



Enhancing the Engagement of Children with Autism Spectrum Disorder through Group-Based Interventions Utilizing the Social Robot NAO: A Synthetic Conceptual Analysis

Professional paper

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Abstract

The rapid development of Generative Artificial Intelligence (G-AI) and specifically Social Assistive Robotics (SARs) introduces innovative approaches in the field of education and especially in special education. This study is a synthetic conceptual analysis and examines key concepts around enhancing the engagement of children with Autism Spectrum Disorder (ASD) in activities, focusing on group interventions utilizing the NAO robot by the teacher in the context of the classroom. The aim of this analysis is to clarify the definition and dimensions of engagement of children with ASD and to analyze the advantages of group interventions using the NAO as a teacher's assistant. The results obtained highlight the associations between the characteristics of the NAO, the dimensions of engagement of children with ASD and the group intervention context. In addition, practical and theoretical implications are discussed, suggesting directions for future research in social robotics and its utilization in special education.

Keywords: *autism spectrum disorder, engagement, group interventions, NAO robot, synthetic conceptual analysis*

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by serious deficits in social skills, communication, and creative imagination (Stolte et al., 2022). In particular, children with ASD, depending on their difficulties, find it difficult to talk, have no company, are isolated, and have difficulty generating imaginative and innovative ideas (Parsons

et al., 2019). The concept of engaging children with or without educational needs in activities implemented in the classroom is a key skill for developing new skills and acquiring functional independence (Onwumere et al., 2020). More specifically, engagement is a complex concept as it contains different dimensions that make it up (Wong & Liem, 2022).

However, engagement in children with ASD is a complex process, as they experience difficulties in maintaining attention and responding to social stimuli (McLaughlin et al., 2021).

To overcome these challenges, group interventions have emerged as an important therapeutic framework for children with ASD (Alahmari et al., 2025). Group dynamics is crucial, as the interaction between group members significantly influences the behavior of children with ASD towards their peers and other people they interact with on a daily basis (Gaitas et al., 2024). More specifically, group interventions create a structured environment where children with ASD have the opportunity to practice academic and social skills, observe the behavior of their peers and receive appropriate guidance from the teacher (Dean & Chang, 2021). However, even in this type of intervention, the active engagement of children with ASD is difficult due to the specific type of needs they have (Deb et al., 2020).

The rapid development of technology and Generative Artificial Intelligence (G-AI) contributes to overcoming the difficulties of engaging children with ASD in classroom activities (Khan et al., 2022). In particular, Social Assistive Robots (SARs) have been used widely in both in general education and special education, due to ability to attract the interest and maintain the attention of children with special educational needs and especially children with ASD (Robinson & Nejat, 2022). Among SARs, NAO has been widely used in the interventions with children with ASD is the social robot NAO because of its anthropomorphic appearance, its diversity of expression, and its ease of programming (Vagnetti et al., 2024).

This study is a synthetic conceptual analysis of the concepts of engagement, group interventions and the social robot NAO. A synthetic conceptual analysis aims to clarify and unify multiple related concepts by examining the relationships between them and how they contribute to a broader understanding of the topic under study, which differs from other methods of conceptual analysis that are restricted to deconstructing individual concepts without aiming to create a coherent total (Jaakkola, 2020). This conceptual analysis takes a synthetic approach, which involves the systematic

examination, delineation and interconnection of three concepts: engagement, group interventions and the NAO social robot. Its main aim is to create an integrated and coherent framework of understanding, recognizing the interdependencies between these concepts, rather than a simple reporting of separate definitions. Furthermore, there is no other synthetic conceptual analysis that considers the correlation between the three concepts. Thus, this research fills this literature gap. The research questions (RQ) we asked are following:

RQ1. How can the engagement of children with ASD in educational interventions be conceptually defined and functionally measured?

RQ2. Do group interventions provide a distinct pedagogical framework for enhancing the engagement of children with ASD?

RQ3. What characteristics and roles of the NAO robot support engagement in group interventions and through which mechanisms?

Conceptual Analysis

The concept of Engagement in ASD

Engagement is a multidimensional condition and essential for both the development and learning of children, especially children with ASD (Kärnä et al., 2018). More specifically, engagement refers to the extent and quality of a child's interaction with people, objects and activities in the environment in a way that indicates attention, interest and intention to participate in both social and academic activities (Martins et al., 2022). Increased engagement is associated with enhanced social skills and better adaptation of children with ASD to everyday life (Kasari et al., 2021). Furthermore, low engagement results in isolation for children with ASD, as they do not participate in social activities that are implemented in the classroom (Dean et al., 2023). The engagement of children with ASD is not just about their physical presence in activities but includes specific dimensions: behavioral engagement, cognitive engagement and emotional engagement (Wang et al., 2019).

The behavioral dimension of engagement refers to children's actions that are observable such as eye contact, joint attention, imitation, motor engagement and

sharing of objects in participating activities (Caporaso et al., 2022). In addition, cognitive engagement refers to problem solving, understanding instructions and the ability to maintain attention in a participating activity. For children with ASD in particular, this dimension of engagement is affected by deficits in executive functioning (Macoun et al., 2021). Lastly, emotional engagement refers to the expression of curiosity, joy, interest and responsiveness to the feelings of others. More specifically, a positive emotional state is often a prerequisite for social interaction (Vracheva et al., 2020).

