Portable Robotic Modular Kit for Teaching Gestures in Children with ASD

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Abstract. Technological advancement in recent years has allowed effective development in various fields, the link between technology and education is undoubtedly one of them. The health emergency that has arisen in recent months worldwide is a call for innovation to continue with learning processes that adapt to new study modalities. That is why this work proposes the development of a portable robotic modular kit for teaching gestures in children with autism spectrum disorder. The aim is to contribute to the development of non-verbal communication. The portable robotic modular kit consists of an Android application, a robot with 20 interchangeable parts and one container box to transport the robotic kit. The Android application has 3 working modes. Two of them are for working without the robot and the main working mode is the one that controls the robot. The validation of the tool was carried out by experts in the field of teaching to children with ASD. 65.57% of the people evaluated considered that the system can contribute to the teaching of gestures to autistic children and 70.49% of people considered that the tool can be used in children without disorder. Finally, the tool was presented in 5 therapy sessions in children with ASD within the Neuropsychological Rehabilitation Center CERENI. The results obtained are quite encouraging. We obtained a satisfaction of 100% in children with autism grade 1, while in children with autism grade 2 and 3 we obtained a satisfaction of 50% on the scale proposed with an increasing trend.

Keywords: Teaching · Autism spectrum disorder · Modular robots · Gestures · Non-verbal communication · Human - robot interaction · Laterality

1 Introduction

Autism spectrum disorder (ASD) is considered a neurological condition, of which very little is known. Several investigations focus on the help of social, communication and cognitive skills, all these related to ASD [1]. According to WHO conclusions, there are 62 people with ASD in every 10,000 inhabitants, that is, 1% of the world's population is affected by the disorder. [2]. Delfos M. and Groot N. said that in Ecuador there are between 85,841 and 165,960 people with autism spectrum disorder [3]. For this study, it is essential to consider the most important problems presented by people affected by this

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disorder. To do this, we refer to the explanation provided by Lorna Wing which says that autism spectrum disorder falls on the well-known Wing triad [4]. According to Lorna Wing, social relationships and social communication are part of the problems that most affect people with ASD. For this reason, it is essential to teach forms of daily communication, such as non-verbal. Section 1.1 presents the use of technology to contribute to the teaching of this type of communication and socialization. Highlighting social relationships, social communication, and rigidity of through behavior and play. The final details of each part of the portable robotic modular kit are presented in the subsequent subsections, detailing its most important characteristics. One of the principal problems was detected by a group of scientists who developed an experiment called "Communication Play Protocol". In this experiment, it was concluded that in the communication between children, the use of gestures is essential, and children with ASD present a significant deficit in the performance of gestures, especially deictic gestures [5]. Also, it is detailed in other studies the great problem presented by children in cooperative games because they don't understand basic gestures, for which they continue with repetitive actions typical of autism [6].

1.1 Autism therapy by robotics

When we talk about therapy, one of the main questions that arises is: Are social robots helpful for children? There are several studies that reflect the great attention that people involved have and the ways of teaching with social robots. In "Robotic assistants in therapy and education of children with autism: can a small humanoid robot help encourage social interaction skills?" [7], it is concluded that after several sessions, social robots become mediators between the child and the therapist, or also once the child gets used to the humanoid, he starts therapies on his own initiative. The child-robot interaction, once trust is established by the patient, can become a form of teaching with quite positive results, or only as the direct link between the teaching field and the child. In a study by Yaoxin Zhang and others, it is concluded that humanoid robots can adapt to the needs of learning, and training of social rules [8]. In view of the great acceptance of people with ASD towards the technology, there are already several robots that are being used in various therapies. However, most robots are designed with more general purposes, so several experts adapt them to the needs of the patient. Such is the case of the robotic kit Mindstorms developed by Lego [9], which seeks a development in the social part of the patient. The Milo robot is another similar case, this robot presents a teaching method aimed at children of early ages and it is used in various investigations [10]. One of the main characteristics that allow the interaction between patient and robot is anthropomorphism, which is defined as the tendency to attribute human characteristics to a robot. However, we should keep in mind not to fall into the valley of the inexplicable. A study carried out by Masahiro Mori called Unexplained Valley, analyzes a level of approval of robots in these patients. As a result, robots that resemble human appearance in a large percentage cause rejection by observers [11]. Therefore, it is essential to be clear about the final appearance of the used robots. Robots with shapes not so similar to humans are ideal for acceptance and communication with children with ASD. AISOY1 robot is another one widely used within this field, but with an approach directed at emotions [12]. NAO humanoid robots are the best known within gestural therapies, imitations, socialization among others. The ease of use and multiple applications of these robots makes them quite adaptable to various needs. [13]. In an experiment with the ZENOS robot, to measure the interaction between the child and the therapist, a spontaneous participation of those affected was evidenced only when they worked with the robot and very little attention when they worked with humans. The learning results were quite satisfactory and with a relevant imitation of basic gestures for communication. [14]. This makes essential the feedback in teaching or an increase in the number of interactions between the child and the robot. In other therapies with adapted robots we find the article "Autonomous Robot-mediated Imitation Learning for Children with Autism" [15], which describes an imitation system for autistic children using a NAO Robot and data collection with Microsoft Kinect. The authors detail in their results that the population tolerated the robotic system and children with ASD worked better with this system than with a human therapist, obtaining relatively better performances [15]. NAO robots are also used in a study by Ryazantsev and Baranova L. In the investigation, one of the most encouraging results was measured by an electroencephalogram. It was evidenced that in a child with autism brain activity increased sharply compared to therapies without robots and this reaction remained throughout the session with the NAO robot [16]. Finally, Zheng in his article detected that a real-time imitation of patients with ASD can occur and that feedback is of great importance for adaptive intervention [17]. Other research affirms the use of interchangeable parts, both in robots and other methodologies to attract the attention of users. However, in the robotic area, the only one found that resembles a modular design is Mindstorms, which is a therapy adapted and oriented to children of advanced ages or young people, so it has different results from this research. However, the similarity between these therapies and this work lies in the level of attention obtained by the patients during therapy, confirming and guaranteeing a high level of attention while the child interacts directly with the interchangeable pieces.

