Designing Learning Activities for Improving Social and Imitation Skills for Children with Autism Spectrum Disorder Using a Humanoid Robot

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"Why save it for sleep when you could be living your daydream"

Lily Meola

27 years of living in a daydream and now I can finally say "Thank you God". This is a bizarre yet fascinating journey. Thank you for the endless support from my parents, Shinta, and my family in Indonesia. I would also express my gratitude to Ton de Jong and Henny Leemkuil as my supervisors. To Jan, words cannot express how lucky I am to have you.

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Abstract

Humanoid robot has been widely used in autism intervention due to their capability to improve children's social and imitation skills. This study aimed to design learning activities using a humanoid robot as an intervention for children with autism. Prior to this, educators were interviewed and surveyed to gather their perspectives on the most challenging skills to teach in the areas of social and imitation skills for children with autism, as well as on their perspective on the use of technology, specifically humanoid robot, in autism intervention. Thematic analysis was conducted on the result of the interviews which involved fourteen participants. The analysis showed that peer interaction, initiating conversation, and commenting to peers were difficult skills in the scope of social skills. Meanwhile, imitation of complex movements was challenging skill in the scope of imitation skills. The next step was the design process, where the game 'Copy Me' was developed to improve children's social skills particularly the interaction skills by initiating conversation and peer commenting through collaborative play. Meanwhile the Imitation of a Complex Sequence activity was developed to improve children's imitation skills. Three field experts participated in the study and evaluated the design of the learning activity through a questionnaire. The results show that the components of each activity including duration, instruments, outcome, activity, and instruction were appropriate for the intervention. Hence, improvement needs to be made in the assessment sheet and the duration between prompt and response. As a next step, this study suggests that an experimental design should be developed to measure the effectiveness of the learning activities.

Keywords: *humanoid robot, autism intervention, social and imitation skills, educators' perspective, design learning*

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Introduction

According to a World Health Organization (WHO) report in March 2022, the prevalence of autism among the children worldwide is to be 1 in 100. In Europe, the percentage ranges from 0,38% and 1,55% (Bougeard et al., 2013). Autism is a lifelong disorder marked by challenges in social interaction, communication, and patterns of restrained and iterative behavior, along with an interest in specific activities (APA, 2013, as cited in Quill & Brushnahan, 2017, p. 15). This disorder is classified as a neurodevelopmental condition in which children with autism do not meet expected developmental milestones in specific areas (Quill & Brusnahan, 2017).

Autism (or autism spectrum disorder, ASD) was initially defined as a diagnostic concept by Leo Kanner, an Austrian psychiatrist, in 1943. Kanner described a syndrome that was marked by a significant “insistence on sameness,” a lack of attentiveness in people, and restricted societal interaction (Vivanti et al., 2020). The DSM-5 diagnostic conduct for autism consists of two groups “fixated interest and repetitive action” and “social communication difficulties” which are aligned to Kanner’s original definition (Vivanti et al., 2020).

Fixated interest and repetitive activities can manifest themselves as repeated simple motor movements, such as flapping, and the repetition of words and phrases, known as echolalia. The disruption of these repetitive action can cause discomfort because children with autism often struggle to adjust to the new situation (Lahiri, 2020). Moreover, children with ASD are also exhibiting deficits in social and communication skills, which are essentials for the development of other skills. Problems related to social and communication areas may lead to solitary behavior, reduced communication, and a lack of eye contact with others (Bauminger-Zviely et al., 2020).

Early social and communication skills are frequently linked to the capacity of imitation and motoric functioning (Dadgar et al., 2017; Nadel, 2002; Pittet et al., 2022). There is a strong indication that children with ASD have limitations in the area of imitation (Soorya et al., 2003; Williams et al., 2004). To overcome this problem, early intervention is crucial for children with autism. Research conducted by Ingersol (2012) indicate that imitation intervention of young children with autism could improve joint attention skills (two persons paying attention to the same thing) and social emotional functioning.

Technology could play a positive role to teach social and imitation skills in autism intervention. Technology in this research is including a variety of common electromagnetic instruments and devices such as computers, smartphones, augmented reality, video modeling on DVDs, tactile cues, robotics, and other technological tools. These technologies can be used as assistive tools or aids that can be removed if the expected goal is achieved. For instance, computer programs counted as helpful in improving emotional understanding (Petrovska & Trajkovsky, 2019), video modeling has shown a positive effect on motoric skills development (Taheri-Torbati & Sotoodeh, 2018) and facilitates the generalization of social play among pre-school children (Petursdottir & Gudmundsdottir, 2023). Additionally, augmented reality can help the students to improve their social communication skills (Sahin et al., 2018).

Robots emerged as another effective form of technology utilized in autism intervention. Research indicates that robots have the capability to support children with ASD in areas such as socialization, communication, and playful expression (Yousif, 2021). Another potential benefit of a robot is providing structured and clear information (So et al., 2018), adapted to meet children's specific needs and present relevant stimuli during learning (Alcorn et al., 2019), and serve as social mediators and encourage the communication ability of children with autism (Robins et al., 2018).

There are different viewpoints in deciding which robot to use in autism intervention. Some authors suggest using non-humanoid robots, such as Pleo, Labo, Keepon, and Probo, while others recommend humanoid robots, such as Nao, Pepper, Q Robot, Kaspar, Face, and Zeno. One argument in favor of the humanoid robot is that robots that have features like a human enable ASD children to more readily recognize the intended social cues displayed by the robot (Scassellati et al., 2012). The benefits of using humanoid robots can be found in the literature are summarized in Table 1.

Table 1

Literature Review on the Development of a Humanoid Robot for Autism Intervention

Author/Year	Robot Model	Method	Result
Billard et al./2007	Robota	Encourage social interaction skills via imitation and turn-taking games	Children exhibited social interaction and communicative competence
Shamsuddin et al./ 2012	NAO	Five modules were prepared to entice a reaction from the ASD children	The robot inhibited child's autistic behavior and enhanced visual engagement among the child and the robot
Costa et al./2015	Kaspar	Teach how to use proper force during physical interaction with a partner	Children were able to identify body parts and perform appropriate physical touch on the robot
Srinivasan et al./ 2015	NAO	Three groups consisting of 36 children with ASD join the gross motor and fine motor activities	Children showed an improvement in gross motor performance
Zheng et al./2015	NAO	Robot demonstrates a targeted gesture and asks the child to replicate the motion	Children demonstrated greater focus on the robot instructor and performed better in imitation task aided

			by the robot compared to human session.
Beer et al./2016	NAO	Robot-assisted therapy provides music therapy for children with ASD	Children could follow robot instructions with a decrease in therapist prompts
So et al./2018	NAO	Two groups of children listen to the story from a robot and imitated the gesture made by the robot during storytelling time	Children with ASD obtained accurate or suitable intransitive action during the practice and were able to reach up to the degree of gestural production observed in typically developing children.
David et al./2018	NAO	Robot-enhanced treatment to provide an activity focusing on joint attention performance from children with ASD	Children were able to maintain their interest during the session because of the well-structured procedure which provide predictability for the children.
Marino et al./2019	NAO	Robot plays as an intervention moderator in a socio-emotional awareness protocol for youngsters with ASD (using Cognitive Behavioral Therapy)	Children in the robot group displayed an improvement in the performance of five basic emotions. All children in the robot group reached the top score on

Emotional Lexicon Test (ELT)

The studies listed in Table 1 have been conducted on the use of humanoid robots in therapy for children with the autism spectrum disorder (ASD) and the findings are encouraging. These studies have demonstrated that humanoid robots can be adequate in enhancing social interaction skills, gross motor performance, and joint attention in children with ASD. Furthermore, humanoid robot-assisted therapy has the potential to assist children with ASD in acquiring appropriate physical touch, helps them to follow instructions and imitate gestures accurately. It appears that humanoid-robot interaction can follow a similar pattern to human interaction. In summary, the use of humanoid robots in therapy shows promise in helping children with ASD to improve their social-emotional understanding and communication skills.

Current study

The success of using humanoid robots in autism intervention to improve social and imitation skills has been documented in many studies. This success cannot be separated from the role of various stakeholders, including teachers and therapists who display an important role in supporting the effectiveness of robot-assisted autism intervention. Nevertheless, there is a gap between humanoid robot research in autism intervention and the acceptance by teachers and therapists of the utilization of robots in autism therapy. The literature dominantly focused on the adoption of humanoid robots in autism intervention instead of teachers' and therapists' opinions despite their crucial position as primary users in this context.

Three studies that investigated the view of educators on the use of robots were found during the literature review. The first study, administered by Alcorn et al. (2019), focused on how educators in England perceived humanoid robots as educational tools in general through interview. The result showed that using a humanoid robot in autism intervention was seen as beneficial for the students because the robot was predictable and provided consistent interaction. Other studies specifically examined teachers' perspectives after implementing a humanoid robot in autism intervention (Garnier et al., 2023; Sochanski et al., 2021). Educators in these studies mentioned that the robot supported child independence in learning

(Sochanski et al., 2021) and that the robot performed neutral in appearance that well suited to autistic children (Garnier et al., 2023). However, there were certain concerns related to the use of a humanoid robot such as the potential to hinder the children from engagement with other individuals (Alcorn et al., 2013); difficulties in providing physical prompt for certain activities (Sochansky et al., 2021), and the need to implement technical programming, such as coordinating gestures and speech to accommodate the needs of the students (Garnier et al., 2021).

