhancing their self-confidence, social skills, and self-esteem. NAO is reported to be a good tool for promoting positive attitudes and perceptions toward special education, thereby encouraging its acceptance within mainstream classroom environments. Observations from classroom applications indicate that children show great interest in NAO and engage with it without hesitation. NAO enables the implementation of educational resources that make children more dynamic, attentive, active, and open to interaction (https://www.aldebaran.com/en/nao

2.3.2. Zeno

ZENO is a small social humanoid robot equipped with an expressive face and conversational artificial intelligence. It is specifically designed as a platform for human-robot interaction research aimed at diagnosing and treating autism spectrum disorder (https://robotsguide.com/robots/zeno). ZENO's appearance is based on a fictional character, resembling a child aged 4 to 7, with a head that is approximately one-quarter the size of an adult human head [33]. The robot's facial skin closely mimics human tissue, and it tends to move in a more realistic manner, paralleling human muscle movements. The primary goal of using this robot is to help children develop skills such as eye contact, joint attention, symbolic play, and basic emotion recognition [34].

2.3.3. Qtrobot

QTROBOT is an expressive social robot designed to support various use cases, including the education of children with ASD and other special educational needs, as well as human-robot interaction research (https://robotsguide.com/robots/qtrobot). It communicates with children with ASD by utilizing facial expressions, gestures, and games to convey emotions and social skills. When examining QTROBOT's features: (a) it has been reported that the robot increases participation in activities that require joint attention. (b) The robot provides comfort to students by behaving consistently and predictably, thereby reducing their anxiety and sensory overload. (c) The robot's exaggerated facial expressions and non-verbal communication through body language facilitate learning for students, allowing them to practice skills in a simplified environment.

(d) The robot repeats everything in the same manner until the student masters a particular skill (https://luxai.com/#LearnMore).

2.3.4. Probo

PROBO represents a fictional stuffed animal designed to provide a soft touch and a huggable appearance [35]. The robot is crafted to serve as a social interface, utilizing human-like social cues and forms of communication with a focus on non-verbal interaction. One of PROBO's most prominent features is its movable body, resembling an anteater, equipped with a screen for interaction. Its head is fully movable, allowing it to express attention and emotions through gaze and facial expressions thanks to a flexible mechanism [36]. The internal mechanics of PROBO consist of coordinated actuation systems and a layered structure made of foam and fabric, ensuring safe physical interaction between the robot and children [35]. The robot's green color often evokes positive feelings associated with relaxation and comfort. Green is linked to nature and trees, which contributes to a sense of calm and soothing emotions [36].

2.3.5. Kaspar

KASPAR is a child-sized humanoid robot designed as a social companion to assist children with ASD and other communication difficulties [37]. By interacting in a childlike manner, KASPAR helps teachers and parents support children with ASD in overcoming challenges related to socialization and communication with others Reference [5]. The social robot serves several functions, including: (a) acting as a mediator to help children engage in better social interactions and communication with adults and peers, (b) assisting children in exploring basic emotions, (c) utilizing simplified facial and body expressions, gestures, and speech to interact with children and break social isolation, (d) autonomously responding to touch using sensors located on its cheeks, arms, body, hands, and feet to help children learn socially acceptable tactile interactions, and (e) participating in various interactive play scenarios to help children learn fundamental social skills such as imitation and turn-taking, which are often challenging for children with ASD. These features make KASPAR a valuable tool for addressing the educational needs of students with special requirements (https://www.herts.ac.uk/kaspar).

