Is It Possible to Improve the Learning of Children with ASD Through Augmented Reality Mobile Applications?

Mónica R. Romero[1(✉)], Estela Macas[2], Ivana Harari[1], and Javier Diaz[1]

[1] LINTI, Laboratorio de Investigación de Nuevas Tecnologías Informáticas, Facultad de Informática, Universidad Nacional de la Plata, Calle 50 y 120, La Plata, Buenos Aires, Argentina
{monica.romerop, iharari, jdiaz}@info.unlp.edu.ar

[2] Facultad de Ciencias y Tecnologías Aplicadas, Escuela de Informática y Multimedia, Universidad Internacional del Ecuador, Quito, Ecuador
esmacasru@uide.edu.ec

Abstract. At present, many researchers and software companies have created a number of mobile applications based on augmented reality that promote learning spaces in children, however, we find few studies where an intervention is carried out with this emerging technology in children with autism. This research sought to verify whether mobile applications can be used in teaching-learning processes in children diagnosed with ASD, the intervention was worked through a multidisciplinary team, which was attended by psychologists, computer engineers, parents and a ASD patient; A curricular strategy was established to verify whether the indicators: cognitive, procedural and communicative after the intervention with RA improve the ability to learn. The experience is described through a case study that shows encouraging results and to some extent promising on the use of new technologies to improve the quality of life of children with ASD.

Keywords: Autism · Mobile application · Teaching · Augmented reality · ICT · ASD

1 Introduction

ASD is a complex neurological disorder that usually lasts a lifetime. Autism is defined as a serious disturbance that affects several areas of development [1], is detected because it affects the development of people who are diagnosed, and is expressed through poor communication, difficulty in establishing social relationships with their environment, and additional language limitation, additionally with problems of imagination and flexibility of thought [2–5].

On the other hand, RA is a technology that allows the user to interact with the physical and real world that surrounds it [6], it is the combination of virtual objects, such as third-dimensional graphics or animations, with real environments [7, 8].

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There are many definitions of RA, in 2010 it is defined as virtual objects or annotations that can be superimposed in the real world, for [9] the RA is a technology capable of complementing perception and interaction with the real world, providing the user a real scenario augmented with additional information generated.

En los últimos años investigadores han generado diversos estudios donde se ha incluido las TIC en la intervención de niños con TEA con resultados prometedores. [10, 11], en este contexto algunos investigadores comentan que estas personas se sienten más confiadas y seguras cuando se utilizan TIC ya que el entorno está controlado y además pueden repetir las actividades propuestas [12, 13].

Augmented reality projects have grown significantly in recent years. obtaining evidence that intervention through augmented reality in activities designed for teaching learning has significantly improved student learning skills in regular schools [6, 8, 14–16]. Through this technology, different learning objects have been created: games, books, teaching material, mobile applications (apps) that are used for different purposes [17–19].

However, from the preliminary systematic review, most studies are based on secondary sources, the reviewed literature lacks research studies on the suitability of these technologies, methodology, quantitative studies and conclusions based on primary sources, [8] Experimental studies aimed at verifying whether this new technology, known as emergent, can improve teaching-learning processes in children with autism are minimal and scarce [20, 21] in this regard, this research conducts a search for mobile applications that contain components of RA to verify, through a multidisciplinary and experimental team if its use in the pedagogical space can be favorable for children with ASD.

The present study is structured as follows: Sect. 2 explains the materials and methods that were used in the execution of the research, structured surveys were conducted for data collection, interviews were performed to the group of informants, and finally conclusions were drawn of direct participation through observation. Section 3 presents the results of the study and last the Sect. 4 presents a critical reflection.

2 Material and Method

This research presents a mixed approach since it uses a qualitative method through interviews led with participants and quantitative by structured surveys [22]. The scope of this work is exploratory, because there are few studies related to evaluations of RA applications where curricular plans are established to measure teaching-learning processes through indicators: cognitive, procedural and communicative [23].