The current study will further examine the perspectives on and acceptance of technology, particularly humanoid robots, by teachers and therapists in educating children with autism. Subsequently, based on the input from teachers and therapists, the learning activities will be designed to develop child's social and imitation skills.

The research questions that are addressed in this study include identifying the most challenging social and imitation skills and possible interventions with a robot, determining teachers' and therapists' perspectives on the use of technology, and designing learning activities for enhancing social and imitation skills using a humanoid robot. The following research questions in this research are:

1. What are the most difficult social and imitation skills and which interventions with a humanoid robot are possible?
2. What is the educators' perspective on the use of technology, particularly the use of a humanoid robot in schools for children with autism?
3. What learning activities can be designed for improving children's social and imitation skills using a humanoid robot?
4. What is the opinion of field experts on the usability and potential effectiveness of the designed interventions?

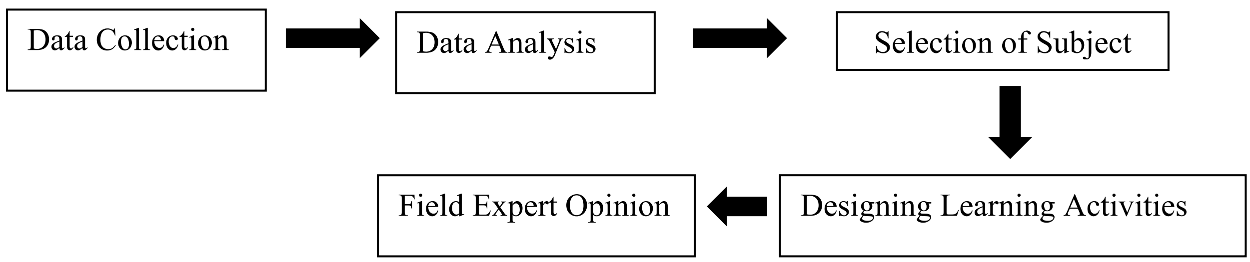
Method

Research design

The present study employed a qualitative research approach to explore the perceptions of the teachers regarding the use of humanoid robots in autism intervention. Qualitative research was considered appropriate due to its ability to provide comprehensive and in-depth information on child-robot interaction during autism interventions. The study consisted of two parts. The first part was a survey and interviews with teachers and therapists of autistic children to collect the data. The second part was the creation of the learning activities based on the analysis of the survey and interviews. This was followed by a field-expert evaluation of the designed activities. The overall design of this study is presented in Figure 1.

Figure 1

Research Design



Participants

Fourteen teachers and therapists who have experience in teaching children with ASD in schools or therapy centers were recruited through direct communication via social media to participate in this study. The participants came from various nations, including Indonesia, Japan, Turkey, and India, and held different roles such as therapist (N=4), teacher (N=5), homeschool teacher (N=1), and professor (N=1). They had various levels of teaching experience ranging from 2,5 years to 18 years and worked with children between the age of 2 to 22 (Table 2).

Table 2

Data of Participants

Participant	Gender	Years of Teaching	Age Level (years)	Location
Participant 1	F	5	1-5	Indonesia
Participant 2	F	5	Up to 12	Indonesia
Participant 3	F	10	4-22	India
Participant 4	F	4	3-22	India
Participant 5	F	6	3-16	India
Participants 6	F	18	2-19	Indonesia
Participant 7	F	10	12-14	Indonesia
Participant 8	M	2,5	7-17	Japan
Participant 9	M	13	3-15	Indonesia
Participant 10	F	8	All age	Turkey
Participant 11	M	16	16-18	Turkey
Participant 12	F	12	7-10	Turkey
Participant 13	F	-	17	Turkey
Participant 14	F	5	2-8	Indonesia

Data collection tools

The chosen data collection tools for this study were a survey and an interview. The survey aimed to measure teachers' and therapists' opinions on social and imitation skills and comprised 22 statements taken from the curriculum "Behavioral Intervention for Young Children with Autism" by Maurice et al. (1996), which has been shown to be effective for intervention programs (Jensen & Sinclair, 2022). Along with the demographic questions, the survey used Likert-type items with a five-point scale ranging from very easy to very difficult (see Appendix A for the survey statements). The survey was created using Google Forms for its ease of accessibility and direct result production.

The objective of the structured interview questions was to gather teachers' opinions regarding the utilization of technology in educating children with autism, particularly the use of humanoid robots. The interview comprised 17 questions that covered various aspects such as demographic information, the skills being taught by the teachers/therapists, and specific inquiries about the teachers' perceptions of the use of robots in autism intervention and the types of activities that humanoid robots could teach (see Appendix B for the interview questions). All fourteen participants were interviewed via a Zoom online meeting, and the interview lasted for roughly 45 minutes. The interviews were recorded and transcribed for the analysis phase.

Procedure

This research employed interviews and surveys as data collection tools. Fourteen participants were recruited via social media. Due to the different time zones, scheduling was arranged between the researcher and the participants. The data collection process was conducted from September to October 2022 with 14 participants. Nine participants (N=2 from Indonesia, N=3 from India, and N=4 from Turkey) participated in group meetings and the remaining five participants participated on a one-on-one meeting. The data collection process took approximately 60 minutes, which included a short introduction, survey, and interview session. All meetings were conducted and recorded via Zoom online meeting. The participants first completed a 10-minutes survey in English with a verbal translation provided for those who needed that. The survey was followed by a 45-minutes interview session where general and specific questions were asked. After discussing the benefits and the drawbacks of technology in teaching children with autism, participants watched a YouTube video about the NAO robot which demonstrated its characteristics and abilities. The subsequent questions focused on the potential use of humanoid robot in autism therapy and the specific skills that can be taught using humanoid robot. Bahasa Indonesia was used for the Indonesian participants while two translators were used for Turkish participants and the interview findings were later translated into English.

Data analysis

The interviews were transcribed and analyzed using thematic analysis. Thematic analysis was chosen to develop an interpretation of the interviews by identifying patterns. The analysis process consisted of six phases: familiarizing with the data, generating the initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Braun & Clarke, 2012).

The data familiarization process as the first phase involved transcribing all the interview results and identifying patterns and meanings of the content. In the second phase, the initial codes were generated using the NVivo software program and then organized in its coding folder. The third phase involved sorting and collating all potential themes. The fourth phase occurred when all potential themes were sorted and collated. After reviewing the themes, codes were clustered into sub-themes and all candidate themes were read and sorted again, resulting in eight sub-themes clustered into three larger themes. In the fifth phase, codes related to technological devices or aids in autism intervention were categorized under the sub-theme of “Intervention Aids” while all codes related to skills being taught by the teacher, such as imitation skills, oral skills, or social skills were categorized under the sub-theme of “Skills”. Codes related to the influence process of teaching such as parents’ expectations, difficulties faced by the teachers, student needs, and student’s condition depict broader contextual factors that were influencing the teaching and learning process were categorized under the sub-theme of “Influence Factors”. Next, codes related to the child’s response, the advantage or disadvantages of technology, the impact and mitigation strategy were clustered into “The Effect of Technology in Autism Intervention” theme to describe the impact of technology in the context of autism intervention.

Throughout the thematic analysis process, the integration of survey results and interview data was undertaken to ensure a comprehensive understanding of the experiences and viewpoint of the participants. Finally, the themes were organized into broader categories such as "Teaching Children with Autism", "Role of Technology in Autism Intervention", and "Child-Humanoid Robot Interaction in Autism Intervention" which encompasses all processes related to the use of humanoid robots in autism therapy. The data from the survey were summarized into tables and compared with the interview findings through triangulation.

Results

Perspectives on difficulties in teaching social and imitation skills and the potential of humanoid-robot intervention.

The combination of survey and interview data provides an extensive comprehension of the areas where autistic children struggled the most. The survey revealed that teachers and therapists faced difficulty in teaching complex sequence imitation with an average score of 3,84 out of 5 on the difficulty scale. Additionally, in social skills, they reported difficulties in facilitating peer commenting during play as reflected by an average score of 4. To corroborate these findings, the interviews with teachers and therapists revealed that initiating conversations and interacting with peers were also challenging teaching skills. Both survey and interviews to the participants emphasized the difficulty of children with autism faced in initiating conversations which is a fundamental aspect of communication. One teacher specifically mentioned the difficulties faced by students when attempting to imitate their peers in vocal responses and complex sequences. In Table 3, the possible suggestions for using a humanoid robot as an aid in autism intervention provided by the teachers and therapists were displayed.

Table 3

List of Activities to Improve Social and Imitation Skills

Social Skills Activities	Imitation Skills Activities
Two-way communication	Gross motor skills: applause, brain gym, wave hand
Asking social questions	Teach how to tidy up the bed
Initiating conversation	Fun dancing, cooking
Role play	Simulation of activity
Helping in peer learning	Sing and dance
	Take object

	Kicking, walking, squatting down, standing up
	Do physical exercise

Perspectives on the use of technology, specifically the use of humanoid robots for children with autism

The analysis of the interviews resulted in three themes with eight sub-themes emerging in the findings. The theme and subtheme were presented in Table 4 and further elaborated in the rest of this section.