1.2 Study proposal

Currently, various robots adapted to therapies are used with quite favorable results. There are also robots developed based on the specific needs of patients with autism spectrum disorder. However, one of the recommendations of specialists is constant feedback on the topics discussed to reinforce the knowledge acquired [18]. This is a very conflictive problem when children with ASD are in therapies with robots considered high cost or fragile. This due to the high possibility of patients damaging a expensive robot. That is why an economical and robust robot is developed. This robot is capable of being portable for users and with intuitive operation for use of therapists and parents of the child with ASD. This robot is also capable of being considered a reinforcement tool at home.

This research seeks to contribute to the development of Social Understanding, seeking a human-robot interaction, and then reinforcing other areas such as imitation and gesture recognition, laterality, and fine motor skills through the use of the robotic kit. All this will be done in this work with a portable robotic modular kit of interchangeable parts controlled from a mobile application capable of being used by the parents of each patient at home at any time.

2 Development of the Modular Robotic Kit

This section presents a brief description of the methodology used in the development of the portable robotic modular kit, as well as the methods used in the design and construction of the kit. It also details in more depth the operation of the robot and the app.

2.1 Design methodology

As described in Sect. 1, the most important characteristic of this design is the direct approach to autistic children between the ages of 3 and 8 years, based on their needs. To do this, a mechatronic design based on the VDI 2206 methodology is used through the "V" model. This model describes the product requirement until reaching the exit. Based on the VDI methodology, it was carried out a conceptual design and sizing, component selection, mechanical design, virtual simulation, construction, and assembly. It was verified the operation with surveys directed to experts in the field of design. The results are presented in the next chapter.

Development of the Portable Robotic Modular Kit Hardware: To give a preamble to the complete robotic kit, Fig. 1 shows all the components of the work developed. The robotic kit has 3 heads, 3 pairs of feet, 5 pairs of arms, 1 fixed torso, 1 container box, the mobile application for its control, 1 system charger and its corresponding user manual. Brief features of the design, manufacture and use are specified in the following sections. The method used for manufacturing and testing, as well as the technologies invested to obtain the complete kit, are also detailed.

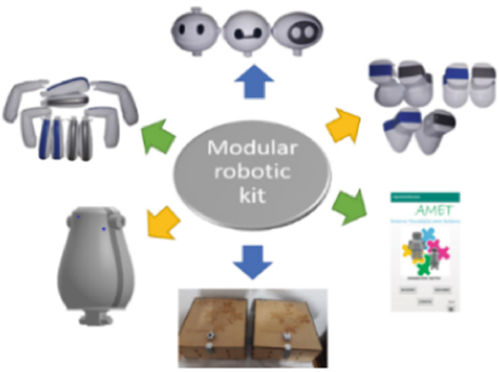

Fig. 1. Parts of the modular robotic kit

2.2 Conceptual design of the robotic kit

Table 1 shows the need for a special approach to the aesthetics of the kit, the gestures it performs, portability, robustness, and its intuitiveness, which are the parameters that the experts consider most important. As it is a technology focused directly on children with autism spectrum disorder, the first step before the design was a needs assessment based on the bibliography which recommends robotic aspects with appearances don't so similar to the human [11]. The use of soft colors and without many details. These concepts are validated with experts in education and therapists who work with children affected with ASD. The needs identified for the project are presented in the Table 1.

