

Augmented reality for children with Autism Spectrum Disorder. A systematic review.

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Abstract-This article collects and analyzes information from various authors dedicated to the investigation of Information and Communication Technologies (ICTs) and in particular Augmented Reality (AR) in the treatment of children with Autism Spectrum Disorder (ASD). RA has ventured into the generation of different cognitive and emotional skills in children diagnosed with this disorder. Descriptive research was used for this study, through bibliographic review.

Keywords - Autism; Learning; Teaching Augmented Reality; TIC; Disorder; Treatment; TORCH.

I. INTRODUCTION

A. Conceptual Approaches: Autism

Autism is defined as a disorder that mainly affects the neurological development of those who have it,[1] they are externalized through deficits in communication, language and social interaction [2] and stereotyped behaviors, these symptoms are usually detected by close family members and at very young ages.[3] [4]

Other authors define ASD as a developmental alteration in children, represented by having a deficit in social interaction and communication with people around them, their interests are very repressed and they constantly show repetitive actions.[5]. On the other hand,[6] defines ASD as those clinical pictures, which begin in early childhood, which restrict social and communication skills, among other cognitive aspects. [7][8]

ASD is "spectrum disorder", that is, the level of involvement in children with it cannot be generalized,[9] therefore, in certain cases they are mild, while in others very serious, however, it will depend on the moment in which these symptoms appear, their severity and exact nature. [10]

An example of children with ASD receiving classes with specialists and caregivers is shown in "Fig. 1



Figure 1. Children with ASD in classes

B. Information and communication technologies

The dizzying advance of ICT has allowed various organizations to turn their eyes towards this new way of teaching, [11][12]. First level and quality education are an essential right of all human beings and is facing a paradigm shift in all its contexts.[13] Improving ICT requires direct intervention and a readjustment in its entire structure to the current educational system.[14]

In general, several authors conclude that the inclusion of ICT in the academic training process is beneficial for children with ASD thanks to the wide range of components that can be added to teaching methodologies, thus providing students with new study environments. didactic and participatory, where they can develop new skills and abilities. [15] [16]

C. Augmented reality

One of the ICTs that has received the most in the learning and teaching process is Augmented Reality, which is the technology that allows the incorporation of content

Digital designed by specialized software, such as images or markers, on the real environment.[17]

“In technical terms, RA comprises a mix of computer graphics, artificial vision and multimedia, so that the user can improve

their perception of the real world, by including virtual information.[18]

For RA to provide an understandable view of the surrounding world, any RA-based system must have the following three characteristics:

1. It combines the real and the virtual: It resides in including 3D images from a computer in the scene. It is interactive in real time: The interactions between the RA system and the user must occur in real time, that is, there can be no slowness between the projected and the increased.
2. Three-dimensional visualization: The objects entered into the RA system must be three-dimensional, and must be made by specialized software in its generation.
3. Contextualization: The problem presented in the article is to be able to determine new Information and Communication Technologies for the help of children with ASD, particularly RA, without leaving aside the limitations of the study, such as the scarce existence of research in populations large enough to successfully conclude if RA really helps children with ASD.

An example of RA application using a smartphone is shown in "Fig. 1"



Figure 2. RA image in ARAnimals software

II. METHOD

In order to summarize the contributions of AR applied to the treatment of children with ASD, a search and analysis of scientific articles was carried out. To carry out the systematic review on RA and ASD, the methodology of [19][20][21]. We follow three phases: planning the review, conducting the review, reporting the review as shown in the "Fig. 3" then

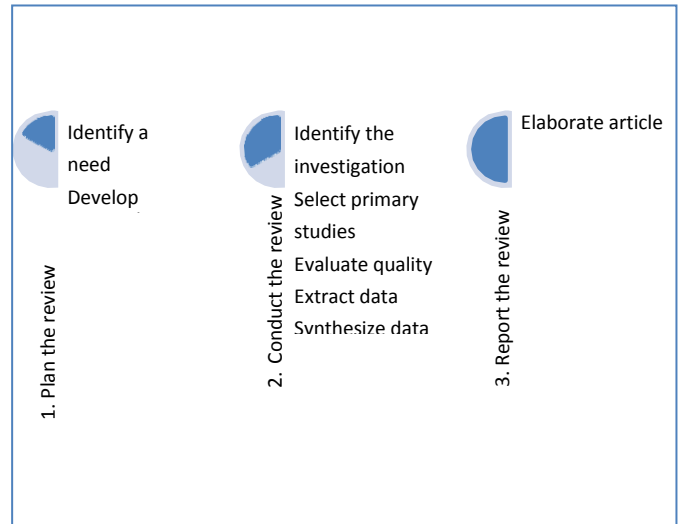


Figure 3. Systematic Review Phases

As a first step, the definition of the review protocol, the following research questions were asked:

