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The utilization of robotics in the study of autism spectrum disorder

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Abstract

This article examines the potential of using robots in Autism Spectrum Disorder (ASD) research. First, the field of Social Assistive Robotics (SAR) is determined and how it is addressed to children with ASD. Then, a study on the interaction between children with ASD and anthropomorphic robots is presented, emphasizing the expression of emotions, verbal communication, exploring the environment and performing a request. These two elements are a prerequisite for the proper development of cognitive and social functions and present deficits in ASD. The aim is to use the results of this study in intervention programs in the school context.

Keywords: Autism Spectrum Disorder (ASD); Social Assistive Robotics (ASR); Neurodevelopmental disorder; Digital Technologies; Special Education;

1. Introduction

Autism Spectrum Disorder (ASD) is characterized by a diverse range of clinical manifestations. Specifically, it is marked by: (a) qualitative impairments in reciprocal social interaction, (b) deficits in verbal and non-verbal communication, (c) repetitive and stereotyped patterns of behavior (American Psychiatric Association, 2013) along with restricted interests and activities, and (d) onset prior to the age of three (Wegiel, et al., 2010).

At a psychological level, the causes of ASD are often linked to deficits in innate motivational mechanisms that regulate social communication and environmental exploration (Trevarthen & Daniel, 2005).

These deficits appear to stem from abnormalities in the Intrinsic Motivation System, which involves brain structures such as the brainstem, basal ganglia, and components of the limbic system. This theoretical framework helps explain deficits in joint attention, symbolic play, and functional play (Charman, 2003).

Children with ASD, for instance, are less likely to take initiative in interactions and, when they do, they often struggle to appropriately adapt their behavior (Warreyn, Roeyers, & De Groote, 2005). Furthermore, they frequently exhibit limited responses to communicative efforts from other (Jackson, et al., 2003). As effective communication is a prerequisite for language development and cultural assimilation (Tomasello & Carpente, 2007), these deficits contribute to the challenges faced by children with ASD in adapting to social environments and solving social problems.

2. Digital Technologies and Educational Robotics

Educational robotics (ER) serves as a valuable and reliable tool in learning, grounded in fundamental theories of education that have evolved over time. These include behaviorism, objectivism, cognitive science, constructivism, and sociocultural theories of learning. Robotics, as a technological discipline, focuses on designing, developing, and studying robots while also serving as an effective medium for fostering cognitive development.

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In an educational context, robotics typically involves students working collaboratively in groups to build and program robotic systems using kits that include processors, sensors, motors, and structural components. The primary objective of ER is to provide a comprehensive, hands-on learning experience that fosters knowledge acquisition, skill development, and positive attitudes toward the design, analysis, application, and operation of robots (Psicharis & Kalovrektis, 2017).

Another goal is to leverage robotics as a tangible, engaging application to motivate students in related fields such as computer science, artificial intelligence, engineering, natural sciences, and mathematics. Educational robotics is suitable for learners of all ages, from early childhood to tertiary education. Within the framework of STEM (Science, Technology, Engineering, and Mathematics) education, students can gain insights into real-world challenges facing cities and simulate potential solutions using robots designed for educational purposes.

Many countries aiming to advance their industrial sectors strive to integrate robotics into primary and secondary education. However, challenges persist, including inadequate training for educators to implement ER programs and the high costs associated with its integration, especially in countries like Greece.

The STEM philosophy promotes a departure from traditional educational models, focusing instead on problem-solving, exploratory learning, and active student engagement (Koenig, , Mataric, & Feil-Seifer, 2007) whilst STEM-oriented robotics activities encourage collaboration, critical thinking, and the exchange of ideas, equipping students with the skills needed to tackle complex problems.

In conclusion, we stress the importance of all digital technologies in the field of education and in Autistics training. These technologies are highly effective and productive and facilitate and improve assessment, intervention, and educational procedures through mobile devices that bring educational activities anywhere [18-19], various ICTs applications that are the main supporters of education [20-33], and AI, STEM, Games and ROBOTICS [34-37] that raise educational procedures to new performance levs. Furthermore, the development and integration of ICTs with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [38-49] accelerates and improves educational practices and results more than those, particularly in children with Autism, treating domain and its practices like assessment and intervention.

3. Educational Robotics and ASD

In recent years, educational robotics has gained traction as an intervention tool for children with ASD, as it is believed to support this population effectively (Di Battista, Pivetti , Moro, & Menegatti, 2020). Research suggests that children on the autism spectrum often have a preference for subjects involving the sciences.

Various educational materials and tools have been developed to assist individuals with ASD in acquiring foundational skills. Studies have demonstrated positive outcomes, such as improved eye contact (Chung, 2019) and enhanced understanding of emotions through robots capable of mimicking and representing facial expressions.

One such intervention involves children mimicking the robot's movements and facial expressions as displayed on a screen, which helps them better comprehend emotions (Robins , Dautenhahn, Te Boekhorst, & Billard, 2005).