Table 4

Explanation of Theme and Sub-theme

Theme	Sub-Theme	Explanation
Teaching children with autism	Curriculum Planning	The method and strategy used by the teachers
	Skills	Various imitation of oral motor movement, gross/fine motor movement, and social skills that were taught by the teacher
	Influence factors	Factors that influence the learning process
The role of technology in autism intervention	Technological devices	Examples of tools or apps that were used in autism intervention
	The effect of technology on autism intervention	Participant’s opinion about technology, the advantage or disadvantage of technology, child’s reaction, and mitigation strategy to reduce

		the negative impact of technology
Child-robot interaction in autism intervention	Opinion on robots	Teachers' opinions and concerns about the use of robots, child's views and responses on robots, the function of robots in autism intervention, and the limitation of robots.
	Robot arrangement	Teacher's effort to familiarized the robots, the robots' set-up, and the expected goal from child-robot interaction
	Robot-assisted intervention	Skills or activities taught by the robots

Description of each theme

Theme 1: Teaching children with autism

Eleven out of fourteen participants reported using the Applied Behavioral Analysis (ABA) method with various strategies to teach children with ASD. This method aims to improve children's social and imitation skills. Participants agreed that every student is unique and that educators had to consider each child's personality, capability, and learning needs when developing lesson plans. Therefore, the diagnose of specific characteristics to create suitable learning activities for each child was considered as important.

Teaching children with autism presents unique challenges. Participants identified problems related to hyperactivity and lack of concentration, as well as external difficulties such as the use of gadgets for online learning. To overcome these issues, participants personalized the learning process by developing teaching strategies such as teaching one-on-one to see their reactions. Another strategy was looking at children's initial condition especially their level of skills and knowledge in social and imitation skills. Afterward, participants arranged a learning program that targeted each student's learning process before encouraging them to learn with their peers.

The involvement of parents was another significant topic. Some parents had high expectations for their child's social and academic skills. Participants reported that parents expected their children to be more social and connected to other people, which proved challenging for children with autism. To address the expectation of the parents, the teachers created activities that emphasized social interaction and reduced the duration of gadget use especially the use of an iPad. On the other hand, some parents placed more emphasis on academic skills, expecting their children to read and write at the same level as their peers. Participants found this expectation demanding and believed that children should first master basic skills and improve their motoric skills before moving on to academic skills. To ensure success, teachers worked with parents to re-teach the material at home and maintain the learning program.

Theme 2: The role of technology in autism intervention

The utilization of technology has become a common practice in autism intervention. Participants utilized a variety of tools to personalize the learning process for their students. This includes basic tools like books, picture cards, puzzles, and toys to stimulate children, as well as advanced tools such as iPads and tablets that provide personalized and interactive learning. This action was taken to engage the children with educational content to enhance their comprehension and retention. Other tools used were smart-boards that provide an interactive lesson through touch-based interaction, virtual objects manipulation, and peers collaboration in learning to enhance their learning experience. Another participant reported using a Wacom pad for teaching imitation skills in drawing and a Mechano robot that provides praise and feedback for the students. Apps such as Matify were also used for learning math.

The use of technology in therapy for children with autism provide advantages and disadvantages. On one hand, participants mentioned the importance of using technology by improving a childs' engagement in learning. One participant stated, "*They feel fun and* *focus*". Other participants stated that the camera in their phone can help them to become aware of the correct movement because "*Children can focus quickly because they see their picture*" in the camera. Additionally, the use of technology was perceived as a successful method for teaching children with autism, who tend to learn from routines and need to be taught repeatedly. Participants stated that the advantage of using technology such as YouTube was laid in the fact that they "*don't have to keep on reiterating the instruction*". The attraction to technology also made it "*easier to learn mathematics*" because "*they can see the picture and hear the sound*" repeatedly. Digital learning also provided flexibility in learning, as "*children can learn at home, and can be taught even when they are at home*".

Participants also recognized that humans sometimes have limitations in describing information, and technology can help to fill this gap. As one participant stated, "*Technology helps to describe the instruction better*". Technology also helps educators in planning and preparing lessons by "*sending notifications about the program for tomorrow. So, the programs warn them and they can create plans and programs about the children with special needs*"

Despite the potential use of technology, educators also emphasized the side effects of technology for children with autism. The high engagement in technology often creates an addiction in children. One participant stated that the students found an iPad to be "*very interesting,*" so the children did not follow the trainer anymore. Because of this, some participants prefer to minimize the use of iPad and YouTube and replace it with simpler tools, such as puzzles, cards, toys, or some imitation activity presented by the teacher. Further, digital technology was indicated by participants as a "*drawback to human-to-human interaction*". Addiction to technology and parents' expectation to make the children more social, make participants feel the need to limit students' technology usage by stating that "*we keep it in our control because few kids are getting obsessed with the iPad*". Additionally, a participant stated that the iPad was given as a "*reinforcer order*"

Another problem related to technology emerged during the pandemic. Participants reported that not all the children with autism were excelled the technology. Younger children found difficulties in operating the device for learning. Another participant commented that some of the children "*lack of focus*" during online learning.

Theme 3: Child-robot interaction in autism intervention

In the subtheme of opinion about the robots, participants shared their views about the usage of robots in autism intervention. On one hand, they reported three potential benefits. Firstly, participants noted that the robots had the capability to repeat the instruction frequently. Secondly, the stability of the robot, include its consistent tone and mimicry. Lastly, the robot interaction that reduced anxiety in children with autism by remarking "*making an eye contact with the person is hard, but with the robot maybe this aspect is removed. You don't have to build common attention or common eye contact with the robots, like human."* On the other hand, participants shared their concern that the robot might distance the relationship between the child and another human.

Participants also used the label "toys" to describe child's impressions of robots. A few participants commented that the robots were considered as a toy because it has a toy nature. This can be seen from participant statement "*perhaps they consider robots like ordinary toys*" or "*in the kid's mind, the robot is definitely a toy*". Participants explained this toy nature could attract children's attention and take further action such as playing or interacting with the robots. Participant also commented that some children "*love to see the robot*" but children that had high anxiety would "*avoid the robot*" or even "*run from the robot*". The potential reaction that occurs during child-robot interaction was described as negative actions such as slamming, dismantling, or even destroying it. To familiarize the children with the robot, participants mentioned few attempts such as showing photo or watching video about the humanoid robot before the intervention.

Although a robot program develops over time, participants were also uttered their opinion about the limitation of robots. They commented that the robots have limitations either in their movement, the way it speaks, or give reaction toward child behavior. One educator mentioned that "*I think until now we maybe haven't like found it, the robot that really like how they call? Uh can react and can do more things. I guess there's a limitation to what robot can do.*" Another consideration emerged regarding the cost of the robots. The participants realized that the development of a sophisticated robot program need a high cost to ensure that the robot could provide the best functionality. Therefore, the participants comment that "*but what I thought of was the affordability of the cost to support the robot. The logistics are so expensive. Can this be exposed at an affordable cost or not? That's what*

I don't know the answer to yet, because the technology is definitely not cheap. That can be one of the points, if for example with that with a high cost/expensive, it can only be used in certain places."

Despite all the concerns, participants were also open to the possibility to use the robot in autism intervention. But before that, it was crucial to understand the robot before using robots in the intervention. Further, the participants stated that "*first, we need to learn that, then we can say that we can try with our child*"

Before the robots were adopted for autism intervention, it was also important to set up the robots. The setup was related to the language, the prompt, and the movement. Some participants stressed the importance to prepare the robot language based on the local language. Robots also need to be set up in the audio system, by setting up the prompt or sentences to respond to the children's voices to create two ways of communication. Another setup was about the movement of the robot. Robots must be flexible in putting the program about certain movements. The setup in the end was also related to certain goals that were expected by the teachers such as the ability to teach imitation and social skills. Meanwhile, according to the participants, the possible activity that can be taught by the robots were two-way communication, labeling, imitate gross motor skills like applause or brain gym that facilitate the imitation of motor skill through simple movement.

Design Activity

Requirements for the design of the learning activity

In designing the learning activities for this thesis, the survey and interview results served as the base input. The survey reveals that participants identify teaching complex imitation and peer commenting during play as challenging skills. Similarly, the interviews indicate that initiating conversations and interacting with peers are difficult skills to teach. These findings align with Nind and Powell (2000) who indicate that communication development necessitates active engagement from both parties to foster reciprocity. Furthermore, Jackson et al. (2003) mention that while autistic children may excel in simple conversations, they often encounter difficulties in other forms of social interaction, such as playing together, which is a crucial aspect of social development.

In addition to selecting the intervention method, it is crucial to personalize the approach and consider each child's unique characteristics. This aligns with Jordan's (2009) research, which emphasizes the significance of focusing on a child's strengths, interests, personality, and experiences to facilitate their development and address challenges. Hence, personalization plays a vital role in autism intervention. For children with attention difficulties and hyperactivity, tailored interventions in the form of one-on-one meetings may be a viable solution before involving them in peer interactions, as suggested by the participants.

Support for autism intervention involves all stakeholders, including parents. Parents play a crucial aspect in their child's care, as they possess unique perspectives, investments, and responsibilities (Vismara & Rogers, 2018). However, it is equally essential to acknowledge that parents also require support to enhance their parenting skills within the context of autism interventions. The involvement and interaction between parents in the role of caregivers significantly impact the development of social skills (Shillingsburg & Juban, 2018). Therefore, providing comprehensive support to parents in a collaborative manner can have a constructive impact on the child's learning and development.