This study is of the micro type since the experimentation is carried out with a single girl, in a controlled space and with a planning previously reviewed by people who treat this disorder. This research is descriptive because it seeks to know in detail about the benefits of the inclusion of RA in the treatment of children with ASD, observing user interactions with applications.

This research focuses on two modalities such as documentary and field, this is because the experimentation must be carried out on specific applications, and on the same environment, and it will also be documentary because the process and the results

are supported by a methodology and in the theoretical support of previously conducted research [24]. The fieldwork of this research was carried out in the city of Quito at the Ludic Place Therapeutic Center, located on Seymour Island N41 225 and Floreana Island. This center provides treatment for children with autism spectrum disorder.

The population is composed of the group of people shown in Table 1. Moreover, inclusion criteria of those who participated in the case study to be developed have been included. For this study there are four groups of informants. The informants are those people who will provide us with relevant information: Child with ASD, people close to the child parent, the third group is defined by professionals in treatment of ASD, the people who are in charge of their care and in group 4 professionals in IT engineers in computer science.

Table 1. Research population

Subjects	Inclusion criteria	Quantity
Professionals ASD treatment. Psychologists	Have studies in psychology or educational sciences Have experience of having treated children with ASD Agree with the study to be carried out	2
Patient diagnosed with ASD	Boy or girl diagnosed with ASD Treated by the Ludic Place Center Age between 4–6 years Authorization agreement signed by their legal representatives	1
ICT professionals	Have studies in ICT or related Have experience in the use of RA applications Agree with the study to be carried out Authorization to conduct part of the study interviews	2
Parents	Having a direct relationship with the child diagnosed with ASD Be able to describe the child's behavior Agree with the study to be carried out Authorization to conduct part of the study interviews	2
Total		7

2.1 Case Study

2.1.1 Work Plan

For this purpose, a strategy is established through a discussion group among the professionals who participated in the experiment [25] with the objective of defining a work plan to carry out the intervention through the use of mobile applications based on RA [26].

The work plan was carried out in four sessions. [27, 28] see as an example Fig. 1. The objectives are to have a metric where the use of augmented reality in children with ASD can be critically assessed, [29, 30] additionally there was the participation of A population with 4 groups of informants.


Fig. 1. Work sessions with Girl with mild autism.

Prior to the use of the applications, a small training was given to the psychologists who participated in the experiment. In addition to the first sessions they were to familiarize the girl with the technological equipment that was later used in the intervention, finally, they told the girl how to use the applications. A tablet was used in two sessions and a smartphone in the remaining two sessions; however, the specialist led the use of the application.

2.1.2 Selecting Mobile Applications for ASD

In the collection of information from secondary sources we located a list of 50 mobile applications for students with ASD [6]. Exclusion processes were carried out, which were based on the year of launch of the application, the operating system, if they included RA if they reinforced teaching-learning spaces for children. Once these criteria were applied, the applications were reduced to 18. A work meeting was held with the patient treatment team and they were exposed, at the end according to an expert judgment, which gives having shared with the girl 4 years of therapy two applications were selected for this case study. The selected applications are indicated in the following Table 2.

Table 2. Selection of mobile applications.

App	Name	System O.	Year
	AR Animals	Android/iOS	2018
	Alphabet	Android/iOS	2018

2.1.3 AR Animals

AR animals is a mobile application created to teach animals (wild and domestic). Its use is free and just enter the website where they allow you to download a list of pictograms, the application can be downloaded from playstore see as an example Fig. 2.