3. Method

This study was conducted using a systematic review method. Systematic review is employed as an appropriate method for collecting, understanding, and summarizing current information related to the subject under investigation [38, 39]. The aim of the study is to critically examine the concrete field experiences related to social humanoid robots used in the educational processes of children with special needs, assess their adaptability for inclusive education, and present a synthesis of this review for the literature, teachers, educators, and other school stakeholders. The methodology of the study is structured into five sections: (1) literature search strategy, (2) inclusion criteria for studies, (3) exclusion criteria for studies, (4) search results, and (5) definitions and information regarding the variables related to the studies. The analysis and presentation of the research were guided by the PRISMA reporting guidelines [40]. The PRISMA protocol can be defined as a guide that reflects advancements in the identification, selection, assessment, and synthesis methods for research related to the subject under investigation, used for transparent reporting of systematic reviews [41]. The diagram used illustrates the studies included and excluded during specific phases of a systematic review. The inclusion criteria for the research were defined as follows: the study must involve the use of social humanoid robots with individuals diagnosed with special needs aged 2 to 15 years, published between 2014 and 2023, each study selected for inclusion had to feature at least one case or participant group regardless of whether it employs qualitative or quantitative research methodologies, and must be published in full text. The exclusion criteria encompassed studies conducted prior to 2014, unpublished research, studies lacking descriptions of one or more robots' educational functions, and those focused exclusively on the robot's design and technical specifications.

During the literature review, systematic reviews that generally involved the use of robotics in education [12, 13], reviews related to the teaching and learning of robotics content knowledge in K-12 education [7], and reviews specifically focused on the current status of robots used in the education of children with ASD [42, 4] were primarily identified. Studies were determined through searches in electronic databases. Keywords such as “educational robotics,” “children with special needs,” “social humanoid robots,” “child-robot interaction,” and “inclusion” were used in the searches. The searches were conducted between June and September 2024 using databases like Web of Science, Scopus, PsychInfo, EBSCOhost, and Google Scholar. Additionally, the selection of search terms is based on the classification of special needs groups (such as autism spectrum disorder, learning disabilities, intellectual disabilities) and follows the framework established in the DSM-5 [43] published by the American Psychiatric Association. Based on the findings from the literature review, a total of 133 studies were identified (see Figure 1). After adjustments for duplicates, a total of 117 studies remained. After reviewing the abstracts and titles of the identified studies, 20 studies that did not meet the inclusion criteria were excluded.

The full texts of the remaining 97 studies were subsequently examined in detail, leading to the final inclusion of 12 studies in this review.