Digital technology, including the use of screens, plays a vital role in autism intervention, as it can enhance interest and engagement in learning. Shane and Albert (2008) highlighted that individuals with ASD spend more time on electronic screen media, while

Westby (2021) emphasized that children with ASD are exposed to screen time at a younger age compared to typically developing children. However, it is important to acknowledge both the potential benefits and drawbacks of technology in autism intervention.

The potential benefits of technology are diverse and include reducing the reliance on instructor support when it is unavailable (Brodhead et al., 2018), supplementing curricular content (Westby, 2021), and capturing data in various learning settings (Bernacki et al., 2020). However, concerns were raised by participants regarding excessive gadget usage, particularly screen addiction resulting from learning apps and YouTube videos as it potentially hinders children's social competence. (MacMullin et al., 2016). Therefore, selecting appropriate digital media content that is engaging, meaningful, and incorporates social interaction with others is crucial (Westby, 2021). Raising attention and understanding of alternatives options will influence the selection process. In addition, sharing insight about the potential of technological use and the effect on families and therapists, can help to facilitate the adoption of an appropriate device (Ghanouni et al., 2019).

Humanoid robots are increasingly being used in autism intervention, and participants mentioned several potential benefits associated with their use. These include the consistency in robot characteristics (Alcorn et al., 2019), the repetitive actions (Huijnen et al., 2019), and the ability to reduce anxiety (Di Nuovo et al., 2020). The presence of a toy-like feature in the humanoid robots has the potential to attract children and enhance their engagement and motivation for learning (Pakkar et al., 2019). However, it should be noted that some children may experience a sense of insecurity in response to unpredictable conditions, which can hinder their learning process (Schadenberg, 2021). Concerns regarding the limitation of robot movement and response were also raised by the participants, as they observed delays in the robot movement and communication with the children. This observation aligns with the research conducted by Sochansky et al. (2021) which emphasizes the relevance of timing in the child's progress during autism intervention. Therefore, several considerations are provided before implementing the use of robots in interventions.

Firstly, it is crucial to familiarize the children with the robot prior to interaction to reduce anxiety. Showing the video about the humanoid robot before the therapy session would be beneficial for the child-robot interaction (Kumazaki, 2020). Another option is to display the robot in a feasible area in the intervention room.

Additionally, personalization plays a crucial role in the intervention. Adjustments in the audio program can accommodate children who have sensory sensitivity. The other option is to personalize the instruction and the feedback because it can improve child's targeted skills (Clabaugh,2020)

Moreover, teachers and therapists are hoping to acquire the knowledge of robot's functionality. This could help them to be prepared for any potential issue that may arise. This finding confirms the importance of providing teachers with training to acquire essential skills before introducing humanoid robots in the intervention (Alcorn et al. 2019; Garnier et al. 2023)

Furthermore, language significantly influences educational results for a person with developmental disabilities (Aguilar et al., 2016). Hence, it is crucial to ensure that the humanoid robot speaks the same language as the students and delivers instruction clearly, concisely, and directly. The robot should also provide prompts to children when they make incorrect gestures during intervention. Research by Miskam et al. (2013) supports the positive impact of two-way communication between the child and the robot in direct social interaction. Lastly, programming the robot with fine motor controllability is vital for its effective use in autism intervention (Sochansky et al., 2021).

To summarize, the design of learning activities for autism intervention must adhere to the following requirements:

1. Focus on improving the child's social and imitation skills
2. Provide personalized learning that addresses the individual needs and basic skills of the students
3. Ensure parental involvement in the intervention program by emphasizing the importance of consistent implementation at home
4. Incorporate interaction with other humans
5. Minimized gadget usage to reduce addiction.
6. Ensure consistency in the intervention
7. Familiarize children with the robot to alleviate anxiety

8. Ensure the robot's programming includes language compatibility, clear instruction delivery, prompt response to a child's actions, and freedom of movement.

Moving forward, the subsequent chapter will delve into the design of learning activities that specifically target the improvement of social and imitation skills using a humanoid robot. These activities will focus on facilitating the development of initiating conversation and peer interaction skills, as well as the mastery of complex sequences. By engaging in these activities, children will have opportunities to refine their ability to accurately imitate complex sequences.

The intervention techniques of the design of learning activities

Applied Behavior Analysis (ABA), is the preferred method chosen by the majority of participants and is widely utilized in autism intervention. Two specific techniques within ABA mentioned by the participant are discrete trial training (DTT) and errorless learning. For this study, the selected intervention technique is discrete trial training (DTT) due to its structured teaching approach. DTT consists of small units of instruction, making it easier for children to comprehend the materials presented by the therapist (Smith, 2001).

DTT has been employed effectively in teaching children with ASD to replicate actions in response to instructions or cues (Bravo & Schwartz, 2022). It has also shown positive outcomes in enhancing children's receptive language skills (Badari, 2020), social and communication skills (Ali & Fazil, nd., 2021, 2022; Liu & Mao, 2022), and play skills (Kasari et al., 2023). Moreover, DTT has demonstrated efficacy in autism intervention involving robots as it improves child engagement (Dicksten-Fischer et al., 2017; Lin et al, 2022) and social behavior (Lin et al, 2022; Louie et al., 2020).

Prompts play a crucial role in DTT techniques by eliciting correct behavior. Four categories of prompts exist: Verbal prompts (verbal instruction to encourage the desired behavior), gestural prompts (physical movement or gestures demonstrated to elicit the desired behavior), model prompts (indication of the intended action by another individual in the suited context, and physical prompts (physical assistance provided to facilitate the desired behavior) (Miltenberger et al., 2022).

To evaluate the impact of the therapy, a direct observation assessment is employed. Miltenberger et al., (2022) mentioned that the direct observation assessment focuses on the essential element such as the target behavior, its frequency, duration, intensity, and latency. To directly examine and assess behavior during the intervention, an event recording is utilized. The purpose is to assess the child's capacity to follow the instruction.

Overall, ABA, particularly the DTT method, has been widely embraced in autism intervention due to its effectiveness in teaching various skills and promoting positive outcomes. The use of prompts within DTT facilitates the acquisition of desired behaviors, allowing for targeted and structured interventions.

The design of the learning activities

Learning activity 1: Collaborative play Copy Me

This activity aims to increase the childs' social skills, particularly in interacting with peers by initiating conversation and commenting the peers through collaborative play. Collaborative play has been widely known as an effective strategy for enhancing social interaction skills in autistic children as noted by Boyd et al., (2015). By involving peers as active participants, collaborative play can transition children from taking passive roles to show active engagement (Penazzio, 2017).

One specific game that promotes interaction among children with their peers is called "Copy Me". This game draws inspiration from the game "Copy Cat" developed by Wainer et al. (2014), which demonstrates a positive effect on social interaction skills, eye gaze, and subtle communication. This game focuses on improving children's social skills by involving multiple participants, including children with ASD and a humanoid robot through the imitation of the movement. According to Ingersoll (2012), the capacity to imitate improves a child's social skills.

In this game, each player, whether it is a child, human instructor, or humanoid robot instructor, takes turns selecting and imitating specific poses displayed on a screen. These activities encourage turn-taking, role-switching, and instructing other players. The presence of a humanoid robot as a social mediator facilitates interactions among children, particularly children with ASD, through group play and supports the development of social skills.

To ensure familiarity and consistency of the movement, the game initially begins with one-on-one sessions between the instructor and the children before progressing to multiplayer sessions. The one-on-one session allows the instructor to personalize the treatment by finding out children's basic skills in the imitation of movement and communication skills.

The duration of this game spans 15 weeks, with two sessions per week. This activity is divided into four phases. The first phase, spanning the initial three weeks (sessions 1-6) is led by a human instructor. In this stage, the humanoid robot is placed in a visible position to familiarize the children with the robot. The second phase which lasts five weeks (sessions 7-16) is facilitated by a humanoid robot in one-on-one sessions. The third phase (sessions 17-24) is a triadic game that lasts four weeks. A humanoid robot in the peer session facilitates this phase by incorporating another autistic peer as the third player. The fourth phase is a generalization process that will be lasting for three weeks (sessions 25-30). This phase depends on the child's progress and will be led by the humanoid robot. Each session has a duration of 35 minutes with a 5-minute break in the middle. To ensure the success of this intervention, the learning activities can be continued at home with parental involvement with a similar procedure.

The structure of the activities is described as follows:

1. Session 1-6: Personal session with a human as an instructor
   During the initial phase of the intervention, the human instructor provides individual instruction to the students regarding the game "Copy Me". In this session, the robot is introduced to evaluate the children's reaction to humanoid robots. The robot is positioned in a visible location, allowing the children to observe, interact, and engage in simple communication with the robot, such as saying hello or waving their hand when approaching the robot during break time in each session. The objective of this session is the improvement in imitation skills.

   Instruments:

   a. Camera to record child's movements
   b. Evaluation sheet
   c. Stopwatch to measure the time needed for the children to follow the prompt

d. Robots (to introduce the children with the presence of the humanoid robot)
e. Tablets that provide a picture of the movement

Expected outcome:

The children can imitate the movement with an accuracy of 80% after completing the session with the human instructor.