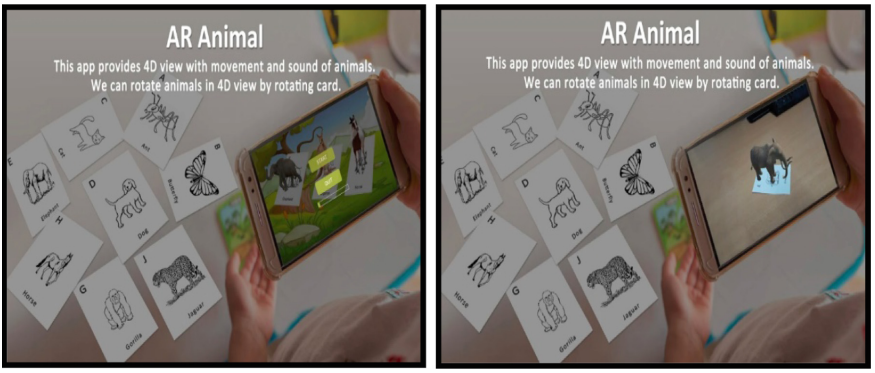

Fig. 2. AR animal application - a graph that represents how through the pictograms and using a smartphone, you can project a chosen animal using augmented reality.

2.1.4 Alphabet FlashCards

This mobile application was created to teach the alphabet and presents with each letter an associated animal. To be able to use it, just download it from Playstore, its use is free, and a pdf with the associated pictograms can be downloaded from the website. Its use is shown in Fig. 3 below.

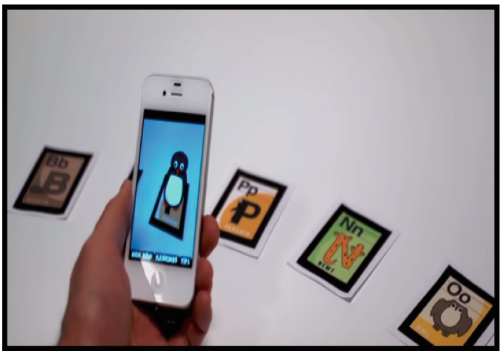

Fig. 3. Alphabet flashcards App - a graph that represents the use of the mobile application, augmented reality [31].

For the analysis of the experiences, a validated form by an expert opinion (of the Research Group on Educational Technology of the University of Murcia) was used. It is included below in Table 3 of the Activity Description Sheet using augmented reality.

Table 3. Activity description sheet using augmented reality.

Basic reference data	*School*	*Ludic place*
	Web page	https://www.facebook.com/ludicplace/
	City	Quito-Ecuador
	Educational stage	School
	Cycles	Sierra/September to July 2019
Facts about activity	Information sources about the activity	Primary source
	Total number of students involved in the activity completion	1
	Use of new complementary technologies	New technologies Emerging technologies Augmented reality
	Faculty information	Silvia Reyes Paola Navarro Mónica Romero
	Description of the activity: evaluation methodology	
	Objectives	Performs a search of mobile applications containing RA to verify, through a multidisciplinary and experimental team if its use can be favorable for children with ASD
	Contents	Establish a curricular strategy to measure a teaching-learning process through indicators: cognitive, procedural and communicative
	Grouping	Group There is a multidisciplinary population with 4 groups of informants
	Activity completion dates	First half of 2019 January to June
	Places of realization of the activity	Ludic Place Ecuador, Pichincha, Quito, Floreana Island and Seymur

(*continued*)

Table 3. (*continued*)

Analysis of the RA technology involved	RA level		
	Classification of the activity in a subtype of RA	Media description	
		Software	AR animals
		Hardware	Tablet Smart phone
Internet connection (yes, no): YES Wifi networks: YES Mobile phone networks: YES			
Evaluation	Available data on evaluations of participating staff	The data is found in structured surveys that were conducted through Google forms, as well as a clinical report by the personnel in charge of Ludic Place, there is a signed consent by their legal representatives	
	Data available on external evaluations and dissemination of the activity	The project has been socialized with the Research Laboratory of New Information Technologies. LINTI Faculty of Computer Science, National University of La Plata	

Source: Activity sheet using RA [32].