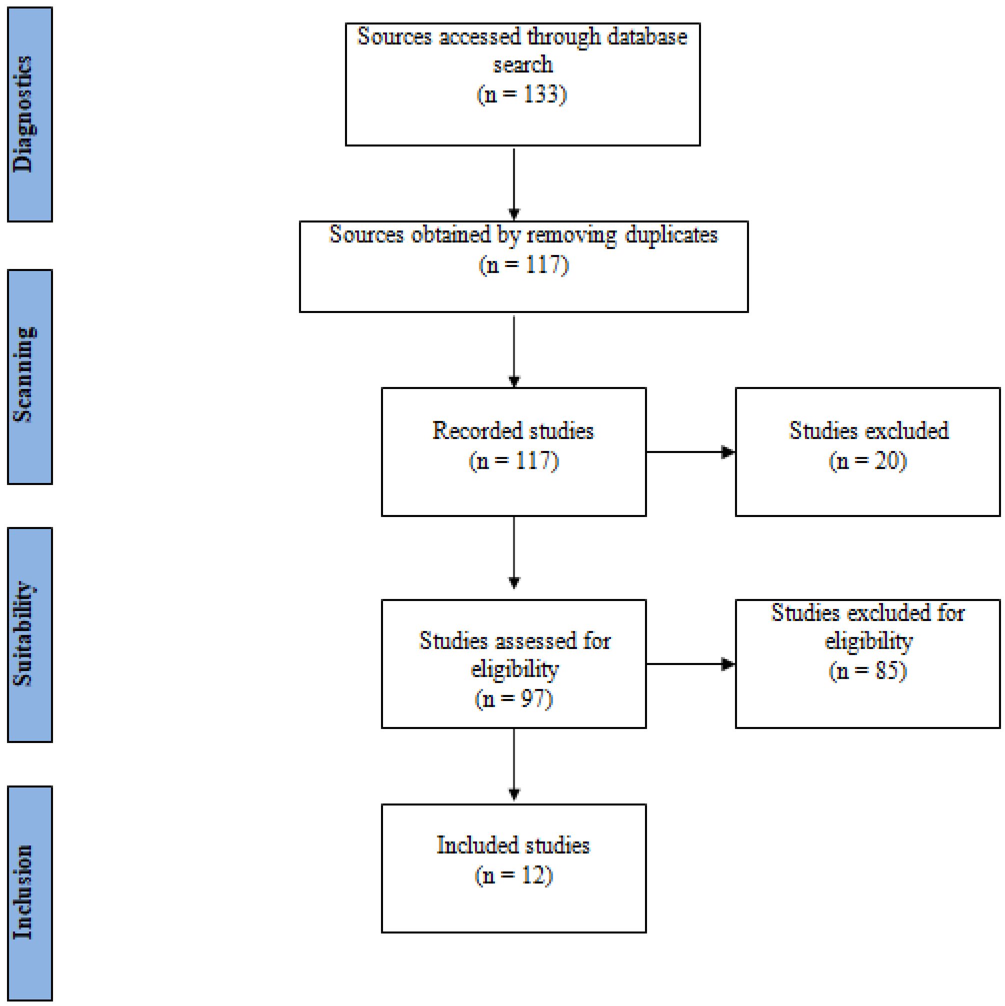

Figure 2: Literature review and study selection flowchart (PRISMA)

4. Results and Discussions

Table 1: General View of the Studies

Researcher	Purpose of the study	Group	Robot	Intervention	Sample	Working Group	Country
[44]	The study aims to compare the learning outcomes of robot-based interventions for	ASD	NAO	Total duration: 12 weeks Pre-test: 9	23 child (20M, 3 F)	12 RG 11 CG	China

	gesture use in children diagnosed with ASD and intellectual disabilities with the learning outcomes of human-based interventions.			robot sessions, each lasting 45 minutes per week Post-test care: Final test: 2 weeks	6-12 ages		
[45]	The study aims to investigate the effectiveness of robotic interventions in increasing social participation among children with ASD.	ASD	NAO	Total duration: 12 weeks Pre-test (× 2) 7 robot sessions, each lasting 30 minutes per week Post-care (× 3)	14 child 9-11 ages	14 RG	Hong-Kong
[37]	The goal is to assist children with ASD in developing their visual perspective-taking (VPT) skills using a humanoid robot.	ASD	KASPAR	Total duration: 1 day Pre-test robot session: 1 session (9 trials) Post-test	12 child 11-14 ages	12 RG	United Kingdom
[46]	The objective is to explore whether the effects of the	ASD	NAO	Total duration:	6 M 6-15 ages	6 RG	Iran

	designed robot-supported protocol on children with ASD vary individually and collectively among different participants.			3 months 12 robot sessions: each lasting 30 minutes			
[47]	The aim is to determine the extent to which social robots can improve turn-taking skills and whether such interventions provide similar or better outcomes compared to standard interventions.	ASD	NAO	Total duration: 20 days Pre-test 8 robot sessions: 1 per day (each lasting 10 minutes) 8 human sessions: 1 per day (each lasting 10 minutes) 4 sessions (robot or human): 1 per day (each lasting 10 minutes)	5 child (4M, 1F) 3-5 ages	5 RG	Romania
[48]	It is believed that social robots serve as motivating tools in play activities for children with ASD. The aim is	ASD	PROBO	Total duration: 10 days 1 robot session: 15	30 child (27M, 3F) 5-7	30 RG	Belgium

	to investigate whether a child's interaction with a human differs from their interaction with a social robot during play activities.			minutes 1 human session: 15 minutes	ages		
[49]	The aim is to examine how children with ASD exhibit participation, socialization, and play behaviors while interacting with social robots.	ASD	PROBO	Total duration: 1 day Pre-test 1 session (8 trials)	11 M 4-7 ages	5 RG 6 CG	Romania
[50]	The objective is to explore a new scenario for robot-assisted play to teach children with ASD about body awareness and how to identify parts of the human body, while also developing a triadic relationship between the child, the robot, and the practitioner.	ASD	KASPAR	Total duration: Unknown Identification Pre-test 7 robot sessions: 10 minutes each Post-test	8 M 6-9 ages	8 RG	United Kingdom
[51]	The aim is to inve The	ASD	QTROBOT	Total duration: 2	15 M	15 RG	Luxembourg

