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ROBOTICS AS A DIDACTIC TOOL FOR STUDENTS WITH AUTISM SPECTRUM DISORDERS: A SYSTEMATIC REVIEW

La robótica como herramienta didáctica para personas con desórdenes en el espectro del autismo: una revisión sistemática

Itsaso Arocena Perez
itsaso.arocena@ehu.eus
https://orcid.org/0000-0002-1551-4405
University of the Basque Country (Spain)

Asier Huegun Burgos
asier.huegun@ehu.eus
https://orcid.org/0000-0003-0703-0766
University of the Basque Country (Spain)

Itziar Rekalde Rodríguez
itziar.rekalde@ehu.eus
https://orcid.org/0000-0002-9297-6734
University of the Basque Country (Spain)

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Resumen

Este artículo describe los resultados cuantitativos y cualitativos de un estudio cuyo objetivo es identificar las tendencias y oportunidades de innovación en el campo de la robótica socioeducativa, utilizada como herramienta didáctica, con el fin de desarrollar las diferentes habilidades, destrezas y competencias de los estudiantes con necesidades específicas de apoyo educativo escolarizados; estudiantes con trastornos del espectro del autismo específicamente. Para ello se ha realizado una revisión sistemática de la literatura, mediante una estrategia de búsqueda rigurosamente definida. Los resultados obtenidos permiten identificar los avances en cuanto a modelos didácticos basados en el uso de la robótica como herramienta educativa, actividades pedagógicas y recursos didácticos; criterios, estrategias e instrumentos de evaluación y experiencias de aplicación en contextos escolares reales

Abstract

This article describes the quantitative and qualitative results of a study aimed to identify the trends and innovation opportunities in the social robotics area. Using robots as a didactic tool to develop different skills, abilities, and competencies of students with specific educational support needs who attend mainstream school classes; students with autism spectrum disorders specifically. A systematic review of the literature was carried out through a rigorously defined search strategy. The results obtained allow us to identify the advances in didactic models based on robotics as an educational tool, pedagogical activities and didactic resources, evaluation criteria, strategies and instruments, and application experiences in real school contexts.

Palabras Clave: Trastornos del espectro del autismo, escuela, robótica socio-educativa

Keywords: Autism spectrum disorders, school, social robotics

Introduction

Social robotics represents an innovative area, especially in education (Bekele, Crittendon, Swanson, Sarkar & Warren, 2014). During the last years, articles written about social robotics have multiplied (Billard, Robins, Nadel & Dautenhahn, 2007). Day by day, more researchers begin to see robots as valuable tools in educational processes, especially for those with special educational needs.

In the case of people with autism specifically, many experiences show us how they are attracted to social robots, how they like and enjoy spending time with them (Fortis, Goedert & Barrett, 2011; Dunst, Trivette, Prior, Hamby & Embler, 2013; Huskens, Palmen, Van der Werff, Lourens & Barakova. 2015). However, do robots give them something positive besides fun? Do they improve their quality of life in any way?

When we review the literature about social robotics written lately, we can see that it is not easy to find special educators or teachers in the primary databases on education (Web of Science, Scopus, and ERIC). Most of the articles are written from computer engineering or mechanical engineering. That is, they have not been addressed from an educational point of view.

Autism spectrum disorders nowadays

Which are the main theories about ASD?

There are several explanatory theories of autism spectrum disorders. These are the ones that are commonly accepted by the scientific community (Wellman, 2016).

Theory of mind

The theory of mind allows us to modulate our social behavior, makes us able to put ourselves in the place of the other, and makes us understand our emotional circumstances (Yun, Choi, Park, Bong & Yoo, 2017).

We decipher what is in the other's mind using the information given by their facial expression, body posture, and intonation to express themselves (Baron-Cohen, Campbell, Karmiloff-Smith, Grant & Walker, 1995). The more we know a person, the more we know about their knowledge, intentions, beliefs, and desires, and the easier it gets for us to know what is "going through their mind." In ASD, the theory of mind deficits carries difficulties, such as understanding one's mind and others' minds, understanding the rules that regulate social interaction, communicative use of language, and symbolic game (Baron-Cohen et al., 1995).

Central coherence theory

Central coherence theory claims that people on the spectrum of autism tend to process information in high-level units of meaning, losing details (Valdez, 2001). On the one hand, this information processing involves a more remarkable ability for analytical tasks and better processing of the visual versus the linguistic. On the other hand, less ability in global stimulus processing, difficulties in differentiating relevant information from irrelevant information, and problems processing the information in a contextualized way (Martos-Pérez, Llorente-Comí, 2013).

Executive function theory

The executive functions are necessary mental abilities. They give us context to execute our mental functions efficiently (Willcutt, Doyle, Nigg, Faraone & Pennington, 2005). We can say that they unify, order, and coordinate all other cognitive functions. Deficits in executive function explain the rigidity people on the spectrum experiment when facing changes, problems to define goals and design strategies, difficulties in anticipating the future, presence of repetitive, stereotyped behavior, and restricted interests (Hujinen, Lexis, Jansens & de Witte, 2016).

Extreme male brain theory

This theory was proposed by Simon Baron-Cohen (2002). Although it is becoming increasingly unpopular, extreme male brain theory argues that there are differences between male and female brains. ASD people's brains could act as they have a male brain taken to the extreme. The observable characteristics would be more systematic thinking, more detail fixing, less empathic capacities, less social abilities, and less skilled conversation (Warren, Zheng, Das, Young, Swanson, Weitlauf & Sarkar, 2015).

Why is it important to develop joint-attention in children with ASD?

People who grow up and progress ordinarily develop joint attention mainly through symbolic play and effective interaction with their caregivers. First joint attention signs begin to occur between 9 and 18 months of age (Charman, 2003). On the contrary, this phenomenon does not occur in people who are within the autistic spectrum. Unlike children with typical development, children with ASD are often more involved with their thoughts and feelings than with other people (Carrasco, Alarcón & Trianes, 2018; Charman, 2003; Matsuda, Nunez, Hirokawa, Yamamoto & Suzuki, 2017).