In summary, educational robotics offers an engaging and playful platform for fostering educational activities. It has the potential to aid children with ASD in social integration, skill acquisition, creative thinking, and cognitive development, particularly in mathematics and problem-solving related to daily life, such as spatial awareness and navigation.

4. Definition – Social Assistive Robotics (SAR)

The term "robotics" encompasses a wide array of fields, systems, and applications, including medicine, space exploration, underwater research, and automation. Within this broad domain, social robotics focuses on human-robot interaction through speech, gestures, and other forms of communication (Breazeal, 2004). while assistive robotics supports individuals with disabilities by aiding in tasks such as repetitive therapeutic exercises commonly found in physical rehabilitation (Kwakkel, Kollen, & Krebs, 2008).

Social Assistive Robotics (SAR) is an emerging interdisciplinary field emphasizing emotional expression, participation, and interaction. Unlike traditional social robotics, SAR systems aim to not only assist users but also guide, motivate, and influence them to modify behaviors in constructive ways (Scassellati, Admoni, & Mataric, M. (2012, 2012).

5. Research Objective

This research aims to investigate the use of SAR as an intervention method for ASD. Specifically, it seeks to determine whether SAR can enhance attention and interaction levels in children with ASD, potentially mitigating or even eliminating the adverse consequences associated with deficits in these areas.

6. Methodology

This pilot experimental study will employ a sample-based exploratory approach, involving four specific activities with BabyRobot technology. (https://babyrobot.eu/, n.d.).

7. Participants and Tools

The study will involve 50 fifth-grade students (25 boys and 25 girls) aged approximately 10 years from Elefsina, Greece. All participants will have a formal ASD diagnosis of mild, moderate, or severe severity from a certified institution (KEDASY). Parents will play a secondary role in providing data about the primary participants.

The experiments will be conducted in a controlled environment using Greek-language commands to ensure comprehension. The independent variable will be the children participating, while the dependent variables will be the five structured tasks, which will remain consistent across participants. Observational data will be collected to evaluate responses based on predefined criteria.

8. Research Procedure

The study will include the following activities:

- **Gesture Imitation**: Children will perform requested gestures, such as pointing to their ears or waving.
- **Emotion Expression**: Children will identify and express emotions using visual aids.
- **Pantomime**: Participants will mimic actions like brushing their teeth or hopping.
- **Object Guessing**: Using verbal cues, children will guess objects based on their characteristics.

9. Timeline

This research begun in September 2023 and to concluded by September 2024. The necessary steps can be completed within a five-month timeframe. Between September and November 2023, the robot will need to be purchased, and efforts will be made to secure funding through an organization or company. All financial aspects must be finalized during this period. By December 2023, a suitable location for the research should be found, possibly within an educational institution that can offer its space. The owners of the location need to be fully informed about the purpose of the study and the equipment involved, and they must agree to allow access to the space during morning hours.

From January to March 2024, participants were selected and carefully briefed on the objectives of the research. Both the participants and their parents provided their consent to take part. In the final phase, from March to September 2024, the research has been conducted, the results were analyzed, and the findings prepared for presentation.

10. Cost and Resources

The robot itself costs around $749, or approximately €690. This amount will also cover the shipping costs needed to bring the robot to the research site. Additionally, we will need to account for the rental of a suitable venue. We will aim to secure a public space to minimize costs as much as possible. To ensure the comfort of the children and their families, we plan to provide juice and light snacks after the trials, with an estimated cost of €200. Basic materials, such as paper, will also be required, but these costs should not exceed €80.

To help cover these expenses, particularly the cost of the robot, we will actively seek funding opportunities. The research team is committed to reaching out to organizations and companies that might be interested in supporting this important project.

11. Conclusion

Autism Spectrum Disorder (ASD) encompasses a wide range of severity, meaning that students with ASD do not all share the same characteristics or challenges, even those classified as having 'mild' ASD. With three categories of ASD severity, it is not guaranteed that the 50 children participating in the study will be evenly distributed across each category. Moreover, the high cost of the robot presents another significant challenge, leading to an overall higher cost for research. This is particularly concerning given the aim of incorporating robots as a rehabilitation tool in Greece. If the robot's cost remains high, it could place a financial burden on both Greek families and the public health system. Finally, the scale used to assess outcomes—ranging from "good," "moderate," to "none"—lacks measurable precision, and the results can often be subjective, depending on the observer's perspective.

In order to address ethical and deontological concerns, it is imperative to secure formal consent from the parents or guardians of minor participants, granting permission for both the students and their families to partake in the research. Furthermore, all fifty (50) participants will be duly informed of their right to withdraw from the study at any time, without any pending obligations or repercussions. They will also receive written assurances regarding the protection of their personal data and the preservation of their anonymity throughout the study. If any photographs or videos are taken, this will only occur upon receiving explicit consent from the participants. However, to ensure the smooth and ethical conduct of the experiment, voluntary and willing participation from each student is deemed essential. Lastly, participants will be informed of their right to access the results of the study once it has concluded.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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