	objective is to explore stigate the utility of a social humanoid robot in interventions for children with ASD by assessing children's attention, imitation, and the presence of repetitive and stereotypical behaviors.			hours Interview	4-14 ages		
[52]	The aim is to enable children with ASD to participate in both collaborative gameplay and social interactions with other players through the design of an	ASD	KASPAR	Total duration: 3 weeks 2 robot sessions 2 human sessions Each child participated in a total of 4 play sessions.	6 child (5M, 1F)	6 RG	United Kingdom
[53]	This long-term study evaluates the use of a humanoid robot in a special preschool for children with ASD. The robot was used as a	ASD	KASPAR	Total duration: On average, each child spent 16.53 months in the study.	19 child 2-6 ages	19 RG	United Kingdom

	tool by teachers or volunteers in the absence of the research team. The staff and volunteers at the preschool were trained on how to work with and utilize the robot.						
[54]	The objective is to explore the impact of a social humanoid robot on the development of social-emotional skills in children with ASD and to explore whether it can assist in recognizing and improving facial expression recognition in these children.	ASD	ZENO	Total duration: 3 weeks Pre-test 6 robot sessions: 15 minutes each, twice a week Post-test	45 child (39M, 6F) 5-10 ages	15 /pre/post/ non-robot intervention 15 /pre/post tests 15 typical development	Portugal

ASD: Autism Spectrum Disorder; M: Male; F: Female; RG: Robot Group; CG: Control Group

The main objective of this study is to investigate the application of social robots in special education, to emphasize the existing potential and limitations of this technology, and to forecast future areas for its implementation. In this context, exploring the value of social humanoid robots in the educational process, their impact on students with special needs, their integration into educational practices, and possible future developments are among the other objectives of the study. This review is expected to contribute to raising awareness regarding the use of social humanoid robots in special education and providing strategic guidance on how this technology can be utilized most effectively. Specifically, the chronological and geographical analysis of published articles reveals an increasing interest from the scientific community in the use of social robots for the education of children with special needs (see Table 1). The necessity of including individuals with special needs as equal members of modern societies, in terms of inclusion, requires the acceleration of integration worldwide [55]. This can be facilitated by the rapid advancements in technology and artificial intelligence, leading to the development of an increasing number of social robots.

Certain characteristics of the social robots used are particularly notable regarding their suitability for specific groups with special needs. In this context, it is evident that most of the publications relate to groups with ASD. For instance, the NAO robot, which is the most equipped among all robots, is preferred for the education of children with more complex cases of ASD. The robots are generally seen to be utilized for developing fundamental skills such as imitation (I), joint attention (JA), interaction (IN), communication (C), eye contact (EC), and others (O) (see Table 2). Aside from the type of special need, another factor determining a robot's suitability is the age of the children in question. Consequently, smaller and more animal-like robots (such as KASPAR, QTROBOT, ZENO, and PROBO) appear to be more appropriate for younger children due to their playful appearances. Nonetheless, additional research is necessary to determine the desired technical specifications for robots tailored to each group of children with special needs and to identify the most appropriate robot for each individual case. It is important to highlight that the majority of robots currently available on the market have been designed primarily for the education, entertainment, and companionship of typically developing children, rather than for those with special needs [56]. Consequently, designing robots specifically for children with special needs is an area that remains largely unexplored and should be prioritized in future endeavors.

Children with ASD tend to show less orientation to social stimuli compared to typically developing peers [57] and are less likely to engage in eye contact [58]. In studies involving the use of social robots with children with ASD, an increase in eye contact has been reported when using the NAO robot [45], PROBO [48], KASPAR Reference [52] and QTrobot [51]. Children with ASD often looked at the robot for longer periods and established eye contact more frequently than with humans [51, 47]. Another study indicated that the robot significantly increased both the frequency and duration of eye contact, as well as the ability to initiate verbal communication in children with ASD [45]. This suggests that children with ASD may be more interested in a robotic partner than in a human one. Therefore, it is possible for social robots to teach children with ASD how to establish and maintain eye contact [55].

Due to difficulties with eye contact, children with ASD also tend to exhibit atypical patterns of joint attention Reference [57]. In a study using the NAO robot [46], it was observed that children with ASD showed an increase in joint attention skills over time. Training joint attention using robots is reported to be more effective than training with humans in improving the initiation of joint attention in children with ASD [44]. However, a reduction in observed joint attention behaviors in some studies may be explained by the distracting effect of the robot, as children may focus their attention on the robot instead of the target object [59]. Future studies are needed to assess the effects of robots on joint attention.