2.1.5 Interview

The interviews were carried out with the four groups of informants, this study collected the opinions from several critical points, initially by the professionals who are in charge of caring for the girl with autism, since it is they who play a fundamental role in indicating whether the intervention carried out through mobile applications with RA favored learning in the treatment center.

Last but not least the interviews were designed to extract relevant information from parents who share the longest time with the patient and were present in the work sessions.

3 Result

The evaluation of these sessions were carried out through interviews and observation of the specialists who executed the sessions to identify if the indicators mentioned in the curriculum plan strategy were met by the child with ASD [33].

A record of each section was carried out (work was done in 4 sessions). In each of them several teaching-learning activities were to be completed, for each session 5 activities were defined, the same ones that were fully completed, at the end the 20 proposed activities were evaluated.

Actions were taken for each session so that the girl with autism manages to perform the:

- Identification/Recognition
- Selection,
- Description,
- Visualization
- Imitation

In the different sessions the treating psychologists made a record, the number of RA activities raised and the successes that were evidenced in the experimentation through a scatter plot are shown as variables, the results are shown in Fig. 4.

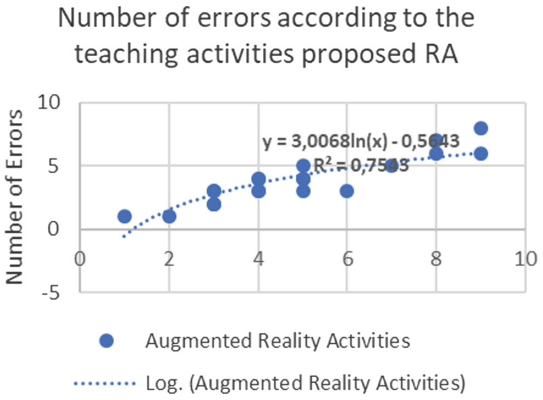

Fig. 4. Below is a graph that represents the number of successes that the girl made according to the activities outlined in the curriculum plan through intervention with the Mobile Application.

In other aspects, a verification of the emotions and reactions of the girl was made after the intervention for this process, several aspects are evaluated, which can be obtained through direct observation and were collected at the end of the planned activities in each of the sessions. This evaluation allows to verify a fundamental aspect such as the behaviors and emotions of the child and are related to verbal communication, non-verbal communication, eye contact, and emotion management.

Moreover, in this space a Likert scale was used, where the people who participate parents and treating psychologists qualify from 1 to 5, where 1 indicates a total disagreement, 2 disagree, 3 neither agree nor disagree, 4 agree and 5 indicate totally agree. For each culminated activity, it was requested to qualify the aforementioned aspects, at the end of the process, scatter plots are made with the collected results. The Fig. 5 shows the results collected.