Joint attention consists of a group of nonverbal behaviors that include directing the gaze, pointing, and teaching objects, which refer to external stimuli during a communicative exchange (Nowell, Watson, Faldowski & Baranek, 2018), as well as the ability to keep focused on something simultaneously with our partners (Carrasco et al., 2018).

This ability allows us to cooperate and socialize with others. Interacting with other children during childhood is fundamental to developing the social and language skills we need in adulthood (Matsuda et al., 2017).

In addition, as seen in Figure 1, we know that joint attention is a pivotal ability, so to say, a skill that is fundamental for developing other areas of functioning. Because of this, the development of pivotal abilities produces generalized behavioral improvements in children (Charman, 2003; Weiss and Harris, 2016).

Etic@net
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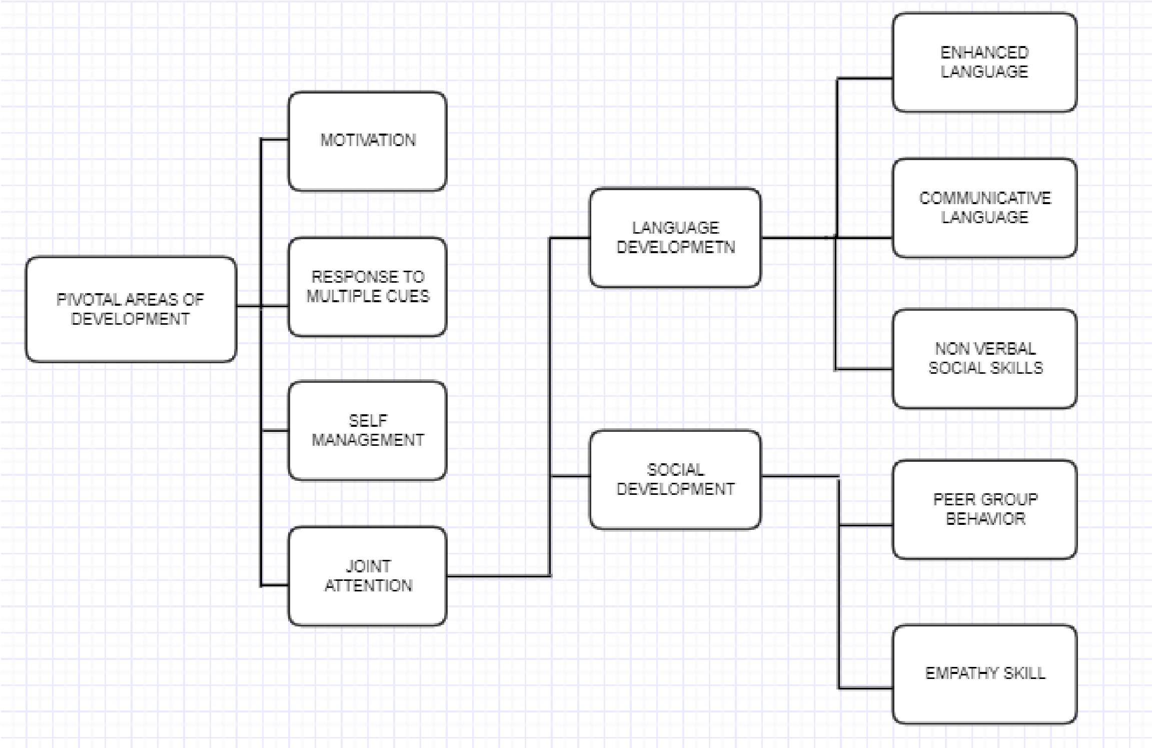
Figure 1. *Structure of pivotal abilities*



Note. Prepared by the author based on Charman, 2003; Nowell et al. 2018; Matsuda et al., 2017

We can conclude that by developing these essential or key skills, we will naturally improve all others, thus working on a generalized development of the quality of life of the person with ASD and facilitating their daily routines.

Which are the common interventions to develop joint-attention in primary and secondary school?

Below are different interventions that are currently used to improve the quality of life of people with ASD (Fuentes-Biggi, Ferrari-Arroyo, Boada-Muñoz, Touriño-Aguilera, Artigas-Pallarés, Belinchón-Carmona & Díez-Cuervo, 2006). There are many more, but we have chosen those based on scientific evidence.

The Discrete Trial Training (DTT) method breaks down specific skills in small steps, which are learned gradually, so they are taught from attention skills to more complex ones such as verbal skills or social behaviors. It starts from simple skills, increasing complexity as the child progresses (Mulas, Ros-Cervera, Millá, Etchepareborda, Abad & Téllez de Meneses, 2010). The methodology is based on four elements:

First of all, the therapist presents a stimulus as a precise order or question. If necessary, the order is followed by reinforcement. Secondly, the child responds correctly or incorrectly. Finally, the therapist provides a consequence: a correct answer receives a boost while an incorrect one is ignored or corrected.

The Denver model presents a checklist composed of four levels of objectives divided into months old the child is (Kim, Berkovits, Bernier, Leyzberg, Shic, Paul & Scassellati, 2013). The model divides the development of the child into four levels: 12 to 18 months, 18 to 24 months, 24 to 36 months, and 36 to 48 months. These goals are milestones that children with ASD need to improve to achieve a better quality of life in their early years. This curriculum was designed from the observation of babies with ASD symptoms to reinforce those most challenging areas. The evaluation is done together with the parents and is mainly observational (Rogers & Dawson, 2010).

Pivotal Response Training (PRT) is a variation of Applied Behavioral Analysis (ABA) type therapy. It focuses on pivotal areas: increasing a child's motivation to learn, initiating communication, joint attention, and self-regulation. By focusing on these main areas, the effects of treatment carry over into many aspects of a child's behavior and skills, including social, communicative, and academic skills (Minjarez, Mercier, Williams & Hardan, 2013).

PRT incorporates into the child's everyday routine, along with family members, peers, teachers, and other professionals (Forment-Dasca, 2017). Each program is carefully customized to the needs of a specific child. The essential components of PRT include:

- Treatment takes place in the natural environment of the kid: home or school
- Family involvement

- Coordination with professionals across all environments (teachers, educators)
- Treatment focused on pivotal areas.