The social challenges encountered by individuals with autism spectrum disorder (ASD) are acknowledged as one of the fundamental symptoms of the condition, resulting in a reduced inclination to initiate social interactions [60]. However, research indicates that children with ASD are more inclined to participate in collaborative play when interacting with the PROBO robot than they are with a human partner [49]. Furthermore, interactions with the KASPAR robot promote better cooperation than when engaging with a play partner [52, 37]. Initiating interactions is thus facilitated through working with robots [9, 37] and this effect can be generalized to human-to-human interactions [61].

Children with ASD are more likely to touch a robot than a human being. The presence of robots facilitates an increase in spontaneous touching behaviors without the need for adult prompting [50]. A study examining the spontaneous interactions of children with ASD with a robot [62] identified four levels of child-initiated interactions: exploratory interactions (such as touching and visual inspection); relational interactions (where another object is used alongside the robot); functional interactions (which include imitating the robot and engaging in dialogue); and social approaches toward adults regarding the robot (discussing the robot with an adult). The findings indicated that children with ASD often engaged in spontaneous exploratory and functional interactions with the robot.

The presence of a robot also supports the verbal and non-verbal communication skills of children with ASD Reference [61]. In studies conducted, the number of interactions with the KASPAR robot has been positively correlated with the development of communication abilities [53, 37]. Similarly, in an intervention study involving the NAO robot [46], significant improvements in verbal communication were observed over time. Therefore, social humanoid robots can assist children with ASD in enhancing their verbal and non-verbal communication skills.

Imitating the movements of others is recognized in the literature as a skill that children with ASD often find challenging [63]. This imitation ability may be enhanced through the use of a robotic stimulus. Research shows that children with ASD are more likely to imitate joyful expressions, such as smiling, from a robot rather than from a human [64]. Moreover, when gesture imitation is carried out by a robotic arm, it can execute the movements more quickly than a human arm [65]. In the presence of a robotic arm, children with ASD perform movements significantly faster than their typically developing peers, while in the presence of a human arm, typically developing children execute movements significantly faster and with better quality than children with ASD [66]. Training aimed at imitating facial expressions with a robot shows a greater increase in performance compared to the same training conducted with a human [54]. In another study, it was found that gesture training using a robot was as effective as training conducted with a human [44]. As a result, children with ASD can improve their imitation skills through robotic training and subsequently generalize these skills to human interactions. However, the enhancements in imitation that a robot offers are not consistently superior to those provided by a human. For instance, another study indicated that imitation training with a robot did not yield significantly greater effects than training with a human [51]. Additionally, interacting with a robot may even result in a decrease in word and gesture imitation compared to engaging with a human [64]. Consequently, the findings regarding the benefits of using a robot to promote imitation are mixed, indicating a need for further research in this area.

Table 2: Robots Examined in the Studies and Intended Skills

Robot	Skills Studied/Intended						Studies
	I	JA	IN	C	EC	O	
NAO	■	■	■	■	■	■	[44, 45, 46, 47, 66]
ZENO	■						[54]
QTROBOT	■				■	■	[51]
PROBO			■		■	■	[48, 49]
KASPAR			■	■	■	■	[37, 50, 52, 53]

I: Imitation; Joint Attention; JA; Interaction: IN; Communication: C; Eye Contact: EC; Others: O (Appropriate/Inappropriate Behaviors)

When examining the intelligence levels of social robots used in special education, it has been concluded that they are not different from typical education. In this context, algorithms such as face detection, face recognition, speech recognition, emotional recognition, visual behavior analysis, and visual tracking [67] are used to create intelligence in social robots, enabling them to interact more naturally with children. However, it is important to emphasize that there is a significant demand for designs focused on enhancing interactions between social robots and children with special needs, particularly in relation to specific behaviors like emotional expression. Consequently, the development of intelligent algorithms and/or the customization of existing algorithms to cater to the unique characteristics of each special needs category is regarded as crucial.