- PI1: What works were aimed at improving the cognitive development of children with ASD
- PI2: What works talk about improvements in social relationships
- PI3: What work developed eye and verbal contact skills?
- PI4: What research seeks to promote ASD language therapy?
- PI5: What jobs increased memory and social skills development?

To answer these questions, it is proposed to carry out a systematic review of research articles.

The quality and value of a review depends on the extent to which scientific review methods have been used to minimize error and bias.[20] This is the key feature that distinguishes traditional narrative reviews from systematic reviews.[22]

The systematic search began with the identification of the keywords and the search terms that were constructed from the research questions. A traditional search was initially carried out, from which some articles were obtained, which were studied to determine the most appropriate search terms for the systematic review and which were subsequently validated and completed. The search terms used in this investigation

The definition of the search strategy used to locate review articles on the subject RA applied to treatment defined the following logical expression for keywords that appear in the article title in Table I

TABLE I: SEARCH STRING

N.-	Keyword	Search string
one	RA AND TEA	(Augmented Reality) AND ("Autis *" OR "Autism Spectrum Disorder" OR "ASD" OR Developmental Disorder)
2	RA OR ASD	"Augmented Reality" AND ("TEA *" OR "TIC *")
3	(RA AND TEA) OR LEARN	"Augmented Reality" AND ("TEA *" OR "Learn *")
4	(RA AND ASD) OR LEARN	"Mixed reality" OR "Mobile augmented reality" AND ("educat *" OR "simulat *" OR "train *" OR "gam *" OR "learn *" OR "pedagog *").

The type of documents was limited to articles published in magazines and conferences from 2005 to March 2020. Then, in the third step, the inclusion and exclusion criteria defined in Table II are defined.

TABLE II: INCLUSION AND EXCLUSION CRITERIA

Inclusion	Exclusion
These are articles on RA and TEA. Published between 2005-2020 -Article of scientific quality published in an indexed journal and / or internationally recognized congress	These are research articles describing a particular experience. Articles that mention RA but do not talk about ASD. Review articles on RA in disorders other than ASD or ASD.

The following were the electronic databases considered in the systematic search: IEEE Xplore, ACM Digital Library, SpringerLink, Science Direct and Scopus. Table III presents for each of the electronic databases considered, the fields where the defined search terms were applied.

TABLE III: DATABASE CONSULTED

Database	Search fields
IEEE Xplore	Summary, title, keywords. (abstract, Publication title, index term.
ACM digital library	Summary, title, all text
Springerlink	Title, abstract, keywords
Taylor & Francis	Summary, title, abstract
Elsevier	Summary, title, all text

To choose the articles named as promising, a quality evaluation was carried out where it was observed if those chosen articles had their objectives clearly defined, the technology used contains elements that make use of AR, the methodology used to carry out the study is clearly explained, research, the techniques and methods that were used are properly defined, the conclusions reached are precise, the population is identified as children with ASD and the limitations found when using the technology are evidenced.

The work team is made up of two expert researchers and two beginning researchers, so the initial selection was made by the researchers and the review and decision of the articles considered as promising were evaluated by the expert researchers.

As results of the search and selection of the articles in the academic databases we have in summary the following: Table IV presents a summary of the selection of articles

TABLE IV: SELECTION OF ITEMS

BBDD	Search terms	Found	Different preselected	Shortlisted	Promising
IEEE	RA-TEA	150	28	fifteen	3
ACM	RA-TEA	96	72	18	4
SPRINGER	RA-TEA	105	28	22	5
SCOPUS	RA-TEA	167	72	eleven	7
		518	200	66	19

She "Fig. 4" Below are the sets of exclusion criteria that were used to determine the studies that would not be covered in reporting the review.

