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COMPARATIVE ANALYSIS OF ROBOTICS AND VIRTUAL REALITY IN THE ENHANCEMENT OF SOCIAL SKILLS IN AUTISTIC STUDENTS

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Abstract

Information and Communication Technologies (ICT) have become one of the fundamental tools for improving the learning of students with special educational needs. The flexibility to adapt to the needs of these students makes them a fundamental element in the classroom. In recent years robotics and virtual reality (VR) are increasingly present in educational environments. These are the ITCs best suited to the visual learning characteristics expressed by students with autism. Therefore, the aim of the research is to analyze in which areas robotics and VR have produced improvements. To this end, we have worked with 8 students with autism aged 6-12 years in 11 sessions with VR and 11 with the NAO robot in the period from April to June 2023. To evaluate the improvements of these children, the Denver questionnaire was used, which is composed of 6 dimensions. Data were collected by the investigators and tutors. The informed consent form filled out by the participants' families explained the objectives of the research and the activities to be carried out. The results indicate that subject 6 is the one with the highest percentage of improvement after the application of VR. Reaching 37.50% in expressive communication. In robotics, subject 1 with 29.63% in adult social skills and subject 6 with 37.50% in expressive communication are the most outstanding. When comparing VR and robotics, subject 2 has experienced improvements ranging from 2-4% in the areas of imitation, joint attention, and expressive communication. As future lines of work, the possibility of including automatic algorithms that can measure in real time the improvements in learning developed by autistic students are proposed. This article was supported by the Programa Estatal de I+D+i Orientado a los Retos de la Sociedad del Ministerio de Ciencia e Innovación Español. PID2020-112611RB-I00/AEI/10.13039/501100011033 and the Agencia Estatal de la Investigación.

Keywords: *Robotics, autism, virtual reality, joint attention behaviour, expressive communication.*

1. Introduction

In school classrooms there is an increasing number of students with learning difficulties related to the area of communication and social interaction. Students with Autism Spectrum Disorder (ASD) are increasingly present in schools, being 0.6% of the world population presenting this disability (Salari et al., 2022). The increased detection of this disorder may be influenced by two factors according to Durkin et al. (2017): firstly, the awareness of families that causes them to try to carry out a work plan to help their children outside the classroom. Secondly, the use of more accurate and less biased diagnostic tools that allow determining the level of autism of children.

Autism spectrum disorder (ASD) can be defined as a developmental disorder that presents difficulties in two areas of development: social and communicative interaction and repetitive patterns of behaviors interests or activities (APA, 2013). Difficulties in the areas of communication and social interaction cause autistic students to have difficulties in expressing themselves verbally and nonverbally in combination with the absence of the ability to identify body language in different social situations (Telisheva et al., 2022). Likewise, these students, depending on the social context, have difficulties in identifying, recognizing, and expressing emotions (Lorenzo & Lorenzo-Lledó, 2024), which causes them to have many problems in assigning a mental state to themselves as well as to others (Premack & Woodruf, 1978). Regarding repetitive behavior patterns, this is a consequence of the fact that autistic students have a detail-focused processing (Happe & Frith, 2006) and therefore have great difficulty in controlling stimuli in real environments (Reeve et al., 2007).

Based on the characteristics of students with autism, there is a need for tools that allow the creation of simple social situations where the control of stimuli can provoke predictable responses in the environment (Robins & Dautenhahn, 2014). Both robotics and virtual reality (VR) are tools that serve this purpose. The great advantage of robotics is that it allows in real environments the development of social interaction activities with the robot acting as a support element (Robins & Dautenhahn, 2014). In addition, robots allow the user the infinite repetition of the activity, which is one of its ways of learning (Lorenzo & Lorenzo-Lledó, 2024). Likewise, the robot can adapt its behaviors in real time to the participant's emotions (Fuentes-Alvarez et al., 2023). As for VR, the main advantage is the possibility to perform the activities in safe environments without suffering the negative effects of errors in a real environment (Moon & Ke, 2021). Moreover, the realism of the environments that are designed favors the transfer of acquired skills to real environments (Moon & Ke, 2023).

2. Objectives

Based on the above analysis, the objective of the research is to determine in which areas robotics and virtual reality have produced improvements in autistic students. The following research questions have been established to develop the stated objective.

- Which tools obtain better scores in the different areas of the Denver questionnaire?
- In which areas have the highest increases occurred with the use of robotics?
- In what areas have the highest increases occurred with the use of virtual reality?
- Which subjects achieved the highest scores with the two technological tools?