Activity:

The game consists of four simple poses and the child must imitate these poses. If the child successfully replicates the instructor's movements, positive verbal feedback is given by the instructor. Conversely, if the child is unable to mimic the movement, the instructor provides prompts to assist them in their imitation effort. Due to the simplicity of the movements, this game is possible to do at home with parents.

The possible movements performed by the human instructor are:

a. Raise up the right-hand
   Gesture representation:
   - raise the right hand until the wrist is taller than the elbow,
   - proceed to lift the right hand and stretch the arm until the elbow is higher than the shoulder.
b. Raise up the left-hand
   Gesture representation:
   - raise the left hand until the wrist is taller than the elbow,
   - proceed to lift the left hand and stretch the arm until the elbow is higher than the shoulder.
c. Reaching the right hand out
   Gesture representation:
   raise the right hand until the wrist and the elbow of the right hand are in line with the shoulder
d. Reaching the left hand out
   Gesture representation:

raise the left hand until the wrist and the elbow of the left hand are in line with the shoulder.

Instruction:

1. Human instructor shows the child a picture on a tablet with a simple action (e.g.: raising up the right hand)
2. The human instructor then performs the action and says “Copy me” while simultaneously showing the child the picture on the tablet.
3. The child is given 5 seconds to copy the action. If the child well imitates the movement, there is positive feedback from the human instructor such as “Great job, you copied me!”
4. If the child fails to copy the movement in 5 seconds, the human instructor prompts the child by repeating the instruction and demonstrating the movement again. The prompt is “Try again. Can you copy me?”
5. If the child fails to copy the movement three times, the human instructor provides tactile cueing by gently directing the child’s hand to follow the instruction.
6. The human instructor continues to present the picture on the tablet with different actions and repeats steps 2-5.
7. At the end of each session, the human instructor records the number of accurate imitations and the number of prompts required.

Observation Assessment and Assessment sheet

In each session of the game Copy Me, an assessment sheet distributed to monitor the child’s performance over time and make any necessary adjustments to the intervention approach. The assessment procedure used in this research is similar with the direct observation assessment by Miltenberger et al. (2022) and customized according to the design of learning activities. The assessment sheets comprise a table with designated columns for the date, session number, the target movement, the columns for recording successful and failed attempts, and the number of prompts given.

During the session, the teachers carefully observe and document the child’s responses by marking tally counts in the corresponding column for successful and unsuccessful attempts. Tally counts is used due to their simplicity and representing the frequency of successful or unsuccessful attempts.

To achieve the success in the game, a child must demonstrate a minimum of eight out of ten consecutive successful attempts across three rounds of play. This criterion ensures a consistent level of performance to be considered as successful. The detailed format of the evaluation sheet provided in Table 5.

Table 5

Assessment Sheet

Date	Session	Name of Movement	Successful attempt	Unsuccessful attempt	Numbers of prompts
	1	Raise up the right hand			
		Raise up the left hand			
		Reaching the right hand out			
		Reaching the left hand out			
	2	Raise up the right hand			
		Raise up the left hand			

		Reaching the right hand out			
		Reaching the left hand out			

2. Session 7-16: One-on-one session with the humanoid robot instructor

   Before engaging in the intervention with the children, some technical preparations are taken to equip the humanoid robot with the essential capabilities. These preparations involve enhancing its perceptual abilities to accurately detect and interpret children's actions in real-time, ensuring a suitable degree of freedom for movement, and enabling speech recognition to provide prompts and instructions based on the children's language. These technical considerations are vital to facilitate effective interaction between the humanoid robot and the children in the intervention process. The main objective of this session is to reinforce the imitation skills.

   Instruments:

   a. Camera to record learning activities
   b. Evaluation sheet
   c. Tablets that provide a picture of the movement

   Expected outcome:

   The children can imitate the movement with an accuracy of 80% after completing the session with the humanoid robot.

   Activity:

   In these sessions, the role of the humanoid robot is equivalent to that of the human instructor. The humanoid robot demonstrates specific poses, and the children imitate the movements performed by the robot. The humanoid robot evaluates and provides suitable feedback and maintains the feedback loop. The humanoid robot employs the same instructional method as the human instructor to ensure clarity and consistency of the instruction.

Instruction:

The instruction provided in these sessions is identical with the session by the human instructor.

Observation assessment and assessment sheet

The observation assessment procedure in child-robot interaction incorporates the activities carried out by the human instructor. A corresponding assessment sheet, following a similar format, is employed to assess the child's performance. The assessment sheet is akin with the assessment during sessions 1-6.

3. Session 17-24: Peer session with a humanoid robot as a player.
   Between sessions 17-24, the introduction of a collaborative play implemented for children diagnosed with ASD. The collaborative games involve a total of three participants, consisting of two children with ASD and a humanoid robot. This controlled group size ensures a manageable and comfortable setting for all individuals involved. The fundamental rules and activities of the game remain consistent with the previous sessions, with peer inclusion as an additional component. The primary objective of this game is to foster peer interaction by initiating conversation (saying "Copy me" to direct other players) and peer commenting (giving a response when the other players fail to follow the movement) during collaborative play.

   Instruments: the required instruments for this session align with those used in the individual robot session.

   Expected outcome:
   a. The children able to imitate the action from another player by at least 80% after completing this phase.
   b. The children able to initiate interaction through the action of directing other players by at least 80% after completing this session.

Activity:

Each player, including the humanoid robot, takes turns selecting a pose presented on a screen and subsequently imitates the chosen pose. The roles of directing and imitating players are alternated between the robot and the children, giving the opportunity for the children to engage in turn-taking, role-switching, and providing instructions to their peers. The sequence of movements is visually displayed on the screen while each player remains within their designated playing area. The determination of the player responsible for directing the next pose follows a clockwise rotation commencing from the robot. Subsequent rounds of play begin as a new set of poses emerging on the screen.

Instruction:

a. The "directing" player sees the pose from the displayed option on the screen
b. The chosen pose should be mimicked by all participants, including the "directing" player themselves
c. The directing player says "Copy me" while simultaneously showing the picture on the tablet.
d. The other participants, including the robot, pay attention to details and mimic the pose as accurately as possible.
e. If the child fails to copy the movement in 5 seconds, the humanoid robot prompts the children by repeating the instruction.
f. If the "directing" child fails to show the movement in 5 seconds, the humanoid robot prompts the children by saying "…. (name of the child), can you do the action and say "copy me"
g. The game continues to present the picture on the tablet with different actions.
h. In the game, the human instructor records the number of accurate imitations and the number of prompts required. The data help observe the child's progress and make any necessary adjustments to the level of prompting.

Observation assessment and assessment sheet:

The observation assessment procedure during the peer session closely resembles those employed in sessions 1-6 to ensure consistency and allows for the systematic assessment of the children's progress and performance.

2. Session 25-30: Collaborative play between the children, their peers, and the human instructor to resemble the real context.
   During this session, the child actively participates in the activity alongside new peers, forming a pair of interaction. This arrangement provides the contingency for the children to apply and adapt the skills they have acquired within diverse social contexts. This session aims to foster generalization of peer interaction among the children.

   Instruments: the required instruments for this session are similar with the robot session.

   Expected outcome:
   a. The children are able to imitate the action from another player by at least 80% after completing this phase
   b. The children are able to initiate interaction through the action of directing other players by at least 80% after completing this session.

   Activity:
   The activity in this session, as well as the instruction and evaluation process remain consistent with those implemented in the preceding sessions held during weeks 17-24. This consistent approach reinforces and generalize the acquired outcomes across various peer interactions.

Learning Activity 2: Imitation of a Complex Sequence

The main objective of this learning activity is to increase child imitation skills, particularly in imitation of a complex sequence. This activity is rooted in the replication of gross motor movements. The selection of the four specific gestural movements is informed by input gathered from participants during the interview process. These chosen gestures also take into consideration the motoric limitations of the humanoid robot, ensuring compatibility with its capabilities.

This activity involves two participants: a child with ASD and an instructor. One-on-one sessions ensure personalization. In each session, the instructor can monitor the child's progress and modify the activity based on the child's needs. The instructor assumes the role of the demonstrator and executes predetermined movements, while the child with ASD is expected to imitate these actions. Before engaging in the imitation of complex sequence activities, the child's ability to replicate simple motoric movements is a prerequisite. No gadget such as an iPad is used in this intervention.

The entire duration of these activities spans 15 weeks, encompassing three sessions per week. During the first phase in the initial five weeks (Sessions 1-9), the human instructor fulfills the role of instructor. To familiarize the children with the robots, the robots will be positioned in the visible area. In the second phase in weeks 6-11 (sessions 10-36), the activity is followed by the humanoid robot as instructor. The third phase in weeks 12-15 (sessions 37-45) is designated for the generalization of the movements under the guidance of the humanoid robot, incorporating variations from the four initially provided gestures. Each session has a duration of 35 minutes, with a 5-minute break in intermissions. The learning activities can be extended at home with parental participation, following a similar procedure.

The structured activities as described:

1. Session 1-9: The human instructor session
   The initial phase of the intervention is led by the human instructor. The robot is introduced in this session to assess the children's reactions to humanoid robots. In this session, the robot is placed in a noticeable position. Moreover, the human instructor encourages the children to interact with the robot by allowing them to see, touch, and engage in simple communication with the humanoid robot. The main goal of this session is to improve the child's imitation skills.