The SCERTS model plans objectives for the child with ASD to meet for a comprehensive evaluation of this in all its contexts. The SAP (SCERTS Assessment Process) is a model evaluation process made of two parts; the recording one and the observational one. It is a long and extensive process and allows educators to determine the key objectives in the intervention. It is composed of three stages.

The first one is the social partner stage. The child communicates with their peers through presymbolic communication systems, gestures, or vocalizations. The second one is the linguistic couple stage, where the child communicates with peers by single words to combinations of several words besides early symbolic communication systems. Finally, the conversational couple stage, where the child communicates with their peers through phrases and interactive speech.

Is it possible to use social robotics as educational intervention tools?

Understanding and using social skills is the most challenging developmental area for people with autism spectrum disorders (Weiss and Harris, 2016). They feel, live, and express their affection and emotions in different and personal ways, making communicative exchanges complicated, which can cause frustration on the participants of said communicative actions.

During the last decades, various types of educational interventions using animals have emerged, especially for people with functional diversity. The value of these interventions assisted by animals is commonly accepted; contact with an animal positively influences the self-perception of the human being and stimulates their social behavior. This effect is called a social catalyst since it facilitates interpersonal interactions (Beetz, Uvnäs-Moberg, Julius & Kotrschal, 2012). Dealing with animals makes people with ASD trust others more easily, develop greater empathy and increase their self-esteem, as they feel able to do something difficult for them (Simut, Vanderfaeillie, Peca, Van de Perre & Vanderborght, 2016).

The animals that have proven to be most effective are dogs. However, we can also find studies conducted with horses, cats, and other animals, which show beneficial effects of this type of intervention in people with ASD (Silva, Correia, Lima, Magalhães & de Sousa, 2011).

The most significant difference between using animals and using robots as a social catalyst lies in controlling the situation. Pets can be trained to be great therapists, but animals will always have a series of unexpected behaviors facing a situation, which we can not completely control. However, we can fully program a robot and adapt it to respond to the needs that arise during an interaction. This control gives us flexibility and a more remarkable ability to reach all users, regardless of their circumstances (Beetz et al., 2012).

Recent studies show that people with ASD tend to feel comfortable interacting with social robots due to their low emotional stimulation (Huijnen, Lexis, Jansens & de Witte, 2016; Kumazaki, Warren, Swanson, Yoshikawa, Matsumoto, Ishiguro & Kikuchi, 2018).

Interacting with robots can be particularly enriching for a child with autism spectrum disorder, as it can overcome the barriers experienced in face-to-face interaction with other people. However, there is always a person behind the robot who must design the objective of the intervention and all the appropriate didactic sequence to achieve it (Hashim and Yussof 2017; Huijnen et al., 2016).

Aims of the current study

The purpose of this study is to provide a systematic review of the scientific literature about using robotics as tools in educational intervention with people with ASD in order to fulfill the following goals:

- Determine the number of articles that have been published in ERIC,

WOS, and Scopus databases
- Identify which is the scientific field where research is being done on this topic
- Determine the impact factor of the articles that tackle this topic
- Analyze the chronological evolution of this topic in the current scientific production
- Identify the main objectives to be developed through robotics
- Determine if the objectives proposed are fulfilled
- Describe the scenario where the interventions have been made
- Establish the participant number on the interventions
- Identify the duration of the intervention
- Detect the main robot models used and their characteristics

Method

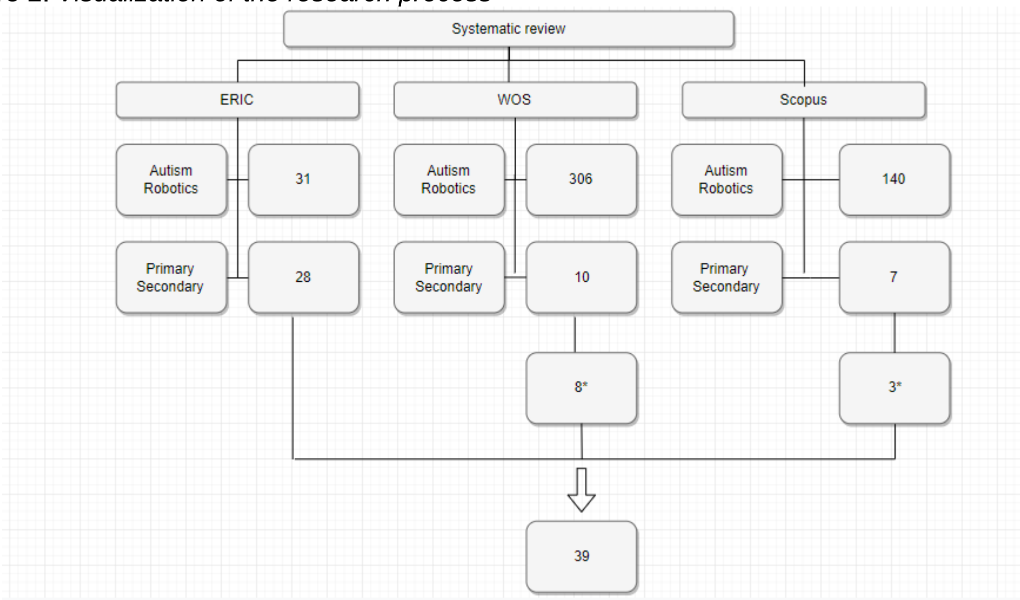
This study aims to deepen the field of science that combines social robotics and learning difficulties, specifically autism spectrum disorders, from an educational perspective. The most relevant databases for research in the socio-educational field were chosen; Web of Science (WOS), Scopus, and Education Resources Information Center (ERIC).

The method chosen was a systematic review. Kitchenham Brereton, Budgen, Turner, Bailey, & Linkman (2009) claim: "Researchers performing a systematic review must make every effort to identify and report research that does not support their preferred research hypothesis as well as identifying and reporting research that supports it" (p.5).

The keywords chosen were autism and robotics. Using the thesaurus the database provides us with, we could do more exhaustive research using the following keywords; On the one hand, autism, Asperger syndrome, and behavior disorders. On the other hand, social robotics, cybernetics, and electronics.

Considering that our focus and interest are on primary education and secondary education, all other educational levels were excluded, leaving us with the final figure of 28 studies in ERIC, ten studies in WOS, and seven studies in Scopus.