Table 1. Needs matrix

	Need	Importance
1	The robot must be visually attractive	5 of 5
2	The robot must be modular (didactic)	4 of 5
3	The robot must teach gestures	5 of 5
4	Two distinctive colors to assemble and as support in the laterality	4 of 5
5	The robot must be small	4 of 5
6	The robot must be easy to transport	5 of 5
7	The robot must be robust	5 of 5
8	The application must be visually attractive	4 of 5
9	The application must be easy to use	5 of 5
10	The application must be able to be used without the robot	3 of 5

In order to meet the needs found and relate them to the technical part, Table 2 shows the technical metrics that the modular robot will contain to cover each need, as well as the evaluation range for subsequent validation of operation.

Table 2. Metric need matrix

Need	Metrics	Importance	Measure
3	Robot movement	5	Degrees of freedom
3	Replicate gestures	5	Subjective
2,4	Interchangeable parts	4	Fits and tolerances
9,10	Control software	5	Subjective
5,6,7	Portable Design	3	Subjective
5,6	Weight	5	Kg
5,6	Dimensions	3	mm
1,2,4,5	Aesthetic design	5	Subjective
8,9,10	Mobile app	4	Subjective

Finally, Table 3 was developed based on the metrics and needs. It describes the main technical characteristics that the system needs to cover to function at the users' home and thus be considered as a reinforcement therapy at home for patients with autism at established ages. A selection of concepts is made for each parameter and specification, with it the best components and methods that were used for the development of the robot are chosen. With all of this we can give the direct focus to children with autism spectrum disorder.

Table 3. System specifications

Parameter	Specification
Software	App in android Studio, through communication with Arduino
Gestures	Yes, no, ok, wrong, greet, hunger, cry
Architecture	Modular Type (detachable)
Mechanism	Minimum 2 degrees of freedom
App language	Spanish
System dimensions	Max 40 cm high and 25 cm wide
Weight	Max 1.5 kg
Power supply	USB charger 5 [V]

2.3 CAD design of modular robots (Simulation)

Using CAD software, the design of the robot is proposed for its external part and its internal components. See Fig. 2.

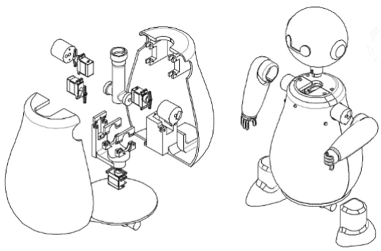

Fig. 2. Robotic kit in exploded mode

In Fig. 3, the simulation of the gestures that can be assembled is shown.

2.4 Final product development

The final result of the portable robotic modular kit is achieved through additive manufacturing. PLA is used as the base material, for subsequent processing with putty and

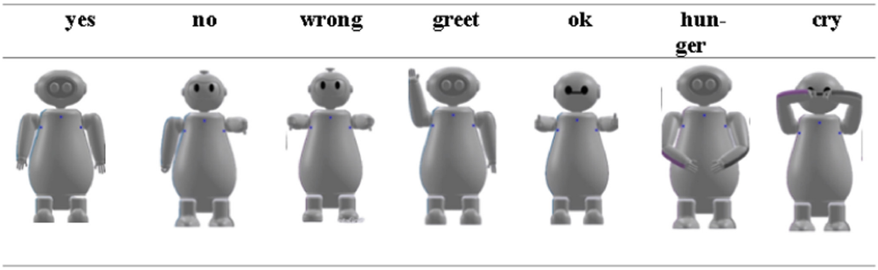

Fig. 3. Simulated gestures

automotive paint. Then, final modular robot and its parts are presented in a robust and smooth way capable of working with children. In the subsequent subsections, the final details of each part of the portable robotic modular kit are presented, detailing its most important characteristics.

Assemble. This technological tool is a system that has a total of 20 interchangeable parts between upper and lower extremities, trunk, and heads. The robotic kit allows 165 possible ways of assembling it by varying its pieces. Figure 4 shows some possible combinations. With these motor games it is hoped to contribute to the development of the users' spatial awareness, as has been done in other studies [19].