3. Method

A pre-experimental design has been chosen where there is a single group in which pretest and posttest measures are taken (Albarracín-Villamizar et al., 2020). In addition, a quantitative approach has been designed to obtain through descriptive statistics which have been the improvements in the scores of the subjects (McCusker & Gunaydin, 2014).

3.1. Participants

Eight participants diagnosed with autism from a regular school were selected. The age of the participants ranged from 6-12 years old. The 37.5% were diagnosed with level 1 autism while the rest were diagnosed with level 3 autism. 62.5% had a level of curricular competence of first grade of primary school and the rest had a level of curricular competence of 3-4 years of kindergarten. In addition, 75% had oral communication and only 25% attended a regular classroom. Finally, 87.5% had a level 3 support level.

3.2. Instrument

For the development of the robotics activities, we worked with the NAO robot. This robot has 25 degrees of freedom and could establish a certain degree of verbal and non-verbal communication (Puglisi et al., 2022). In addition, its microphone and sensor system allow it to collect information about the environment. To work with VR, the Oculus Quest 2 glasses were used, which according to Lorenzo et al. (2023) have a resolution of 1832x1890 and a liquid crystal display. In addition, it is integrated into a system that allows the user's point of view and the associated audio to be updated. Furthermore, a field notebook has been used to record the behaviors performed by the participants in their interaction with robotics and VR.

3.3. Design

The eleven sessions that took place in VR covered a variety of areas. For example, the first session worked on classroom rules. While from session 2 to 6 the user focuses on the area of emotions, identifying them, associating them, analysing the causes that produce them. For session 7, symbolic play is worked on with the elaboration of the Macedonian. Sessions 8 and 9 continue with the work on emotions with the colour monster. Finally, in session 10, the executive function is worked on by preparing the school bag and in session 11, another activity on emotions such as the thermometer of emotions. For the development of robotics, the same activities are implemented in real environments but with some variations with relaxation activities, the bingo game, and the association of a pictogram with an animal.

3.4. Procedure

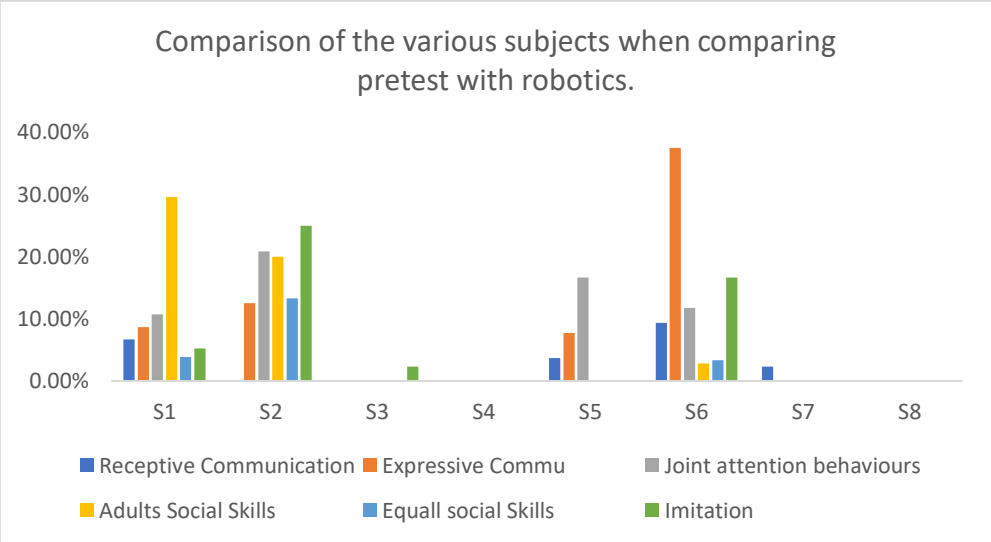
In the development of the intervention, an initial meeting was held where the researchers met to obtain a first list of schools, which would be made up of those with specific units. After contacting the selected schools, a meeting was arranged with them to explain the project and to familiarize them with the

technological tools. Subsequently, another meeting was held with the families to obtain the authorizations, the format of which followed the criteria established by the UA ethics committee (Exp UA 2022 05 01). In addition, we explained to them what the activities consisted of. The children's teachers and the researchers were present during the intervention. Eleven sessions lasting 15 minutes were developed and implemented for both robotics and VR.