Figure 2. *Visualization of the research process*



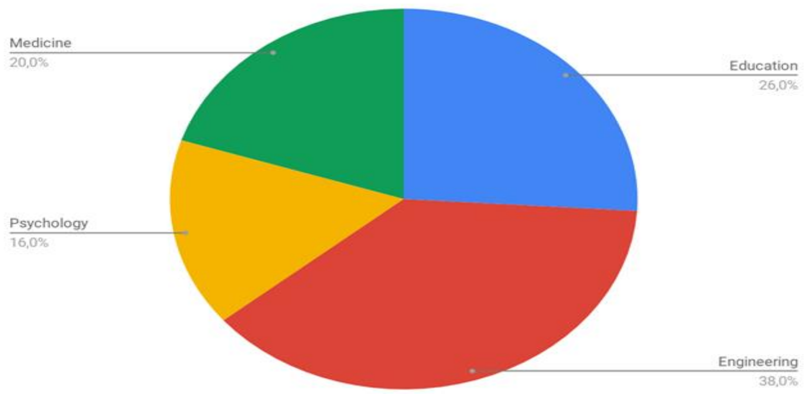
The analysis started through the ERIC database because it references education, continued with WOS and ended up with Scopus. As the work progressed, we noticed that some articles were repeated in the three databases. *These repeated articles were manually discarded. We are aware that the number of articles found in this search will vary from when the article was written until its publication date since socio-educational robotics is a field that is now emerging.

In order to keep these articles organized, an index file was created (Díaz-Posada, Varela-Londoño & Rodríguez-Burgos, 2017). The selected articles were sorted according to the date, from the oldest to the newest. In addition, the following data were also collected in the files; the name of the article, journal, type of publication, country of publication, and name and surname of the authors. Those files were encrypted with code names and added to other files according to the items analyzed.

Results

Firstly, the scientific field where the papers belong was analyzed. To do so, the areas from which the authors of the selected articles came were taken into account. Most of them show us the result of collaborative works, so they belong to different fields simultaneously.

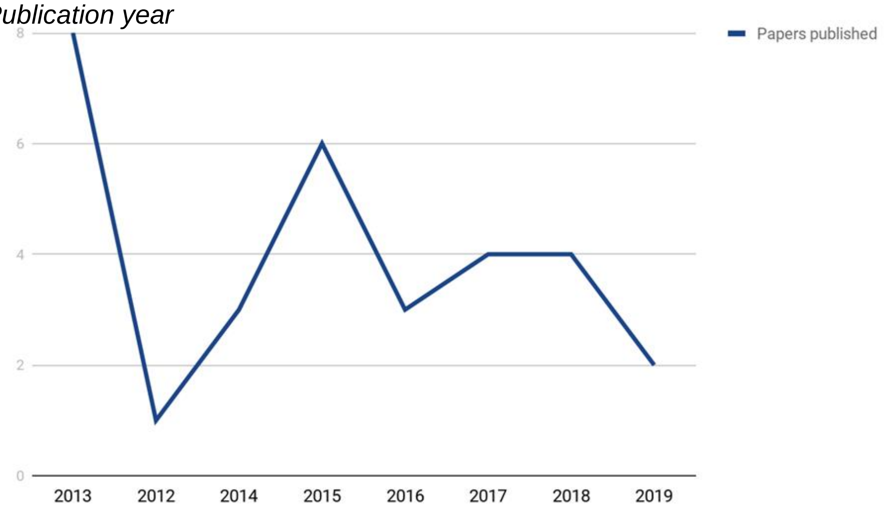
Figure 3. *Scientific field*



Engineering is the field from which more was researched on the educational robotics subject (Figure 3), closely followed by education. Finally, something less has been investigated from psychology and medicine.

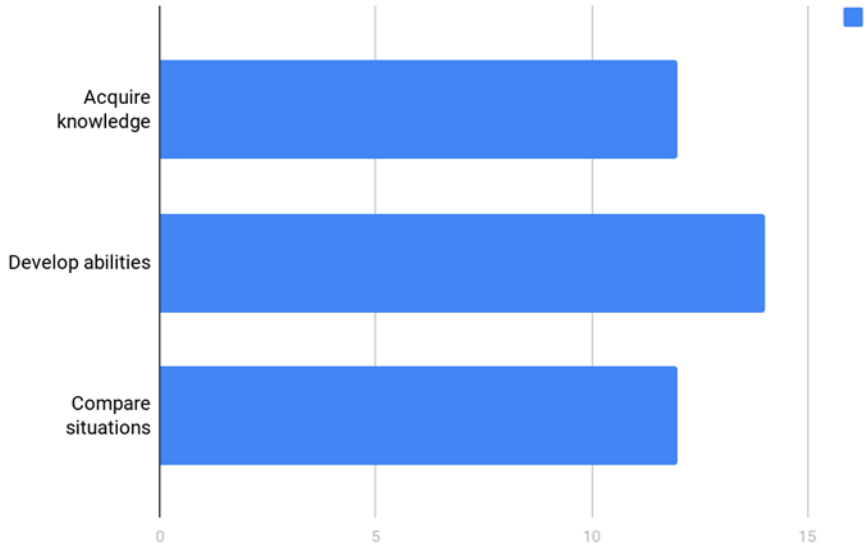
Afterward, we will focus on the years in which these articles were published.

Figure 4. *Publication year*



The first article found in this search was published in 1968. Since then, there have only been one or no publications per year, until we arrived in 2013, where there is a prominent production peak (Figure 4). As of this moment, production declines although it remains higher than in the previous period.