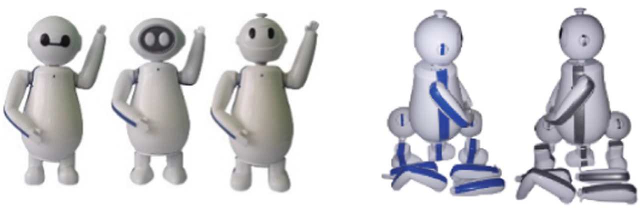

Fig. 4. Possible assembly models

For the particular case of teaching gestures, there is a special design for each movement. This design is presented in the App before executing the movement. These 7 special assemblies are presented in Fig. 5, with a brief description of their movement.

To ensure correct assembly, the modular robots have a light warning system located near each upper extremity and head, as shown in the Fig. 6A.

The robotic kit was designed with a direct approach to people with ASD. Therefore, it ensures the positioning of the parts before movement with grooves that allow the parts to be inserted in only one direction and position, as shown in Fig. 6B. Which means that the piece will always be placed in the ideal way to start the imitation of the selected gesture.

Another feature that the portable robotic modular kit presents is the identification of its right and left part. With this, the user cans identify the correct positioning of each part. It was described in the CAD design section, then the final result is presented in the Fig. 4. This presentation of the robot also seeks to work on laterality in children.

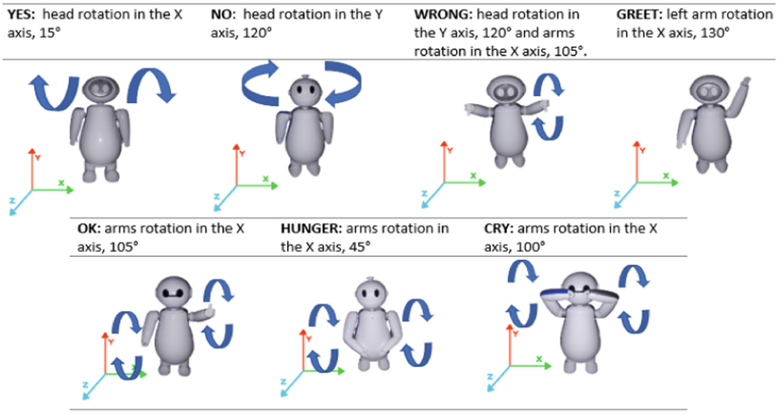

Fig. 5. Gestures

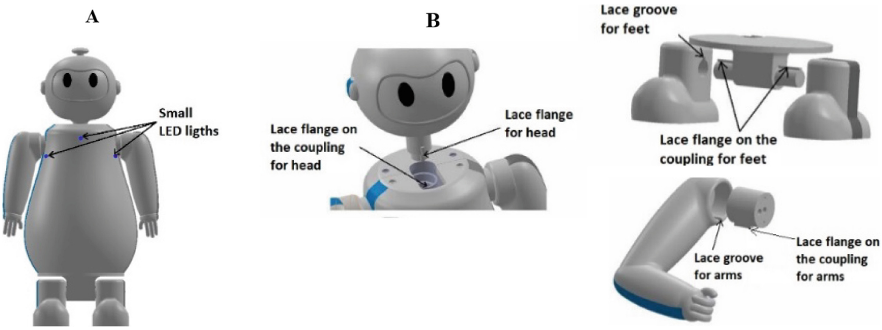

Fig. 6. Assembly details

Container Box: A box is designed; it can transport the modular robotic kit and it is made with laser technology in MDF to make it light. The box is finished inside with sponges to take care of the integrity of the pieces.

Mobile App: The operation of the robotic kit is controlled and monitored from the mobile app. It was developed for any device that has an Android operating system. This App is part of the robotic kit.

The application has the screens that you can see in Fig. 7.

The mobile app has three modes of operation, they can be shown in the Fig. 7A and which are: A: Button that opens the screen “Sin Robot”; B: Button that opens the screen “Con Robot”; C: Button that opens the screen “Cuentos”; D: Button that closes the application.

The screen “Sin Robot” is a setting for the system, in which the user can select the desired gesture and the application will show the robot as a gif for recognition. The details of this screen can be seen in Fig. 7B. This screen has the following functions: A1: Gesture selection buttons; A2: Animated gif showing selected gesture; A3: Return button to main screen; A4: Button that closes the application.