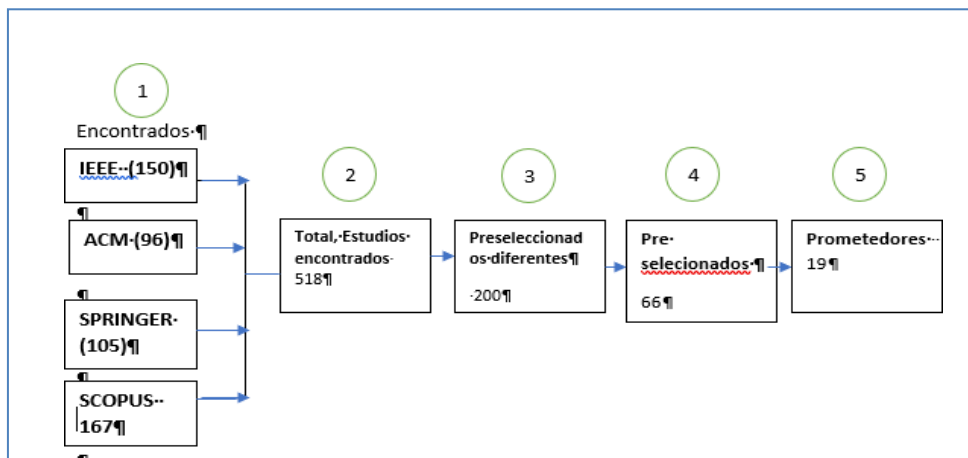


Figure 4. Systematic Review Phases

For this study, variables that were derived from the research questions were defined, such as cognitive development, social relations, visual and verbal contact, language therapy, increased memory and development of social skills, indicators were

defined and the desirable characteristic of the studies to be considered as promising. Table V analyzes these criteria in greater detail.

TABLA V: VARIABLES ANALYZED ON RA IN CHILDREN WITH ASD

Variable	Indicator	Desirable feature
Improvements in the cognitive development of children with ASD	RA as a teaching tool	It directly influences the user, facilitating its learning in a didactic way, through a virtual interface.
Improvements in social relations	Trust builder for children with ASD	It allows a very wide interaction with the user, generating self-confidence.
Development of visual and verbal contact	RA as a tool that can help establish visual and verbal contacts.	Demonstrate high viability, usability and tolerability. Improvement in non-verbal communication, eye contact and social commitment of children with ASD.
Boost in language therapy	Improvement in the way of learning language in children with ASD	Educational application can be used for language therapy, vocabulary, reading and writing, among others
Increased memory and development of social skills	Innovation in children's content books through RA	Allow children with ASD to interact with different settings and contexts, hoping to create emotions and improve cognitive abilities.

III. RESULTS

As a result of the studies carried out on ASD, it allows us to understand the complexity that researchers face when they want to design new and innovative technological tools that improve the quality of life of children diagnosed with ASD. From the study we can understand that in autism it is unlikely to generalize since the patients present different degrees that can range from mild, moderate, severe; in some children the intelligence is intact and they have a greater problem with communication spaces, on the other hand, there are children whose intelligence and language are not affected but their social relationships are deficient.

From the experiences analyzed each one is based on particular points in search of generating an optimal result, usually the studies are carried out in small populations.

PI1: What works were aimed at improving the cognitive development of children with ASD.

For Herrera his research allows improving the cognitive development of the children who used the pictogram room [2. 3]. For Cheng, who considers and reflects on existing research on multi-touch table technology for ASD, these innovative technologies are beneficially used in a number of critical areas that affect people with autism, their families, and the professionals who support them.[24]

For Montecé, who indicates that augmented reality is a technology that contributes resources to the world, in his study he determines that the incorporation of technologies contributes an enrichment to the teaching-learning process.[25]

PI2: What works talk about improvements in social relationships

For Gavilánez, who considers that the RA revolutionizes educational processes at all academic levels due to

their high level of motivation and innovation [26], in conjunction with Jaramillo who defines augmented reality systems, which enrich real environments with additional information generated by computer [27]

Andrunyk considers in his study that AR can provide children with ASD with a significant improvement in communication, the development of social skills and academic training.[28]. For Izurieta who in his research defines DIR Floor-time therapy based on the premise that the acquisition of cognitive, motor and linguistic skills [5]

PI3: What work developed eye and verbal contact skills?