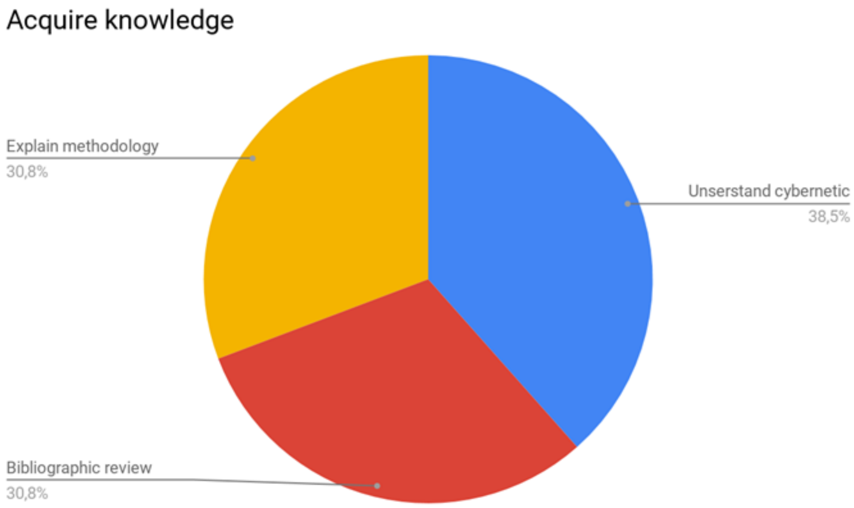
Figure 5
Objectives



Hence objectives of the articles chosen were analyzed. They were classified into three areas; Acquire knowledge, develop abilities and compare situations. Watching Figure 5 gives us the feeling that it is commonly accepted that social robotics can be used to improve different skills in people on the autism spectrum.

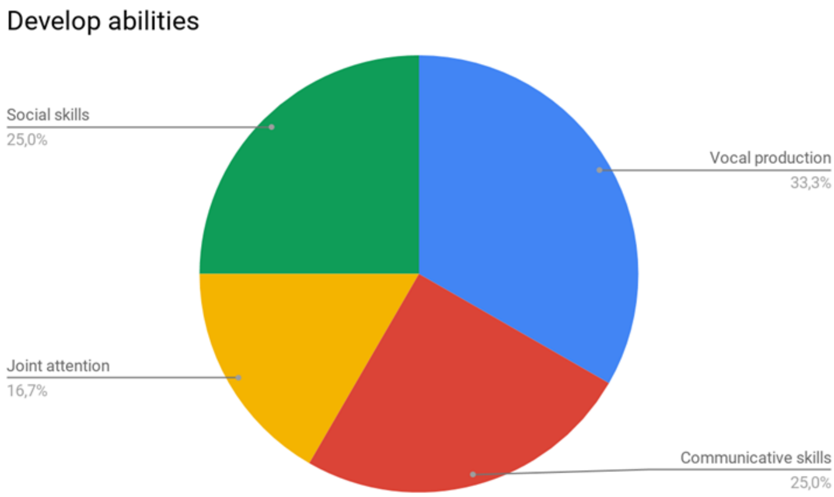
Most of the works aims to develop the skills of the participant. Many of them seek to gain knowledge in this area, and some aim to compare different situations. Each area was individually analyzed.

Figure 6
Objective: Acquire knowlidge



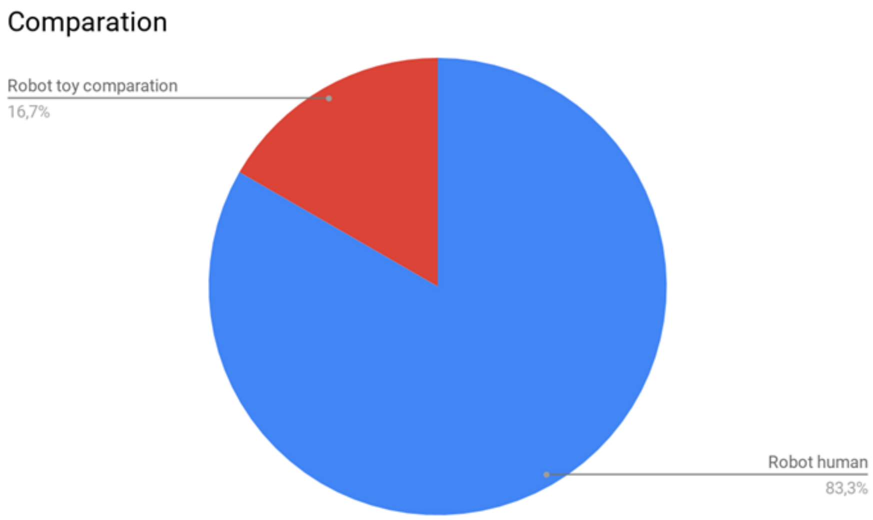
Henceforth, we will focus on those articles that aim to gain knowledge (Figure 6). The majority does it through understanding the cybernetic systems and explaining how they work. Some works aim to review the subject bibliographically, and the rest aims to explain or publicize the working methodology used.

Figure 7
Objevtive: Develop abilities



As Figure 7 shows, most of the works intended to increase the vocal production of the participants in terms of skill development. In the second place, we find those works aimed to increase the communicative skills of the participants, and finally, we find those works aimed at developing joint-attention and social skills to the same extent.

Figure 8
Objective: Comparison



The vast majority of comparative works base their comparison on the same scenario; the same intervention is repeated with both a human and a robot (Figure 8). Only one of the analyzed works compares the effectiveness of the robot with a traditional toy.

Now we turn from the objectives to the conclusions of the articles analyzed. Regarding the level of compliance with the objectives set, ten of the papers met their objectives, six of the works claim not to have met their objectives, and two of them show an intermediate level of compliance.

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Table 1
Objectives met

Objectives met	Objectives not met	Unexpected objectives	Not educational objectives
13	8	5	13

As seen in Table 1, 33,3% of the articles have undefined educational objectives. Those who do not come from pedagogy have the object of studying the robot, its design, and its operation. Therefore, after doing a couple of sessions with children, the conclusions obtained throw no light on robotics as an effective tool to work with people on the spectrum of autism. In this section, we want to clarify that we refer to those articles that do not have any goal regarding the students as not educational objectives.

On the one hand, among the works that claimed to meet their objectives, six articles aimed to communicate with the robot. Two of them intended to improve the students' vocal production, and two others made comparisons of two similar situations. In one of them, students interacted with the robot, and in the other, students interacted with a person.