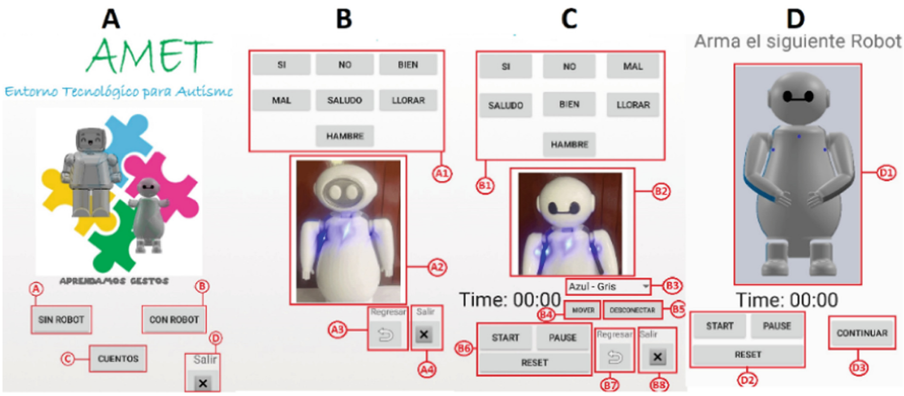

Fig. 7. App screens

The screen "Con Robot" is the interface that has the characteristics to control the robot. After connecting via Bluetooth, the App will show the tab seen in Fig. 7C. This screen is intended for the child's tutor during the therapy and it has the following functions: B1: Gesture selection buttons; B2: Animated gif showing selected gesture; B3: Robot colors picker; B4: Button that commands the robot to move; B5: Button that disconnects the App from the robot; B6: Buttons that control the chronometer for recording part recognition data; B7: Return button to main screen; B8: Button that closes the application.

Within the option "Con robot", when we select the gesture, a complementary tab will open. It will show the robot that the child should assemble before executing the movement of the robot, the interface of this tab can be seen in the Fig. 7D. This screen contains the following functions: D1: Image showing the robot that the child should assemble; D2: Buttons that control the chronometer to record arming time data; D3: Button that alerts the application that the child has finished the arming.

The screen "Cuentos" is a waiting method for children in which the user can choose between several stories selected by experts as a distraction or wait. These stories are recommendations of education experts, and it has pictograms in their description. This screen has the following functions: Story selection buttons; Return button to main screen; Button that closes the application.

Through the features presented in Subsects. 2.2 and 2.3, it is expected that the therapist or tutor who carried out the therapy, can collect information in color distinction, laterality, and location of upper and lower extremities. This result can be delivered to the professional in charge of the patient to observe the evolution of the child affected with autism spectrum disorder.

2.5 Operation mode

Once the communication between the robot and the application is established, the parent or person with whom the reinforcement therapy is carried out will follow the following steps:

– Choosing the characteristic color of the robotic kit (2 colors available)
– Selecting the desired gesture. The application will show a specific way of arming the robot.
– Showing the image to the child and take the time that the child takes to assemble the robot (The application has tools for data collection)
– Once the assembly process is completed, the application will send the robot the movement that it has to realize. The patient will be asked if he recognizes the gesture or if he can imitate it.
– The person in charge provides the information of the assembly times and the number of gesture acknowledgments to the charge therapist.

Figure 8 shows an operation diagram of the robotic kit.

Fig. 8. Operation diagram of the robotic kit

3 Results and Discussion

The two test scenarios are presented in this section. The first one is a validation with experts in education and therapy. The second scenario is the field tests. These tests are divided into 2 parts. The first tests are realized with a sample of 11 children without ASD to validate the functioning of the system. The second tests are realized with 4 children affected with the disorder who regularly attend therapy at the "CERENI" center.

3.1 Preliminary tests

Before having direct contact with children, the tool is presented to education professionals who currently work with healthy children and in some cases with children affected with autism spectrum disorder. The portable robotic modular kit is presented virtually and with the support of multimedia tools. To validate the use of the tool in the target population, the opinion provided was from 61 experts in the area of education, among which we have: Psychologist, Teachers of Basic Education and Students in the last levels of initial Education. The opinion was obtained through questions given to the participants on a scale with ranges from 1 to 4, where 1 represents total dissatisfaction and

4 total satisfaction in the question asked. According to the data, except for question 4 which refers to the movement of the "WRONG" gesture, in general the observations and considerations of the education experts are positive. It was obtained a 65.92% of responses totally agree, which means a value of 4, and 23.65% of responses with value 3.

Regarding more detailed questions such as 8 in which it refers to the final appearance of the kit, an average evaluation of 3.79 is obtained in a satisfaction scale of maximum 4. Which is why it is considered that modular robots are attractive for the children. With respect to the portability of the system an average evaluation equal to 3.58 of 4 is obtained. This result affirmed that the kit is considered portable for the users. With the results obtained, it can be concluded that the portable robotic modular kit is suitable for working and contributing to the learning of gestures, laterality, and fine motor skills in children.