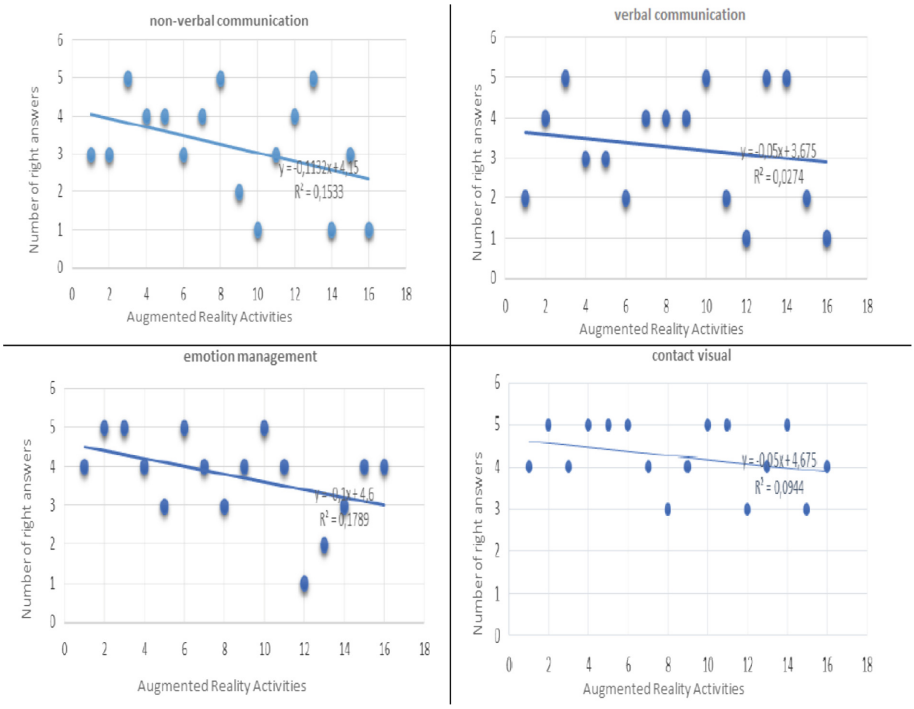

Fig. 5. The following shows the results of various aspects such as Verbal Communication, Non-Verbal Communication, Visual Contact, Emotion Management. On the X axis the 20 teaching activities proposed with RA are shown and on the Y axis the degree of satisfaction determined by the informants is identified

4 Discussion

It is important to consider the presence of a multidisciplinary group for the correct intervention of new technologies or emerging technologies in teaching-learning processes in children with ASD. For this study, work tables and brainstorming were organized where the participation of the treating psychologists was fundamental to guide the intervention process through mobile applications with RA. On the other hand, the parents had a positive impact since they provided all the collaboration including the signing of an informed consent.

From the wide variety of mobile applications that are in the market it is important to make an assessment, defining several aspects in this sense the definition of exclusion criteria can make the number of apps be significantly reduced. From the group of final applications for the process of intervention applications must be socialized with the work group to choose the most suitable, according to the cognitive, social, and academic development information of the patient.

Once the mobile applications have been chosen, it is very important to carry out a technical training to the professionals treating children with ASD. In our case study to

the psychologists who participated, since they will be the ones that guide the sessions, so it must be previously defined. The intervention is a space where training, installation, use and any doubts regarding the operation are carried out.

The hardware that is going to be used has an important space since for this experimentation a smartphone was initially introduced and after that a Tablet since the visualization is an important aspect. This strategy that was not initially contemplated made the development of the sessions improve and that the girl can interact better with the app.

In order for the process to be execute correctly, a curricular plan must be adequately considered, where the participation of personnel or expert judgment is essential. Initially, a topic to be addressed must be identified, sub-themes, specific activities.

Future work must be defined and finally the achievements must be stated through indicators. In our case, three were used: cognitive, procedural and communicative that allowed us to evaluate the effectiveness of the intervention.

From the results obtained through experimentation, it can be concluded that the number of successes in the activities raised with the augmented reality intervention were higher than expected, or the average that the student performs without the application of RA, which answers the question posed in this research. It can be indicated that this technology is suitable for teaching and intervention in this type of disorders, the results collected are encouraging.

For the evaluation of different spaces through the direct observation of the participants, referring to the behaviors and emotions that the intervention of mobile applications based on RA, it can be concluded that the most notable improvement is established by eye contact, followed by communication, emotion management and nonverbal communication.

This process went through in an ethical and objective way, with several groups of informants that allow us to collect the results from different points of view after the intervention with RA. However, this strategy to be replicated in other environments, will depend largely on the Autism diagnosis level of the population to be operated or the therapeutic center, since each child with ASD has unique characteristics which makes this work even more complex.

As a future line of research it would be important to expand the study to verify other processes such as multiple intelligences through RA. In Chile there is a mobile application that was developed through a playful space that allows students to reinforce several competences, this initiative was used in regular school, however, it would be important to do it in children with autism.

Augmented reality is an element that can positively influence teaching-learning spaces. Nevertheless, the primary studies carried out, as well as the present research presents limitations in terms of population, so it would be important to replicate the intervention in larger populations and with different severity Autism.

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