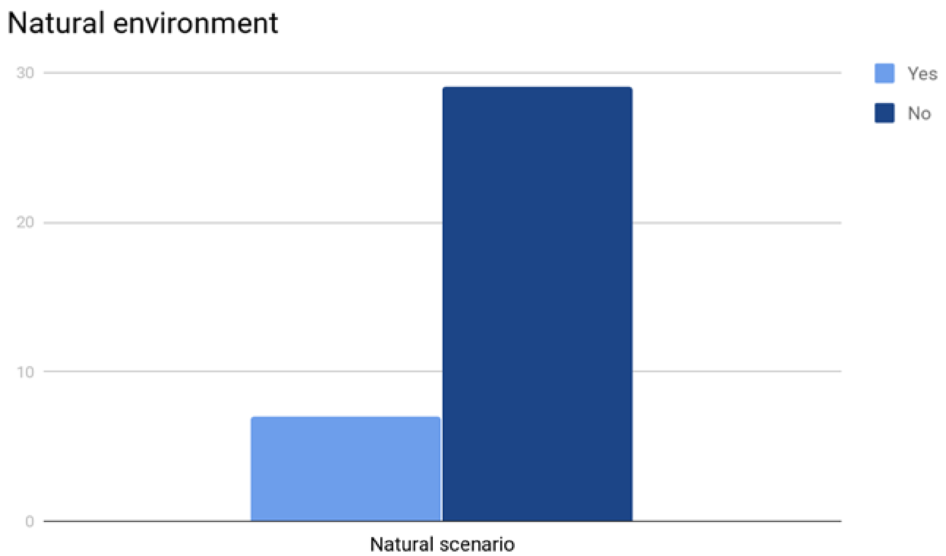
On the other hand, we have articles that did not meet their objectives. Four of these works compared two similar situations. In one, the student interacted with the robot, whereas in the other one, the student interacted with a human. Another one of the articles that did not meet their objectives tried to increase the students' vocal production through a robot. The last of the articles aimed to compare students' behavior after performing an intervention of a few sessions. However, when comparing these results with the control group, which did not participate in the intervention, no conclusive differences were found.

To conclude with this section, we will mention two articles that achieved objectives and unachieved objectives. The first of these aimed to reduce the anxiety of the participants and improve their social skills. After finishing the intervention, it was observed that although students did reduce their anxiety, there was no significant improvement in social skills.

Finally, we found an article that the authors present as unfavorable, although it could be considered differently. This work aimed to ensure that students imitate the robot better than a person. It was carried out with a group of people on the autism spectrum and neurotypical people. Interestingly, people on the spectrum imitated the robot better, while neurotypical students imitated the person better.

Next, the works in which socio-educational interventions were carried out were analyzed. Specifically, we focused on whether these interventions were carried out in the participants' natural environment or occurred in an artificial environment.

Figure 9
Scenario



As we can see in Figure 9, most of the interventions were carried out in artificial environments, such as; a research center or an isolated room inside a school. Few were made on natural scenarios to the participants, as their school, ordinary classroom, or even their own homes.

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Figure 10
Participant number

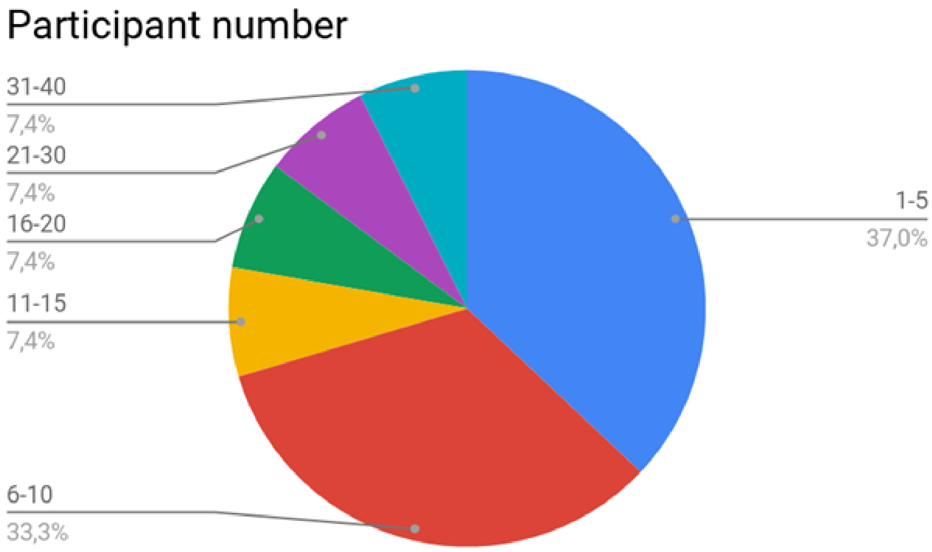

Figure 10 shows that more than half of the interventions analyzed were carried out with less than ten participants, and one-third of the studies analyzed were put through with less than five participants in them.

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Figure 11
Inclusion criteria

All the articles were analyzed to explain selecting the participants and the sample of participants in detail. However, only six articles mention the selection criteria used: they were based on choosing the intervention participants.

In Figure 11, we can see the inclusion criteria that these researchers used when choosing participants for their interventions. As shown in the image, the condition to participate in the most repeated interventions is to have a minimum intelligence quotient.

The second most repeated criterion is very close to the first and is the vocal production; Some researchers require their participants a minimum of spoken production capacity to participate in their project.