3.2 Field tests

The second evaluation was carried out in two parts. The first one directed to children without ASD in the province of Pichincha and Ambato. The second one directed to children with autism spectrum disorder at the Comprehensive Neuropsychological and Neurological Rehabilitation Center "CERENI". This subsection presents data and evidence from the sessions. To carry out the field tests, the research followed the rules and recommendations of the ethics committee belonging to the Universidad del Valle and approved with the document number 003–020.

Children without ASD. Once the signing of the informed consent for participation in research and publication of results for academic purposes has been obtained, the study was carried out with a sample of 11 children between 4 and 7 years of age, among them 5 male and 6 females. In these tests the portable robotic modular kit was delivered to the parents with a user manual and after its use they were asked to fill out an evaluation survey, which contains the questions shown in Table 4. Some of the tests carried out can be seen in Fig. 9.

Fig. 9. Function test, children without ASD

Once the information was collected, we obtained the data shown in Table 5. It should be noted that they are statistical data of opinions of the parents or people with whom the children did the therapy.

Table 4. Questions for parents of chindren without ASD

No.	Question
Q1	Consider that that modular robots (interchangeable parts) arouse interest in children?
Q2	To what extent do you consider these robots are innovative?
Q3	To what extent do you consider that the process with modular robots is intuitive?
Q4	Consider that that the application interface allows easily handling of the robot?
Q5	To what extent do you consider that a modular robot is a useful tool?
Q6	Consider that that the repetition of gestures is attractive and useful for children?
Q7	Do you consider that the colors of the robot help the recognition of the left and right?
Q8	To what extent do you consider that the size and shape of the robots are adequate to be considered a reinforcement tool at home? (Easy transportation to home)
Q9	Consider that that the process of assembling the robot is easy for children?
Q10	To what extent do you consider that the entire kit is easy to use?

With a total of 70.91% responses with a value of 4, "Strongly agree", the tool is validated as useful in children without autism spectrum disorder, and it doesn't present any inconvenience during its use. These results allow the passage to the next stage of tests in children with autism spectrum disorder.

Table 5. Statistics of children without ASD

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Media	3,91	3,64	3,55	3,91	3,36	3,45	3,91	3,82	3,82	3,64
Std. dev	0,30	0,50	0,52	0,30	0,50	0,69	0,30	0,40	0,40	0,50
Var. coeff	0,08	0,14	0,15	0,08	0,15	0,20	0,08	0,11	0,11	0,14
Var	0,09	0,25	0,27	0,09	0,25	0,47	0,09	0,16	0,16	0,25

In questions with more interest, the result of question Q1 is presented, which gives an average of 3.91 out of 4. This tells us that the portable robotic modular kit caused a high interest from users. In question Q8, which refers to the portability of the robotic modular kit, we get a 3.82 out of 4. This shows that the parents of the children don´t had problem transporting the robot and its components.

Children with ASD. In children with ASD the tests performed were different from those performed with children without ASD. This is because, in children without ASD only the function was tested, while in children with ASD, the kit was used as a therapy tool. Children with autism spectrum disorder who participated in the testing sessions are between the ages of 4 and 8, among them affected by autism in grade 1, 2 and 3. They regularly attend the Neuropsychological Rehabilitation Center and integral neurological "CERENI", which is currently working with all biosecurity standards, and with admission protocols such as: admission with some symptom is prohibited, disinfected footwear and body, mandatory use of mask, hand disinfection and keep a distance of 2 m. The participants were selected by the specialist therapists of the center according to the time they have been treating them. Before the process the parents of each one was informed, recording their consent in writing to participate in the study and publication of the data with academic purposes. The field test was carried out on 4 children, some details of them are presented below: Male of 8 Age, Grade 1, Total session 5; Male of 7 Age, Grade 1, Total session 3; Male of 4 Age, Grade 2, Total session 5; Male of 4 Age, Grade 3, Total session 5.

Within the first intervention, it was observed a behavior in children with autism of grade 1 of great interest in the tool. In grade 2 there is a very slight interest, so the therapist intervenes very frequently to attract the child's attention. While in grade 3 the interest is totally null. A stronger attention is shown in the following sessions compared to the first in all cases. One of the children of grade 1 perfects the assembly and reduces their times to less than a minute in the second session. While the children of grade 2 and 3, despite not assembling the robot until the third session, they begin to recognize gestures.

The results of the last session were quite favorable for the few sessions carried out due to the pandemic. The 2 children of grade 1 assembled the robot without the help of therapists in less than 1 min. The child of grade 2 recognized all the gestures except for the "WRONG" gesture and he assembled the robot in less than 3 min. While the child of grade 3 recognizes all the gestures except for the "HUNGER" gesture, and he manages to assemble the robot with minimal help from the therapist in less than 4 min. Figure 10 shows evidence from the last session of each child. The results of the tests performed on children with ASD are separated by the degree of autism.