The Theoretical Background and Advantages of Group Interventions for Children With Asd

Group interventions for children with ASD are a model that utilizes the group dynamic to achieve objectives set by teachers (Yuan & Wang, 2024). A group intervention for children with ASD involves a small number of children (usually 3-6 children) participating in a series of structured activities under the guidance of the teacher (Drüsedau et al., 2023). Group interventions are based on specific learning and social theories. First, Bandura's social learning theory mentions that children learn by observing and imitating the behavior of their peers. In a group, multiple models of behavior are provided to children with ASD. In addition, Vygotsky's Zone of Proximal Development (ZPD) theory states that learning is achieved to a greater extent when the child collaborates with peers in activities that are above their developmental level, a context provided by group interventions (Ahmed Abdel-Al Ibrahim et al., 2023).

The benefits of group interventions for children with ASD are as follows: Initially, opportunities for social interaction are provided, as it creates an environment where children with ASD can enhance their social skills in real social situations (Ke et al., 2020). Furthermore, through the group, the generalization of skills is enhanced, as the competences that children with ASD are required to learn in the group setting are more likely to be generalized to other physical environments (Erhard et al., 2024). Lastly, the group dynamic provides a sense of community and at the same time reduces their isolation, as they interact with the other members of the group (Hassanli et al., 2020).

However, despite the advantages, group interventions require the correct management of the different needs and behaviors of the group participants (Morrison-Smith & Ruiz, 2020).

The Contribution of the Nao Social Robot in Enhancing Engagement

The NAO robot is SARs that is characterized by its small size, its 'rounded' features, its expressive capabilities, its 25 degrees of freedom, the 20 languages it speaks and its low cost (Robaczewski et al., 2021). The general characteristics of the NAO that enhance the engagement of children with ASD in interventions are the following: First, the NAO has human characteristics (e.g., arms, legs, head, etc.), so while it is familiar to children with ASD, it does not create anxiety, as is often the case with social cues derived from humans (Lin et al., 2025). In addition, the NAO gives the teacher the opportunity to program it to perform the same actions and repeat the same words or expressions repeatedly and accurately (Podpečan, 2023). This predictability is very important for students with ASD, who benefit from routine and repetitiveness (Maharjan et al., 2023). Furthermore, there is the ability to program the expressions, gestures and voice of the NAO to be clear and simple, making it easier for children with ASD to understand than more complex human expressions, gestures and voices (Schiavo et al., 2024).

NAO can have three roles to enhance engagement: First, it can enhance the initial interaction between children with ASD in the group and the robot, as the children's attention is focused on the NAO, creating a common point of interest (Lorenzo & Lorenzo-Lledó, 2024). In addition, it can be used as an educational tool to teach social skills through structured group role-playing and imitation games and group music and dance activities (Papakostas et al., 2021). Finally, the external characteristics of the NAO (small size, LED-lit eyes, etc.) increase children's desire to participate in group activities (Fragakis et al., 2025).

The NAO in Group Interventions to Strengthen the Engagement of Children with ASD: *Convergence of Concepts*

The contribution of the NAO social robot as an intervention tool for students

with ASD is particularly demonstrated when used in group interventions, significantly enhancing children’s engagement (Al-Nafjan et al., 2023). There are studies that have been implemented that highlight the enhancement of engagement of children with ASD in group activities (Chung et al., 2024; Marino et al., 2020; Mutawa et al., 2023; Qidwai et al., 2020). More specifically, the NAO social robot is not only an educational tool. It acts as a “catalyst” for engagement, making group interventions more effective (Schiavo et al., 2024). The correlation between these three concepts-elements (engagement - group interventions - social robot NAO) creates a synergy, which would not happen if each element operated in isolation.

The relationship between these three concepts is bi-directional, which means that there is interaction and constant influence between them (see [Figure 1](#)). First of all, the NAO is attractive, due to its external features, to all children with ASD in the group and is the focus of attention, creating

positive emotions in the children and thus enhancing the engagement of all children in the group in the activities proposed by the teacher with the help of the NAO (Syriopoulou-Delli & Gkiolnta, 2020). In addition, the NAO, initially, can be used by the teacher for individual interaction with the child with ASD and then this interaction can be extended to the other children in the group, enhancing the children’s engagement as the robot provides stimuli for social interaction (Saleh et al., 2020). Finally, the NAO can be programmed by the teacher to show behaviors and expressions that children with ASD are able to imitate, enhancing children’s engagement, particularly in the context of group activities (board games, imitation games, etc.) where children have to cooperate (Zhao et al., 2024). The present convergence highlights the capabilities of the NAO social robot in group interventions to enhance the engagement of children with ASD in classroom-based activities. A concept diagram is presented below.

Figure 1.