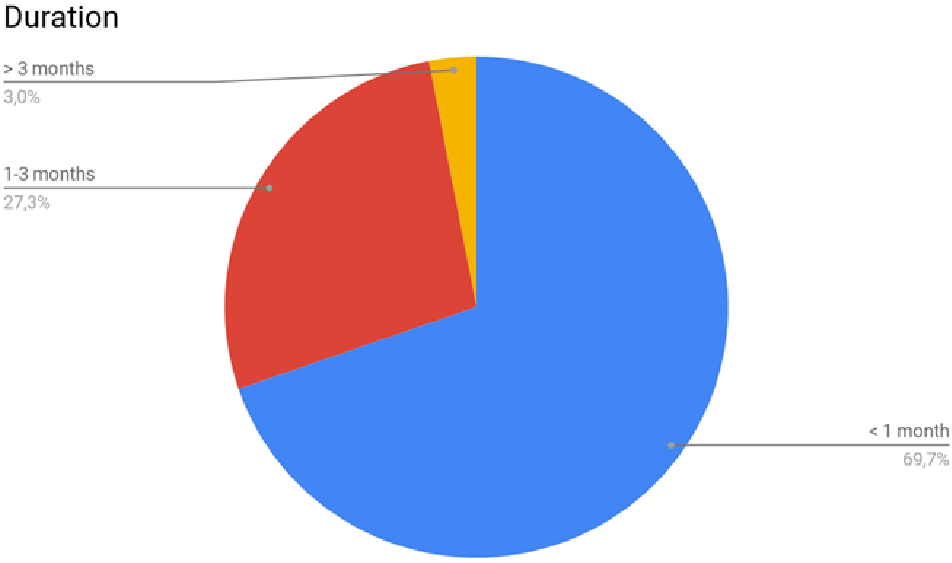
The third most repeated request is the age of the participants. All studies ask for participants between the ages of four years and 13 years. We conclude from this that the literature focuses on students who are in the primary school stage.

Fourth, we have another criterion that refers to the skills of the potential participants. Some researchers ask students who will participate in their interventions not to have any visual or hearing disability, nor should they have any psychiatric disorder. We should remember that we are analyzing those works that do include the selection criteria. Since most of the articles analyzed in this meta-analysis do not mention any criteria, we can find students with Down syndrome or generalized developmental disorder.

We start now with those criteria that are mentioned once. The first one says that the selected participants should not be participating simultaneously in another intervention. Another one of the selection criteria says that the participating students should show a lack of social initiation.

Continuing with the skills required of the participants, one of the studies requires its potential participants to have the ability to recognize emotions and facial expressions. We have left for the end the selection criteria that have seemed most relevant to us, and that is inclusion in schools. One of the articles stipulates that participant must attend school and must be included in the scholar system.

Figure 12
Intervention duration



The next item analyzed was the duration of the interventions. 59,7% of the interventions examined lasted less than one month, 27.3% lasted between one and three months. Finally, a single work carried out an intervention beyond three months (Figure 12).

In the next section, the methodologies used in the reviewed research will be analyzed. As we can see, most of the interventions have used video recordings to collect their data. Out of 23 articles that have used the video recording methodology, 21 have defined their indicators of success and have analyzed the recordings quantitatively, adding numerical values to each segment of the video, according to the number of indicators met. However, two of these 23 articles have analyzed the videos quantitatively but using pre-existing research applications to do so.

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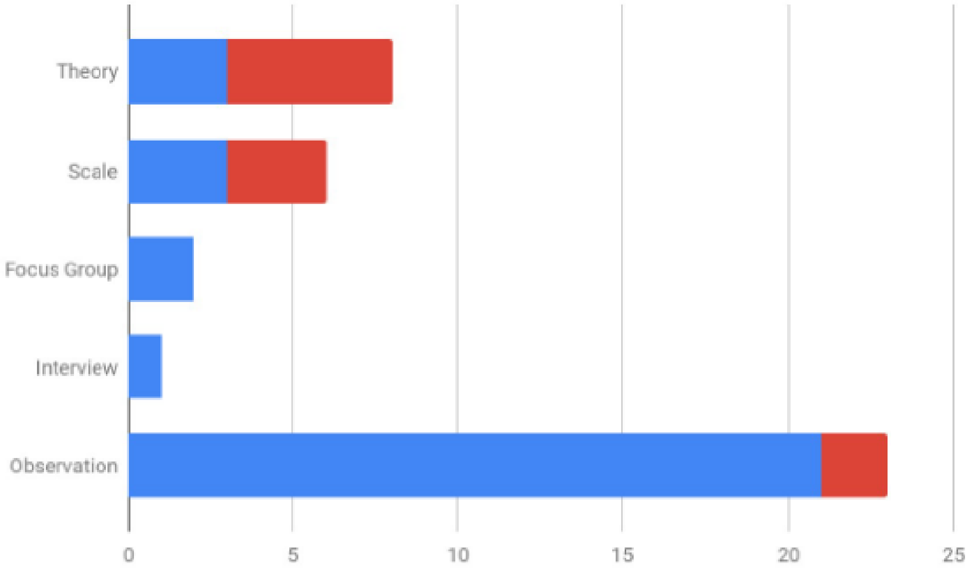
Figure 13
Research methodology



Following the numerical order, in second place, we find the theoretical works, three of which are intervention proposals. Five are reviews of previously carried out interventions, making a total amount of eight papers. In third place are the investigations that have used scales to measure their results. They used pre-existing scales, three used the test system, and three used the pre-test and post-test system.

Finally, we find the least used data collection methodologies in this field: the focus group and the interview. A Focus group was used in two investigations to collect opinions and perceptions of the participants. The interview was used in a single intervention, along with a scale, for the same purpose.

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Figure 14
Robot models

As we can see in Figure 14, the most used robot among the analyzed works was Nao, closely followed by Popchilla, Kaspar, and Probo. All the works carried out to explain the characteristics of the robot that they chose to carry out the intervention. However, only four of them justify this choice.

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Figure 15

Robot model justification

"A useful feature of the NAO robot is its programmability. It comes off the shelf with several behaviors that can be used in human-robot interaction, and other behaviors can be implemented for special-purpose behaviors"

Charron, Lewis, Craig, 2017

"Studies indicate that KASPAR can contribute to positive results in the area of increasing body awareness, encouraging collaborative skills (Wainer et al. 2014b); prolonging children's attention span (Costa et al. 2013); mediating and encouraging social interaction (Ben Robins et al. 2009); and learning appropriate physical interaction (Costa et al. 2015)"

Huijnen, Lexis, Jansens, 2017

"This robot was chosen because of its ability to roughly simulate human movement and because it is publicly available for purchase"

Kaboski, Diehl, Beriont, 2015

"The soft touch and huggable appearance of Probo, as well as its capacity to show emotions and use language, make Probo an appropriate tool for an intervention that improves social skills, like SS, with a special focus on ASD children."

Pop, Simut, Pintea, Saldien, Rusu, Vanderfaeillie, David Lefeber, Vanderborght, 2014

As we can observe in Figure 15, the characteristics that make researchers choose a robot model or another are mostly programmability, accessibility, the

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humanoid form, or the shape of a stuffed toy. Depending on the objectives of the intervention, one or the other form was chosen.