For Moore, who in his study determines that children with autism could understand the basic emotions represented by a humanoid avatar, identical facial expressions. [29]. Tseng designed a novel prototype, called the Facial Expression Wonderland (FEW), to train children with ASD in visual expressions.[30]

For Bai who carries out two investigations related to the potential of AR technology to visually conceptualize the

representation of simulation, he developed an interactive system that explores the inside of an open play environment that allowed children with ASD to improve their mental representation of simulation along with immediate reality.[31]

The same author conducts an experimental evaluation of a proposed AR system to support and encourage children with ASD to simulate play. The authors recorded all the interactions of the children in both conditions, that is, RA and not AR. The analysis of the recorded sessions was carried out based on five categories of play: simulated play, constructive play, relational play, simple play and no play.[32]

PI4: What research seeks to promote ASD language therapy? Moralejo who describes the progress of his AuthorAR tool, aimed at creating educational activities based on augmented reality (AR) that allows generating exploration and sentence structuring activities, which can favor processes of language acquisition and communication training.[33]

PI5: What jobs increased memory and social skills development? For Renilla who carried out an empirical exploratory study where it is concluded that using technology allows for greater attention and acceptance of routine activities in children with ASD. [34]

Talavera in his study analyzes the improvements that music therapy brings to the development of communication in students with ASD in the classroom.[35]

Bartoli determines in his study the opportunities offered by full-body contactless games for the therapy and education of children with ASD and verifies the effectiveness of games for autistic children [36]

Among the articles and scientific information collected, the researchers agree that ICT and especially RA are valid tools for the generation of new and innovative teaching mechanisms for children promoting skills and abilities.

AR as part of ICT is an element that does not go unnoticed, it is known that one of the main ways to help children with ASD through a natural interaction with the environment in which it operates; using and using different stimuli such as visual, auditory and sensory, RA can play an important role in creating pleasant and safe environments for the emotional development of children with the disorder.

Currently, several establishments that provide therapy services have already chosen to integrate RA-based multimedia tools into their teaching methodologies, and the results are encouraging with a promising future. Applications with RA gain strength and begin to emerge as a help tool for different disorders such as ASD

Many authors mention the term "mixed reality" as the conjunction of physical reality and AR technology, that is, that it contemplates the real environment, whether additional

information generated by software is incorporated for a specific purpose.

The inclusion of AR as a tool for the treatment of ASD is novel, incorporating different stimuli in the applications in the form of games or didactic activities, where the user can select objects, body movements, figure identification and other tasks, in an entertaining way.

their treatment that allows them to improve their quality of life through science and technology.

The introduction of ICT into the pedagogical environment is not an unknown topic in society, based on the reviewed bibliography, and citing what has been investigated by various authors, these technologies can be an ideal instrument for learning processes, even more so in children with different types of disorders, such as the case of ASD.

This article reviewed recent publications on how AR has ventured into the generation of different cognitive and emotional skills in children with ASD, thus observing that in recent years this technology has been widely received by various authors and has even come to consider theoretical models and experimental applications of AR on populations of autistic children, with pleasant and encouraging results for the near future on the use of AR to treat this disorder.

One of the main advantages of RA is the ease of adaptation with various technological elements such as webcams, motion simulators (Kinect), smart glasses, computers, smartphones. Most researchers agree that AR supports the generation of safe, reliable, and pedagogical environments for autistic children through activities and games that allow the user to interact with the system.

Another point considered in the reviewed publications is the type of stimulus that should be used for children with ASD, this because it is not possible to generalize that everyone has the

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IV. DISCUSSION

ASD, is a complex disorder from its identification to its treatment, it does not manifest in the same way in all children, its severity can be mild, medium or very severe, and for many authors it is a disorder that has no cure and lasts lifetime. In recent years, and thanks to clinical advances, its detection is easier and, therefore, it seeks alternatives to same behavior or reaction to the same stimulus, which results obvious, because ASD can manifest itself in children in different ways and percentages, which makes them susceptible to different stimuli, and therefore other specific areas must be attacked to improve their relationship with the environment.

One of the peculiarities of children diagnosed with ASD is the great reception with the visual stimulus, for many of the researchers, it is the most developed stimulus in them, this being taken advantage of by augmented reality, inciting the user of the applications developed with this technology to the use of this stimulus and to be able to quantify if its application allows to overcome the own limitations generated by the disorder.

Finally, RA technology is a highly viable alternative for the treatment and improvement of the quality of life of children diagnosed with ASD, the theoretical concepts have been applied in controlled groups of children with autism and the results were satisfactory; Children's abilities, skills and capacities improved markedly after being exposed to treatment with RA-based systems.

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