Fig. 10. Children with ASD last sessions; A: Child with ASD grade 1, fifth session, 06/08/20; B: Child with ASD grade 1, third session, 07/08/20; C: Child with ASD grade 2, fifth session, 06/08/20; D: Child with ASD grade 3, fifth session, 07/08/20

In children with autism grade 1, it is evident that gesture recognition increases as the sessions increase. Figure 11A shows the media of gestures recognized in each session. The help of the therapist decreases so they can handle the system (Robotic kit and application) alone as can be seen in Fig. 11B. The arming times decrease until reaching the initial objective of minus 1 min, the results are observed in Fig. 11C.

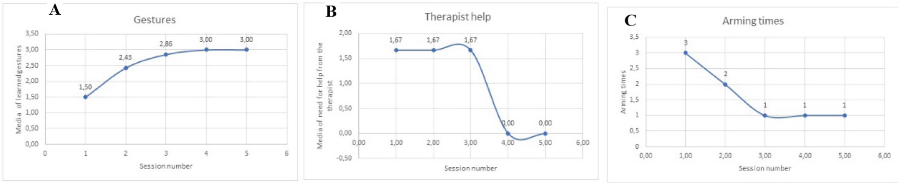

Fig. 11. Results of children grade 1

The results in the child with autism grade 2 are also favorable. The gestures learned increase as more sessions are performed. An increase in the media from 0.29 to 1.29 is evidenced in a range of 3, as can be seen in Fig. 12A. The therapist's help, although still a bit high, tends to decrease as shown in Fig. 12B. And the arming times went from not assemble the robot to assemble it in less than 2 min, despite only placing the extremities, the results are observed in Fig. 12C. In the fourth session a peak is observed in Figs. 12A and 12B, this is due to the fact that in that session the child presented very high hyperactivity, according to the therapists this is due to his diet in that day.

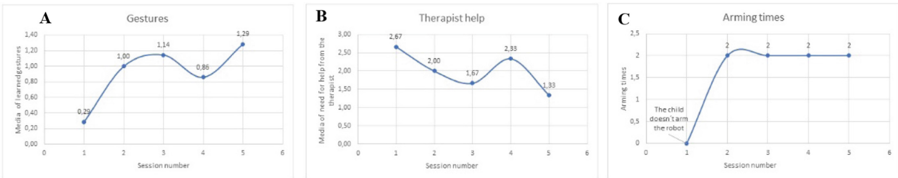

Fig. 12. Results of children grade 2

Finally, in the child with autism grade 3, considering that his degree of autism is serious, the advances that he presents, as more sessions are carried out, are significant. He passes in the recognition of gestures of a media from 0.14 to 0.86 of a maximum value of 3, as we can be seen in Fig. 13A. The therapist's help, however, continues to be maximum, but it came to this by not paying any attention to the robot in the first sessions, as shown in Fig. 13B. The arming times went from not assemble the robot to assemble it in a time of less than 3 min, despite only placing some parts, the results are observed in Fig. 13C.

Fig. 13. Results of children grade 3

4 Conclusions

The portable robotic modular kit is a tool designed for reinforcement therapy at home (easy portability), with a direct approach to children with ASD. It contributes in the teaching of gestures, laterality and development of motor skills. It allows children with ASD to do reinforcement work at home, with a data collection for later delivery to the therapist in charge.

The portable robotic modular kit is an educational tool. According to an average of 3.82 out of 4 on the satisfaction scale by the parents who used the robotic kit, they consider that it has the correct shape and weight to be carried and used as a reinforcement tool at home. In addition, the system allows a rapid collection of information by parents or guardians of patients, the same that is provided to therapists for the evaluation of progress in the therapies carried out.

In all the children with autism, there was a noticeable improvement for each session. The best results are observed in children with autism grade 1, where on the scale proposed by therapists, a 100% of satisfaction is achieved. While in children with autism grade 2 and 3, a 50% of satisfaction in the proposed criterion is achieved with an increasing trend. Also, several recommendations given by parents of children without disorders show the desire to use the tool as a toy for the development of motor skills in their children.