Conceptual relationship among the NAO social robot, group interventions, and engagement



Discussion

This study examined how the engagement of children with ASD can be conceptualized in a meaningful way, whether group interventions provide a pedagogical advantage for enhancing engagement, and how the NAO social robot can function in these contexts. The resulting synthesis promotes a coherent approach that treats engagement, group work, and social robotics as interrelated elements of a broader educational framework rather than separate interventions.

The findings provided integrated answers to the three research questions, offering a multidimensional conceptualization of engagement, a clearer pedagogical rationale for group interventions, and evidence of NAO’s mediating role. Initially, regarding how engagement in ASD interventions should be understood and evaluated, the analysis shows that the concept is inevitably multidimensional.

Behavioral, cognitive and emotional engagement together reflect the quality of a child with ASD’s engagement, while single-dimensional indicators risk underestimating meaningful change. Identifying these dimensions enhances conceptual accuracy and supports a more consistent evaluation of pedagogical practices, providing educators and researchers with essential knowledge for designing and improving educational options.

Secondly, with regard to the discussion on group interventions, their unique potential is highlighted when they are explicitly based on guided participation and structured collaboration. Under these conditions, groups of children can create opportunities for shared attention, imitation, and feedback, which are particularly important for students with ASD who experience communication difficulties. At the same time, the analysis showed that the effectiveness of group interventions depends on careful organization, such as clarity of tasks, pace, and role switching, in order

to keep each student in a feasible zone of engagement, a fact that is confirmed by the literature (Morrison-Smith & Ruiz, 2020).

Thirdly, the NAO social robot appears to function as a mediator. More specifically, NAO's ability to attract and maintain the attention of children with ASD, the provision of predictable but repetitive stimuli, and the rendering of social cues in simple but easily recognizable forms seem to help create social reference points around children, enabling them to coordinate their actions with their peers. In group activities, NAO reinforces processes related to engagement, orientation, response, and imitation, thus linking the behavioral, cognitive, and emotional aspects of engagement (Robaczewski et al., 2021). The value of NAO, from this perspective, is catalytic: it helps educators organize and maintain interactions designed to elicit group work.

Furthermore, a brief empirical review reinforces this synthetic approach. A large number of studies have already shown that group interventions supported by social robots can significantly improve the behavioral and emotional engagement of children with ASD, which is in line with the literature (Chung et al., 2024; Marino et al., 2020; Mutawa et al., 2023). These findings provide an empirical basis for the present framework, suggesting that the integration of NAO into structured group activities is not only theoretical but also supported by emerging evidence.

In summary, this information refers to a comprehensive approach: engagement is defined as a multidimensional construct (Wang et al., 2019), the design of group activities (Yuan & Wang, 2024) and the utilization of NAO to focus attention and enhance the engagement of children with ASD keep children productively involved with their peers (Qidwai et al., 2020). This synthesis treats engagement not as a simple outcome, but as a teaching process that offers, as a consequence, a basic principle for designing teaching that is consistent with the goals of educators in inclusive environments.

Conclusion

This article analyzes current views on the engagement of children with ASD, the pedagogical rationale for group interventions, and the role of the

NAO social robot as a mediation tool in inclusive learning environments. These elements were treated as interdependent, and the study provided a clear conceptual framework for understanding engagement as a multidimensional concept that incorporates behavioral, cognitive and emotional dimensions. Such a framework seems to support educators in designing more coherent interventions to enhance the engagement of all children with or without special educational needs in the classroom. Beyond its theoretical contribution, this article may be of particular interest to readers as it addresses an important social issue that is emerging today: how to enhance the participation of children with ASD in inclusive learning environments through innovative G-AI tools, such as social robots. By providing a clear conceptual framework linking participation, group interventions, and the NAO robot, the study enhances the existing literature with a synthetic proposal that has not been systematically addressed in the past. Thus, it offers both scholars and practitioners a basis for future empirical research and for the design of more effective educational practices.

However, there were some limitations. First, the analysis was theoretical, based on existing literature rather than empirical data. Therefore, the proposed framework cannot yet be generalized to all contexts or populations. Furthermore, the heterogeneity of children with ASD complicates this issue, as engagement seems to manifest itself differently depending on the level of development, cognitive profile, and previous experience of children with technology. An additional limitation concerns the NAO robot itself, as it is expensive and requires constant technical support, which limits its use in the school environment. These limitations do not diminish the significance of the synthesis, but they do underscore the need for careful interpretation of the results. Furthermore, a predictive growth theorem can be proposed: future developments are likely to frame the engagement of children with ASD in adaptive and technological ecosystems, where social robots such as NAO act not only as simple mediators but as dynamic partners of children in learning. This direction has already been highlighted in recent Chinese research (CNKI database) and shows that the field is

moving towards more personalized and data-driven G-AI group intervention models. Future research should aim to operationalize the multidimensional model of engagement through validated tools and to apply these tools in classroom interventions. In this context, empirical studies could investigate how NAO-supported group activities affect different aspects of engagement over time. Empirical examination of these questions will not only strengthen the theoretical foundations described here, but also provide practical information for educators who want to promote the meaningful engagement of all children in the inclusive classroom.

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Ethics Declaration

The authors declared that this study did not require an ethics committee approval. This study did not include any personal information. The authors further declared that the highest ethical practices were followed during this study.

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