   Instruments:
   1. Camera to record the child's movements
   2. Evaluation sheet
   3. Stopwatch to measure the time for students' responses
   4. Robots (to familiarize the children with the presence of humanoid robots)

   Expected outcome:
   a. The children can imitate the complex sequence by 80% after completing the session with the human instructor

Activity:

During the one-on-one sessions, the human instructor provides instruction to the students to imitate the complex movements. In this phase, the human instructor guides the students through two activities centered around gross motor movements. Subsequently, the instructor proceeds with a two-step instruction, such as directing the students to touch their heads and their noses simultaneously. To familiarize the children with the movement, this activity can be applied at home with parents.

The possible movement performed by the human instructor is:

a. Clap hands and touch eyes with the right-hand

   Gesture representation:

   - raise the right hand and the left hand until the wrist is taller than the elbow
   - simultaneously put the palm of the right and left hand
   - direct the pointer finger of the right hand to touch the right eye

b. Wave with two hands and touch the nose with the right hand

   Gesture representation:

   - raise the right hand and the left hand until the wrist is taller than the elbow
   - simultaneously put the palm of the right and left hand
   - direct the pointer finger of the right hand to touch the right eye

Instruction:

1. Human instructor says "copy me" while simultaneously demonstrating the movement (e.g.: clap hands)
2. The child has 5 seconds to mimic the action. If the child successfully replicates the movement, the instructor gives positive feedback such as "Great job, you copied me!"
3. If the child does not imitate the movement within 5 seconds, the human instructor prompts the child by repeating the instruction and demonstrating the movement again. The prompt is "Try again. Can you copy me?"
4. If the child fails to imitate the movement three times, the human instructor provides a physical prompt to the child by gently directing the child's hand to follow the instruction.
5. The human instructor continues with different actions and repeats steps 1-4.

6. At the end of each session, the human instructor records the number of accurate imitations and the number of prompts required.

Observation assessment and assessment sheet

To monitor the progress of children during the imitation of complex sequences, an assessment sheet is utilized to track both successful and unsuccessful attempts made by the children. The assessment comprehends a table consisting of various columns including the date, session number, specific movement names, columns for documenting successful and failed attempts, and a column for recording the number of prompts given.

During the sessions, the teacher closely observes the children's responses and records them using a tally count system. To be deemed successful, the child must consistently demonstrate a minimum of eight out of ten consecutive successful attempts across three rounds of play. This criterion ensures a sufficient level of proficiency and skill acquisition. The assessment sheet provided in Table 6.

Table 6

Assessment sheet

Date	Session	Name of Movement	Successful attempt	Unsuccessful attempt	Numbers of prompts
	1	Clap the hand and touch the right eye with the right hand			
		Waving and touching the nose with the right hand			

	2	Clap the hand and touch the right eye with the right hand			
		Waving and touching the nose with the right hand			

Before these sessions, specific technical preparations are taken to equip the humanoid robot with the imperative capabilities. The preparations involve the perceptual abilities for accurate real-time detection and interpretation of the children's actions. Additionally, ensuring the humanoid robot has sufficient freedom of movement and enables speech recognition to offer prompts and instruction based on the children's language. These sessions aim to improve child imitation skills in a complex sequence.

Instruments:

a. Camera to record child's movements
b. Evaluation sheet

Expected outcome:

The children can imitate the gross motor action in a complex sequence by 80% after completing the sessions with the humanoid robot.

Activity:

The humanoid robot, in a manner identical to the human instructor, performs the expected movements and subsequently requests the children to imitate those movements. Following their imitation, the humanoid robot evaluates the children's performance and provides relevant feedback, thus establishing a closed-loop interaction. The humanoid robot employs the same prompts and sequence of instruction as in the sessions 1-9 to maintain consistency and predictability.

Instruction:
The humanoid robot utilizes the same prompts and sequences of instructions as those employed during the session 1-9 to ensure consistency and predictability.

Observation assessment and the assessment sheets
The observation and the assessment sheet utilized closely resemble the observation process employed during sessions 1-9.

2. Session 37-45: The humanoid robot session with various possible movements.
During this session, the children are expected to acquire the ability to adjust and accommodate themselves to various patterns of movement distinct from those encountered in sessions 1-36. This session aims to improve the generalization of imitation skills in a complex sequence.

Instruments:
a. Camera to record child's movements
b. Evaluation sheet
c. Stopwatch to measure the time for students' response

Expected outcome:
The children can imitate the gross motor action in a complex sequence by 80% after completing the generalization phase.

Activity:
In this session, the instructional approach remains consistent with that employed during sessions 1-9. However, the sequence of movements is diversified to facilitate a comprehensive understanding and imitation of all movements.

Instruction:
During this session, the instructional content maintains the consistency with the material presented in sessions 1-9. Nevertheless, there is an enhancement in the sequence of

movements introduced to the children. This modification aims to provide them with a more varied and challenging set of movements to learn and imitate, thereby, promoting further skill development.

Observation assessment and assessment sheet

The observation process in this phase follows a structure identical to sessions 1-9 utilizing a table format to track and assess the children's progress. However, there are variations in the activities included within the assessment sheet. This modification aims to provide a fresh and diverse set of tasks for evaluating the children's performance and skill acquisition, enhancing the comprehensiveness of the observation process. The assessment sheet is provided in Table 7.

Table 7

Assessment sheet

Date	Session	Outcome	Successful attempt	Unsuccessful attempt	Numbers of prompts
	1	Clap hand and touch the nose with the right hand			
		Clap hand and touch the nose with the left hand			
		Waving and touch the eyes			

		with the right hand			
		Waving and touch the eyes with the left hand			
	2	Clap hand and touch the nose with the right hand			
		Clap hand and touch the nose with the left hand			
		Waving and touch the eyes with the right hand			
		Waving and touch the eyes with the left hand			

Field Experts Opinion

The final step of this research was a field expert opinion by four special education teachers as the field expert. These field experts worked in autism centers in Indonesia and had a minimum of 13 years' experience in autism therapy. They were able to read the information and the questions in English, and two respondents provided the written feedback in English.

These field experts had to filled the online evaluation form that was conveyed in the form of a questionnaire through Google form. The evaluation form focused on the effectiveness of the overall content such as the duration, tools, expected outcome, activity, instruction, observation assessment, and a short essay where the field experts can share their feedback about the improvement that can be made from the design (see Appendix C). The questionnaire used the combination of a Likert scale with five points ranging from totally disagree to totally agree, and all the questions were written in English. Questions in the survey that aimed to rate the effectiveness of the design were inspired by the evaluation provided by Hamzah et al. (2013).

Results from the evaluation form

Overall, according to the questionnaire findings from the game Copy Me and Imitation of the Complex Sequence, respondents agreed that the duration of the activities, the instruments used (such as camera, evaluation sheet, and stopwatch), the expected outcome, and the activity given were adequate for the intervention. Additionally, two out of three respondents totally agree that instruction and interaction in the Imitation of the Complex Sequence are appropriate for the intervention.

Nonetheless, all respondents agreed that the assessment sheet could be enhanced by including information on the child's reaction if they could accomplish the activity, whether they needed more prompts to accomplish the activity, and whether the activity was unsuccessful. The assessment should also show how many times the children require the prompt, how many successful attempts from each session, and which instruction the children were able to follow independently. Furthermore, one of the responders stated that a 5-second response is too long for autistic children.

Meanwhile, one respondent added a comment about the design of the game Copy Me. She stated that the children benefited from the gradual level of difficulty, which progressed from imitation skill to triadic game, because imitation skill were a foundation for the improvement of social skills.

Discussion

The main finding from this study will be discussed in this chapter based on the research questions that were formed at the initial chapter.

The most difficult social and imitation skills and possible interventions with a humanoid robot.

The initial phase of this study was completed through a survey and an interview, both administered among teachers and therapists. These steps were initiated to determine the most challenging skills in the domain of social and imitation skills. The results revealed that initiating conversation, interacting with peers, and commenting to peers emerged as the difficult social skills. Additionally, the imitation of the complex sequence emerged as a challenging skill in the scope of imitation skills. This finding is unsurprising, as Maurice (1996) had previously classified these skills at an advanced level.

This result can be interpreted by acknowledging the distinction between typical development children and children diagnosed with autism. Social interaction within the typical development children initiates from an early year, often manifested through gestures such as shared attention, shared social smiles, and the imitation of movements. These competencies were reduced during the second year of life for autistic children (Vivanti et al., 2020), thereby affecting their capacity to engage with others. As the child grows, peer interaction demands interdependence, reciprocity, and mutual enjoyment (Nind and Powell, 2012), which is an impairment for children with autism. Supekar (2013) explained that these impairments are rooted in an occurrence of brain dysfunctionality, thus contributing to social dysfunction. Furthermore, Pino (2020) suggested that the challenges in processing social information added with the slow development of this competence, collectively contributing to the difficulties encountered in peer interaction and forming adequate behavior responses.