4. Results

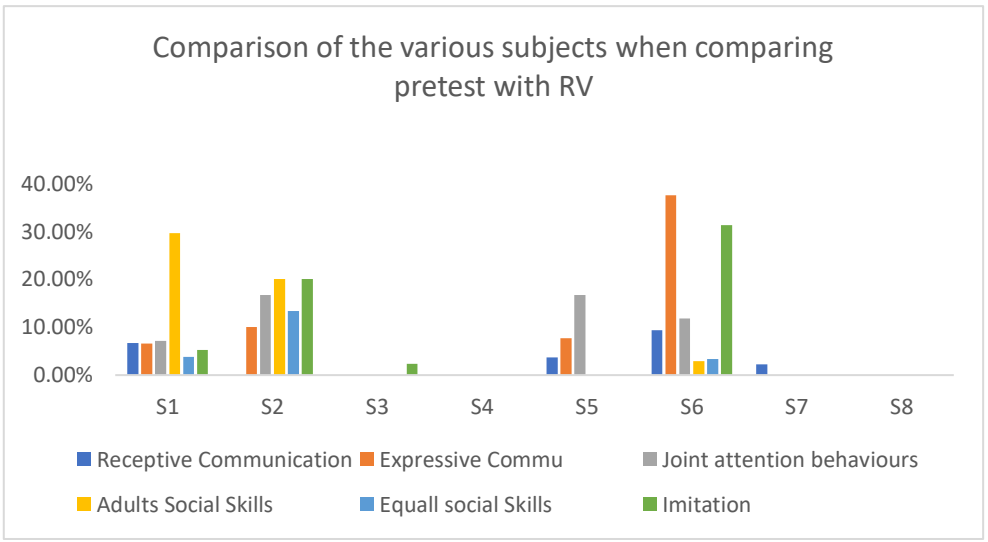
The analysis of Figure 1 shows how subject 6 is the one with the highest scores with respect to the pretest after the application of robotics. Expressive communication stands out with 37.50% and imitation with 16.67%. It reached an average percentage increase of 13.58%. Despite not reaching the highest values, subject 2 has the highest average percentage with 15.28%. In this sense, the areas with the highest mean increases are expressive communication with 8.30% and joint attention behaviors with 7.50%.

Figure 1. Comparison of the various subjects with comparing pretest with robotics.



With reference to the analysis in figure 2, also with the VR, subject 6 is the one who obtains the highest score increases. It also has the highest average percentage increase with 16.03%. Subject 2 has the second highest mean score with 13.33%. In this sense, the area of expressive communication with 7.71% average growth and imitation with 7.35% acquire the best scores with VR.

Figure 2. Comparison of the various subjects with comparing pretest with VR.



5. Discussions

With respect to the first research question, robotics is the tool that obtains the highest scores. This is a consequence of the fact that the robot can be used in real environments as an element of support and explanation of how to act in a social environment (Lorenzo et al., 2024). In contrast to VR where three-dimensional real environments are worked on without contact with the real world (Lorenzo et al., 2023).

Regarding the second research question, robotics provokes higher improvements in joint attention behaviors because the NAO robot has rotating mechanical parts, its body parts present different colors (Cabibihan et al., 2013). Moreover, the improvement in expressive communication may be a consequence of the robots displaying basic emotional expressions through simple activities (Robins et al., 2009). This leads to a better understanding of emotions and their subsequent manifestation.

In the third research question, VR favors expressive communication due to the characteristics of realism and anthropomorphic behaviors presented by the avatars (Garau et al., 2005). In this way it is easier to understand emotions and therefore there is a better expression of verbal and non-verbal information. In this sense, the improvement in imitation may be a consequence of the ability presented by VR to repeat activities as many times as the user desires (Moon & Ke, 2021).

In the fourth research question, both subject 2 and subject 6 have in common that they possess high IQ and oral communication development, which are the conditioning factors in the high cognitive loads generated by VR and robotics activities (Moon & Ke, 2021).

6. Conclusions

Throughout the study, it has been possible to see the improvements that both virtual reality and robotics have generated in the different areas of communication and social interaction. Therefore, the following conclusions can be drawn from the research questions.

- Robotics is the tool that leads to the greatest increase in communication and social interaction for autistic students.
- Robotics has led to the highest increases in the areas of expressive communication and joint attention behaviors.
- Virtual reality has led to the highest increases in expressive communication and imitation.
- Subject 2 in robotics and subject 6 in VR had the highest mean increases.

In this way, it can be concluded that activities have been developed with technological tools that will allow their future application by teachers in the classroom. Despite this, future lines of research include the possibility of adding more activities that are applicable to different contexts. Furthermore, a follow-up plan should be included at the end of the interventions.

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