Discussion

We can arrange the difficulties that a person in the spectrum of autism lives in three major categories; Difficulties of social interaction, communication difficulties, and difficulties of activity and interest (Taylor, 2015; Javed & Park, 2019). Of these three blocks, we can see that the literature focuses more on working on the first two.

However, it is known that working on pivotal skills like joint attention, other areas such as communicative language or empathy improve as well (Charron & Craig 2017). It seems logical to think that if individuals feel more comfortable in their social environment, they will feel less anxiety. Their communicative language will improve as well as their vocal production. They will be more inclined to communicate with the people around them.

Nevertheless, most of the works carried out were aimed to improve vocal production, that is, getting the child to say more words by using a robot. Although vocal production is essential, it is even more critical to work joint attention and social skills with people on the spectrum of autism (Hujinen, Lexis, Jansens & de Witte, 2017), which, as a curiosity, make up the less researched objectives in this area.

The individual with ASD condition likes things to stay the same, with no changes. Often, the person with ASD has difficulty moving from one thing to another (Jung, Lee, Cherniak & Cho, 2019). In the case of children, this is shown as stress when a transition is necessary (Taylor, 2017). Considering this, we can expect that bringing the child to an experimental room where he/she has not been before, his/her behavior will not be the same as it usually is.

It will take a while for them to accustom to this new situation. We will have to establish a routine where we carry out the same sessions simultaneously for a while so that the results are conclusive. Moreover, the goal of a robot should be to provide educational support in the classroom, never to replace the teacher (Warren, Zheng, Swanson, Bekele, Zhang, Crittendon & Sarkar, 2015).

Despite this information, the vast majority of the researches have not taken place in the natural environment of the kids (home, school), but they were carried out in experimental rooms. In addition, in many cases, they made less than five sessions total, so we consider that the results shown by these experiments are inconclusive.

In the fifth edition of its diagnosis and statistical manual of mental disorders, the American Psychiatric Association calls the condition so far known as ASD, more precisely, disorders of the autism spectrum (American Psychiatric Association, 2013). To be accurate, we could not even talk about disorder, and we would talk about people within the spectrum of autism.

We call it that because it is an extensive range, where each person is different from the rest, they have their strengths and weaknesses (Silva et al., 2011). We say that someone is within this spectrum when it picks up some common characteristics such as those mentioned up to now. For all this, we consider that an investigation with less than 5 participants in it cannot be considered transferable to other environments, nor can generalizable conclusions be drawn from it.

Finally, we were surprised that only one of the articles analyzed mentioned selection criteria to recruit participants. The children selected must be attending school and receive a formal education (Kim et al., 2013). As educators, we believe in educational inclusion and the importance of each student's space in the classroom.

Conclusion

The total number of articles found in the three databases on educational robotics with people with disorders in the autism spectrum has been 39. As this is a current and booming issue, we expected to find many more but were not so. This literature sprout could be because we sought primary education and secondary education among the keywords and robotics since we wanted to see how robotics was being used in schools.

Regarding the scientific field from which the analyzed interventions were carried out, we can see that, firstly, most of the selected studies have been carried out from engineering. Secondly, we found the studies carried out by professionals in education, as educators or special education teachers. Finally, a minority percentage of the selected articles were made from psychology and medicine.

We can see then that it is in engineering and education where there is greater interest in this subject.

Regarding the impact factor, we must say that, on the one hand, only slightly more than half of the articles analyzed have an impact factor on Journal Citation Report. On the other hand, each journal belongs to a different scientific area, with its criteria when measuring impact. Taking into account both factors, we will not venture to conclude this point.

Chronologically speaking, we can observe a very high production peak in 2013. Since then, it dropped a bit, but a constant production was maintained. It seems to be a new topic, which is unknown about much, but the scientific community trusts.

In terms of objectives, the majority of the analyzed articles aimed to increase the vocal production of the participants, followed closely by those articles that aimed to improve the communicative skills of the participants. Considering that communicating with their environment is one of the most significant difficulties people with autism face in their daily lives, looking for these capabilities seems coherent.

On the one hand, it seems that the use of robotics in people on the spectrum of autism is a subject that arouses interest in the scientific community since there are many works whose objective is to delve into existing knowledge. On the other hand, there are also many works whose objective focuses on the robot; this means that the child is not the protagonist but a way to test the robot.

Finally, we see the same amount of work that explains a work methodology or an intervention. As educators, we think that the representation of research projects with educational purposes is shallow.

Regarding the level of fulfillment of these objectives, most articles claimed to have fulfilled their purpose. This majority is just over half, though, which leaves us almost half of the articles analyzed, which could not meet the objectives set on their interventions.

Next, we will put our attention on the scenario where the selected interventions were put through. Almost all of the interventions were carried out in a fictitious scenario, created for the intervention, not in the participant's natural scenario, such as students' classroom or even students' own home. This scenario election does not seem appropriate since people with autism suffer when changes and uncertain situations happen while they feel comfortable within tight spaces and routines.

Almost half of the studies carried out were accomplished with less than ten participants. In addition, almost all of the selected works lasted less than a month. We believe that more accurate data would be obtained by performing a more extensive intervention and more participants. In addition, the inclusion criteria used when choosing the participants of the intervention are not substantiated. Some articles mention some required characteristics when choosing their participants, such as age or intellectual quotient. However, there is no justification for why these attributes make these participants more appropriate for such interventions.

Let us look at the criteria used to choose the subjects of the interventions. We can see that a part of the scientific community considers robots more appropriate or beneficial in people on the spectrum of autism but require less support.

Finally, we will focus on the robot model used in the selected interventions. The most used robot is Nao, followed by Popchilla, Kaspar, and Probo. Except for Nao, which was created by the French company Alderaban, the rest of the robots were created by research teams from different universities. We can conclude that there is no agreement on the scientific community on the characteristics that make a robot better than the others to work with people on the spectrum of autism.

Although robotics is not a recent issue, its application in the field of education is. We live in the boom of social and educational robotics right now; it is time to join forces and investigate where this path leads us.

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