Despite the benefits reported in prior studies on robotic intervention, participants emphasized the child's acceptance of the robot is a necessary. The unpredictable reaction exhibited by the children towards robots is rooted in the diverse array of human emotions displayed by autistic children. The emotional linkage between the instructor, and the children plays a crucial role in the context of autism intervention and the humanoid robot could be perceived as inadequate to this level of emotion (Diep et al., 2015; Sochansky, 2021). Thus, a safe interaction scenario for autism intervention emerged to prevent undesirable outcomes. This safe interaction was obtained by incorporating a human instructor together with the humanoid robot in the learning rather than replacing the role of the human therapist (Alcorn et al., 2019; Coeckelbergh et al, 2016)

Lastly, to address the potential intervention involving the humanoid robot, participants identified thirteen distinct activities encompassing social and imitation skills (see Table 3). The activities mentioned before, demand robot's flexible movements (degrees of freedom), verbal responsiveness (encompassing prompting, responses, and instructions), and mobility. Puglisi (2022) listed five frequently employed humanoid robots within the domain of autism intervention namely NAO, Q Robot, Kaspar, Face, and Zeno. Each robot exhibited distinct attributes and advantages. Nevertheless, finding a humanoid robot that fully aligns with all those requirements remains a challenge. Consequently, the conception of possible learning activities was approached in a simple manner, a combination of the inputs provided by the teachers and therapist, while remaining in conformity with learning objectives and robotic specifications. Among the learning activities, the game Copy Me and the Imitation of the Complex Sequence emerged as fitted candidates that cater to the specified criteria. More detailed information on the design of the learning activities will be discussed further in research question 3.

Perspective on the use of humanoid robot

The adoption of technology, including the integration of the humanoid robots, has emerged as a common practice in autism intervention. However, in this current study, it was found that only one out of the total fourteen participants had prior experience with the humanoid robot in the conventional educational context. The remaining participants had merely been acquainted with the robot through the video presented during the interview phase. Consequently, when the humanoid robot was deployed as part of the autism intervention, it evoked various responses from the participants. Six out of the fourteen participants sustained the integration of the robot in autism intervention while the remainder participants expressed their hesitation regarding its utility.

Participants highlighted the advantages of robots pivoting upon their ability to alleviate anxiety and facilitate repetitive learning. Rasouli et al. (2022) indicated that children with autism often experience social anxiety, particularly in social interactions. The robot provides non-judgmental feedback which is a feature that can help to reduce child's anxiety level. Additionally, participants emphasized that the robot provides repetitive learning which proves beneficial for autistic children. Repetitive learning helps these children anticipate and comprehend subsequent learning processes. This consistent and predictable approach has been recognized as an effective strategy for enhancing the engagement of children with autism (Giannopulu et al., 2014; Schadenberg, 2019).

However, this current research identifies three specific obstacles to the integration of humanoid robots in schools or therapy centers. The first challenge is the inadequacy of robot technology. Participants expressed a reduced level of confidence and, in some cases, a sense of rejection when asked to envision the use of humanoid robots in autism intervention. This feeling of unfamiliarity can potentially hinder the successful implementation of humanoid robots in autism interventions. This outcome is not surprising, as educators who have little to no prior experience with robots in their daily lives would require training to effectively utilize humanoid robots. Huijnen et al. (2017) emphasized the significance of teachers having knowledge and experience in using humanoid robots, as they are the end-users of this intervention. Furthermore, comprehensive training on the proper utilization of humanoid robots can enhance their confidence and proficiency in working with this technology (Huijnen et al., 2017; Schina, 2021) and proper integration in therapy (Alghamdi et al., 2023). Two key areas of knowledge recommended for educators to master are acquiring a deep understanding of robot intervention (Alghamdi et al., 2023) and the ability to design a curriculum that seamlessly incorporates the use of this technology (Silvera-Tawil et al., 2022). By integrating the humanoid robot into the curriculum, educators can optimize its potential as an educational tool and enhance the learning experience for students.

Second, participants foster a critical perspective regarding the technological development of the humanoid robot. The humanoid robots were regarded as unsophisticated in comparison to the human attributes, thus failing to capture the depth of human emotions and expressions. This finding confirms the findings of Diep et al. (2015) who observed that teachers experienced a deficiency in robot programming and emotional readiness. Similarly, Alcorn et al. (2019) reported that robots exhibited a low capability to engage in complex conversation that requires nuanced comprehension of emotions. Recent research further supports this assertion. Spezialetti et al. (2020) noted that also the latest advancements in humanoid robot technology still struggle to fully comprehend the depth of human emotion. From a technical standpoint, there are significant challenges in the development of programs associated with emotional recognition.

According to Mohammed and Hasan (2020), the development of a robotic system with the capability of emotional recognition necessitates the incorporation of pattern recognition, machine learning, and artificial intelligence techniques. Additionally, their research highlights the challenge of developing a system of speech-based emotion recognition that can discern emotion over various languages and in cases of mixed language. Consequently, considering the limitations of the recent technology utilized by the humanoid robots, it is important to view these robots as supplementary tools for autism intervention (Huijnen et al., 2019).

Lastly, the financial burden associated with the ownership and maintenance of the humanoid robot particularly for autism therapy within low socioeconomic areas might be a problem. Participants expressed that the expenses associated with providing humanoid robots are higher compared to other technologies. This cost is further combined with the maintenance expenses. This viewpoint aligns with the findings of Alabdulkareem et al. (2022) and Silvera-Tawil et al. (2022) who noted that advanced technology administered by the humanoid robots and the ongoing maintenance are regarded as costly factors. Additionally, the concern arises that the financial burden of maintaining the robot may impact the budget allocated for other resources. Consequently, this financial obstruction was considered as contributing factors to the absence of robots in schools (Singh et al., 2023).

Design of the learning activity

To accommodate the eight requirements identified by the participants, two design activities are selected. These activities are specifically aimed at enhancing the child's social and imitation skills through imitation of movements. The personalized learning approach is implemented by facilitating one-on-one activities to ensure mastery of the targeted skills. In the game, gadget usage is limited by providing static pictures to prevent addiction. The humanoid robot is strategically positioned in a visible location to familiarize the children with its presence. Consistency is maintained through the activities, with identical instructions, tasks, and evaluations being provided. The learning activities involve therapists/teachers in the initial phase as human instructors and later as collaborators in subsequent phases. The participants consider the involvement of a human in the intervention as a crucial requirement due to concerns about the potential emotional attachment of the child to the robot and the subsequent adoption of robotic behavior. Tanevska et al. (2016) stated that the emotional attachment to the robot can have detrimental effects on their health and potentially undermine the progress achieved by the children.

Further discussion is required regarding the requirement of parental involvement in autism intervention. It has been observed that children who receive support from their parents tend to acquire skills at a faster rate compared to those who do not.

More about parental involvement, it is crucial to examine the dynamics within the families of children with autism. Families of children with autism experience challenges as their children require a different kind of support compared to typically developing children (Alberta Learning, 2003). This situation can often lead to increased stress and anxiety within the family members. According to Wolf et al. (1989, as cited in Sato et al., 2022), parents of children with ASD experience higher levels of stress compared to parents of children with other disabilities. The sources of stress are multifaceted, ranging from the child's specific characteristics such as language difficulties, social deficits, and challenging behaviors, to the financial burden associated with accessing special education services and experiencing productivity loss, and lastly related to child intervention which is associated with the multiple effort to get sufficient intervention (Sato et al., 2022).

From this perspective, it is important to provide proper support for parents to effectively handle children with autism. This support can be in the form of training or coaching before their involvement in school programs. According to Siller et al. (2018), parents who participate in coaching programs enhance their ability for self-reflection and self-evaluation. Consequently, they become better equipped to adapt to and implement intervention strategies. Within this point of view, parents also need proper support to handle children with autism through training or coaching before involving them in the school program. Siller et al. (2018) experiment result mentioned that parents who join the coaching increase their capacity for reflection and self-evaluation. Consequently, they become better equipped to adapt and implement intervention strategies. Syriopoulou-Deli and Poluchronopoulou (2017) proposed two ideas for establishing collaboration with parents in school activities. Firstly, it is crucial to consider the complexity of parents' needs. Secondly, continuous training and technical assistance should be provided to enhance parental collaboration and support.

Further is the design activity. The first activity is the game Copy Me which is inspired by the game "Copy Cat". This game served as a collaborative game, employed to enhance peer interaction and foster the initiation of conversation among peers through the imitation of the movement. The game is designed to progress through gradual levels, starting with a simple movement of imitation before advancing to more challenging states. One respondent specifically noted that the gradual level of complexity from imitation of the movement to peer interaction is an essential procedure to support the improvement of children's skills. This perspective aligns with the findings from Dawson and Adams (1984) who assert that mastering imitation skills plays a fundamental role in the acquisition of social ability. Through the process of imitation, children not only acquire the ability to replicate action but also cultivate their capacity to direct their focus toward the instructor, thereby constituting a facet of non-verbal interaction. According to the field expert, each component in this game such as the duration, the instruments, the expected outcome, the activity, and the instruction and interaction has been considered sufficient for teaching children with ASD.

The subsequent activity, The Imitation of the Complex Sequence mandates the child to first be proficient in the imitation of a single movement before gradually advancing to the complex movements. Similar with the game Copy Me, all components in the second activity were considered sufficient for the learning activity.

Field Experts Opinion

Two relevant inputs referred to the two activities were given by the field expert. Firstly, the assessment sheet has been examined for its simplicity, lacking in providing comprehensive insights into the child's progression. Guided by the input from the respondent, the assessment sheet must comprehensively indicate each child's response, indicating whether the execution is accomplished successfully (S), assisted by prompting (P), or even when there is no response (NR) in every instruction. Furthermore, it must depict the specific attempt during which the child performed the activity independently. The assessment sheet should also encompass the child's milestones, which are made when the child achieved an 80% success rate for the first time.