In the context of recent studies, this systematic review analyzes current robot-based educational practices to gain insights into the potential of robotic tools to enhance inclusivity in education. Systematic reviews on social humanoid robots for children with special needs overlap with this research in some aspects but do not share the same theoretical framework. The study by [56] focuses on rehabilitation and health programs rather than learning activities in schools. The review by [16] analyzes educational applications limited to social humanoid robots. Another study examine learning experiences in which children program social humanoid robots [11]. Finally, the studies by [15,42] focus on the robot's performance and technical challenges. Social humanoid robots can interact with humans and encourage children with ASD to repeat and practice various social interaction scenarios without the anxiety of human contact. In general, social humanoid robots can provide children with ASD with self-regulation abilities and can become an important teaching tool for the professional assisting the child (teacher, therapist). Various factors, such as the robot's appearance, way of movement, and facial expressions, contribute fundamentally to the success of educational processes [68]. While the use of social humanoid robots in the education of children with ASD provides benefits, it also raises ethical concerns. One of these concerns is the possibility of emotional attachment when social humanoid robots are used in therapeutic interventions. Children with ASD may perceive the social humanoid robot they interact with as an independent entity capable of responding intelligently, considering it a friend. A solution to this issue could be to clearly state that the robot functions as a learning tool and does not replace the teacher when it is introduced [69] Additionally, it is clear that robots can be important assistants in intervention studies with children with ASD. Intervention programs using robots to improve cognitive skills in children with ASD have been reported to enhance motivation, empathy, attention, imitation, and facial expression recognition, which positively contribute to social interaction [70].

As a result, the study has some limitations. In this context, one of the key areas for researchers to focus on is conducting large-scale studies with a significant number of children to investigate the impact of social humanoid robots on the education of individuals with special needs. The studies reviewed have various limitations, particularly in terms of small sample sizes, low female participation, and the absence of control groups. Furthermore, when examining the interactions of children with special needs and social humanoid robots, the long-term effects of robots on children have not yet received the necessary attention through follow-up sessions in the studies. Finally, another area that requires further investigation is the examination of intervention methods suggested in various studies. There is inconsistency in the methods for developing intervention scenarios in the reviewed studies, leading to results that are not very convincing. Future research should include comparisons of intervention methods and interaction scenarios to make the results more reliable. In order to establish an interaction that is adapted and personalized according to the needs of children, individual factors such as ethnicity and cultural background should be taken into account. By developing a rigorous research methodology, studies with control groups, follow-up sessions, and larger sample sizes can be conducted.

5. Conclusion

This study seeks to present a systematic review of the existing literature regarding the utilization of social humanoid robots in the educational experiences of children with special needs and to suggest potential directions for future research. Social humanoid robots have significant potential to enhance the learning, active participation in education, and social interactions of children with special needs. The use of social humanoid robots in special education offers innovative solutions tailored to the individual needs of students with special requirements [11]. These robots possess the potential to enhance the social skills of students with special needs, extend their attention spans, and improve their engagement with educational materials. However, ethical, technical, and educational challenges that may arise during the integration of this technology into educational processes must be addressed carefully. Educators must possess sufficient knowledge and skills to use these robots effectively. The use of educational robots should be embraced and supported by teachers, students, and parents. Furthermore, the long-term effects of educational robots on students represent a topic that requires comprehensive investigation [10].

In the future, it is expected that social humanoid robots will become more intelligent and adaptable, leading to their more widespread use in special education. However, the increased usage of these robots carries the risk of exacerbating inequalities in education. Therefore, the accessibility of this technology and the necessary infrastructure requirements must be carefully planned. In conclusion, integrating social humanoid robots into special education offers substantial opportunities to enhance the educational experiences of students with special needs. To maximize this potential, it is essential to engage in thoughtful planning and research while equipping educators with the appropriate support. Consequently, it is important to raise awareness about the application of social humanoid robots in special education and to formulate effective strategies for their integration into educational practices. Despite the complexity of addressing the needs of all students in educational environments, the integration of social humanoid robots into educational processes and the growing interest in educational robotics and child-robot interaction can be seen as significant developments. All of these factors offer new and encouraging opportunities for students with special needs continuing in inclusive education, the diversity of research in the field, advancements in teacher training, and student-friendly classrooms.

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