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References

1. Robertson, C.E., Baron-Cohen, S.: Sensory perception in autism. Nat. Rev. Neurosci. **18**(11), 671–684 (2017). https://doi.org/10.1038/nrn.2017.112
2. López-Chávez, C., Larrea-Castelo, M.-L., López-Chávez, C., Larrea-Castelo, M.-L.: Autismo en Ecuador: un grupo social en espera de atención. Revista Ecuatoriana de Neurología **26**(3), 203214 (2017)
3. Moncayo, C., Carofilis, J.: Situación de la inclusión eduacativa de niños y jovenes con trastorno del espectro autista (TEA), en las instituciones educativas en las ciudades de Santo Domingo y Manta durante el año lectivo 2013 – 2014. Pontifica Universidad Católica del Ecuador (2014)
4. Naguy, A., Abdullah, A.: Autism: the second triad of impairment demystified. J. Nerv. Ment. Dis. **207**(5), 417 (2019)
5. Dimitrova, N., Özçalışkan, Ş., Adamson, L.B.: Parents' translations of child gesture facilitate word learning in children with autism, Down syndrome and typical development. J. Autism Dev. Disord. **46**(1), 221231 (2016)
6. Boucenna, S., Narzisi, A., Tilmont, E., Muratori, F., Pioggia, G., Cohen, D., Chetouani, M.: Interactive technologies for autistic children: a review. Cogn. Comput. **6**(4), 722–740 (2014). https://doi.org/10.1007/s12559-014-9276-x
7. Alhaddad, A.Y., Cabibihan, J.-J., Bonarini, A.: Head impact severity measures for small social robots thrown during meltdown in autism. Int. J. Soc. Robot. **11**(2), 255270 (2019)
8. Zhang, Y., Song, W., Tan, Z., Zhu, H., Wang, Y., Lam, C.M., Weng, Y., Hoi, S.P., Lu, H., Man Chan, B.S., Chen, J., Yi, L.: Could social robots facilitate children with autism spectrum disorders in learning distrust and deception? Comput. Hum. Behav. **98**, 140149 (2019)

9. Soares, F., Costal, S., Gon, N.: Robotic-Autism project: technology for autistic children. In: 2013 IEEE 3rd Portuguese Meeting in Bioengineering (ENBENG), pp. 14 (2018)
10. Sánchez, X.E.B.: Efectividad del 'Robot Milo' en el desarrollo de habilidades sociales y comunicación en niños de 5 a 7 años con trastorno del espectro del autismo de grado 1. Universidad San Francisco de Quito, Quito (2018)
11. Matovelle, L., César, D.: Diseño y construcción de una cabeza mecatrónica de aspecto realista 2013. Accessed 23 Apr 2020
12. Paracuellos de los Santos, D.: Programación de Robots para mejorar la atención terapeutica de niños con Trastornos Generalizados del Desarrollo (TGD). Dec. 2017
13. Telisheva, Z., Turarova, A., Zhanatkyzy, A., Abylkasymova, G., Sandygulova, A.: Robot-assisted therapy for the severe form of autism: challenges and recommendations. En: Salichs, M.A., Ge, S.S., Barakova, E.I., Cabibihan, J.-J., Wagner, A.R., Castro-González, Á., He, H. (Eds.) Social Robotics (pp. 474–483). Springer International Publishing (2019)
14. Schadenberg, B.R., Reidsma, D., Heylen, D.K.J., Evers, V.: Differences in spontaneous interactions of autistic children in an interaction with an adult and humanoid robot. Front. Robot. A **I**, 7 (2020). https://doi.org/10.3389/frobt.2020.00028
15. Zheng, Z., Das, S., Young, E.M., Swanson, A., Warren, Z., Sarkar, N.: Autonomous robot-mediated imitation learning for children with autism. In: 2014 IEEE International Conference on Robotics and Automation (ICRA), pp. 2707–2712 (2014). https://doi.org/10.1109/ICRA.2014.6907247
16. Ryazantsev., A., Baranova, L.A.: Android NAO robot as a correction tool of abnormalities in children with autism. TEST Eng. Manage. **83** (2020)
17. Zheng, Z., Young, E.M., Swanson, A.R., Weitlauf, A.S., Warren, Z.E., Sarkar, N.: Robot-mediated imitation skill training for children with autism. IEEE Trans. Neural Syst. Rehabil. Eng. **24**(6), 682–691 (2016). https://doi.org/10.1109/TNSRE.2015.2475724
18. Martos, J., Freire-Prudencio, S., Llorente-Comi, M., Ayuda-Pascual, R., Gonzalez-Navarro, A.: Autism and intelligence quotient: stability? Rev. Neurol. **66**, S39–S44 (2018)
19. Sandoval, V., Irene, C.: Programa de juegos psicomotrices para el desarrollo de las nociones espaciales en niños de 5 años de la I.E.I. N° 011 "Juan Ugaz". Chiclayo-2017 (2018)