Secondly, the respondent mentioned that the 5-second pause of the prompts is considered lengthy. Time plays a crucial role in autism intervention. A delayed prompt or feedback could hinder the progression of the learning. While the human instructor was capable to provide prompt and feedback on-time, the humanoid robot as noted by Sochansky (2021), exhibits delayed feedback.

Limitations

This study is not without limitations. First, the untested design of the learning activities is due to the challenge of finding suitable participants within the Netherlands. Thus, evaluating the efficacy of the learning activities becomes challenging.

Subsequently, the small sample of participants in this study also stems from the difficulties encountered in participant recruitment. The primary objectives of this research derived from the perspectives of educators from diverse countries, with a specific focus on their perceptions regarding the integration of a humanoid robot for autism intervention. The limited sample of participants from each country underscores the challenge of ensuring objectivity within their nation.

Future Work

Potential follow-up work on this thesis is to carry out a clinical trial to assess whether the learning activities that have been made can improve children's social and imitation skills. Children who will participate in this study must fulfill certain requirements such as:

1. Obtaining a diagnosis judgment based on the DSM-V criteria from a qualified psychologist
2. Possessing an IQ score above 70
3. Demonstrating verbal communication skills to minimize disruptive behavior.
4. Not having any physical impairment

These specific criteria should be implemented to ensure an adequate level of cognitive ability and communication skills, enabling the participants to comprehend and actively engage with the instructional materials provided.

Meanwhile, the activities designed in this thesis are not specified for a certain humanoid robot. Therefore, the selection of the humanoid robot during the intervention must be determined carefully. To achieve the goal of the learning activity, the humanoid robot must possess these abilities:

1. Perceptual ability: The humanoid robots must possess the capability to accurately perceive and interpret children's intended actions in real-time. To achieve this, equipping the robot with a camera system that can track the child's body movement and provide relevant prompts is essential. This feature serves as an evaluation tool to assess the child's comprehension of the instructions provided by the robots.
2. Degrees of freedom: The humanoid robot should possess appropriate degrees of freedom in its movements, encompassing the head, hands, and legs. This range of motions allows the robot to effectively demonstrate various poses and movements to facilitate the learning and imitation process for children.
3. Speech recognition: Incorporating speech recognition capabilities into the humanoid robot is crucial. This enables the robot to understand and respond to spoken commands and questions, fostering interactive communication with the child.
4. Programming and customization: The humanoid robot should provide a platform for programming and customization. This feature empowers users to develop application behaviors, language, and sequences using a programming language, thereby tailoring the robot functionalities to suit specific educational objectives.

Conclusion

The exploration of teachers' and therapists' perspectives regarding the utilization of humanoid robots offers valuable insight for the formulation of learning activities. This study constituted an addition to the existing literature, given the rareness of prior research that inquired into activity design in autism intervention using humanoid robots from an educational standpoint. Additional research is important to analyze the efficacy of this design approach. Lastly, the result of this study provides a new perspective through the perceptions of educators across different nations about the role of humanoid robots in autism intervention.

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Appendix A

Survey for Teachers

Name:

How long have you been teaching children with ASD

What age level that you teach

Imitation Skills

Imitation Skills-Please select the difficulty level of teaching these following skills according to you. 1-very easy, 2 easy, 3 neither easy nor difficult, 4 difficult, 5 very difficult

Skills	1	2	3	4	5
Imitates gross motor movement					
Imitates actions with objects					
Imitates fine motor movement					
Imitates oral motor movements					
Imitates gross motor movements from a standing position					
Imitates sequenced gross motor movements					
Imitates action with objects					
Imitates actions paired with sound					
Imitates block patterns					
Copies simple drawing					
Imitates complex sequences					
Imitates peer play					
Imitates verbal responses of peers					

Social Skills

Social Skills-Please select the difficulty level of teaching these following skills according to you. 1-very easy, 2 easy, 3 neither easy nor difficult, 4 difficult, 5 very difficult

Skills	1	2	3	4	5
Imitates action of peers					
Follow direction from a peer					
Response to peer play-initiation statements					
Play board game with peer					
Initiates play statements to peer					
Reciprocates information to peer					
Comments to peer during play					
Asks peer for assistance					
Offers assistance to peer					

Appendix B

Interview Questions

1. How many years have you been teaching children with autism?
2. Which age group do you teach?
3. Can you tell me about the strategies you use to teach social and imitation skills in your setting?

   a. Could you tell me some examples of social and imitation skills on which you usually focus for your pupils, which are difficult to teach?
   b. Could you tell me some examples of specific activities you use for teaching social and imitation skills?
   c. How difficult or easy is it to teach social and imitation skills with the current tools/methods? Are there specific skills that are easier or harder to teach? Are there specific parts of the skill that are difficult to teach, such as generalization to different contexts?

d. More specifically, what kind of practices, games, technologies do you use to teach your pupils social and imitation skills?

4. What kind of tools or props do you use? Do you use any sort of technology (e.g., iPad/tablet, sensory floors etc.)? What are the advantages and disadvantages of using such tools and how do the children react to them?

   a. Do you think you could teach social and imitation skills to children in a better way if you had some tools or piece of technology available for you? If so, how?
   b. Do you use any types of technology as part of the specific programmes?

Show pictures and a video of the robot which shows the abilities (talk, dance, walk, etc.) of the robot (not a video from teaching children with autism)

Now, let's suppose that one of the tools that you can use is a human-like robot – a robot that has human-like features, such as arms, hands, legs, a head and is able to be programmed to talk.

5. How do you feel about the use of robots in schools for children with autism?

a. Can you mention ways in which a human-like robot could be integrated to activities for children's learning? In the context of these activities, what kind of goals could you address with the use of a human-like robot?
b. In what ways do you think a human-like robot could be used to help the children with autism?
c. Might a human-like robot be useful for helping with children's learning on social and imitation skills?
d. How do you think your pupils would respond to a human-like robot? Would you need to make any adjustments to ensure that children could access the robots in teaching
e. Do you have any concerns about the use of robots?

6. What kinds of activities (using humanoid robots) would you suggest to teach these skills?

Appendix C

Questionnaire for the Design of Learning Activity

Design Learning Activity 1: Game Copy Me

Please select the appropriate option for the following questions according to your opinion:

1-totally disagree, 2 agree, 3 neither disagree nor agree, 4 agree, 5 totally agree

1. Duration: Evaluate the time allocation in autism intervention

   - Does each phase provide enough sessions?

   - Does each session provide enough time slots?

2. Instrument: Evaluate the suitability of tools in autism intervention

   - Are the instruments used (camera, evaluation sheet, stopwatch, and tablets) suitable for the intervention?

3. Expected outcome: Evaluate whether the expected outcome aligns with the main target which is to improve social and imitation skills.

   - Does the expected outcome phase 1(sessions 1-6) fit with the main purpose?

   - Does the expected outcome in phase 2 (sessions 7-16) fit with the main purpose?

   - Does the expected outcome in phase 3 (sessions 17-24) fit with the main purpose?

   - Does the expected outcome in phase 4 (sessions 25-30) fit with the main purpose?

4. Activity: Evaluate whether the learning activity effectively improves the child’s social and imitation skills.

   - Does the difficulty level gradually increase in each session?

   - Is the assistance (prompting) given by the instructor suitable for the intervention?

5. Instruction and Interaction: Evaluate whether the given instruction and interaction suitable for the intervention - Is the interaction scenario suitable for the intervention?

- Does the instruction use appropriate language for children with autism?

6. Observation assessment: Evaluate whether the assessment sheet is suitable to be used as a tool to measure the effect of the intervention.

- Is the assessment sheet suitable to measure the effect of the intervention?

7. What kind of improvement can be made for this design?

Design Learning Activity 2: Imitation of the Complex Sequence

Please select the appropriate option for the following questions according to your opinion:

1-totally disagree, 2 agree, 3 neither disagree nor agree, 4 agree, 5 totally agree

1. Duration: Evaluate the time allocation in autism intervention

 - Does each phase provide enough sessions?

 - Does each session provide enough time slots?

2. Instrument: Evaluate the suitability of tools in autism intervention

 - Are the instruments used (camera, evaluation sheet, and stopwatch) suitable for the intervention?

3. Expected outcome: Evaluate whether the expected outcome aligns with the main target which is to improve social and imitation skills.

 - Does the expected outcome phase 1(sessions 1-9) fit with the main purpose?

 - Does the expected outcome in phase 2 (sessions 10-36) fit with the main purpose?

 - Does the expected outcome in phase 3 (sessions 37-45) fit with the main purpose?

4. Activity: Evaluate whether the learning activity effectively improves the child's social and imitation skills.

 - Does the difficulty level gradually increase in each session?

 - Is the assistance (prompting) given by the instructor suitable for the intervention?

5. Instruction and Interaction: Evaluate whether the given instruction and interaction suitable for the intervention - Is the interaction scenario suitable for the intervention?

 - Does the instruction use appropriate language for children with autism?

6. Observation assessment: Evaluate whether the assessment sheet is suitable to be used as a tool to measure the effect of the intervention.

- Is the assessment sheet suitable to measure the effect of the intervention?

7. What kind of improvement can be made for this design?