Hoope Project: User-Centered Design Process Applied in the Implementation of Augmented Reality for Children with ASD

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

[1] Faculty of Computer Science, National University of La Plata, LINTI, Calle 50 y 120, La Plata, Buenos Aires, Argentina
{monica.romerop,iharari,jdiaz}@info.unlp.edu.ar
[2] International Ibero-American University - UNINI Mx, Calle 15 y 36, Campeche, Mexico
estela.macas@doctorado.unini.edu.mx

Abstract. In the present investigation, a little-known disciplinary field that integrates aspects of computer science is delved into: HCI human-computer interaction, usability, accessibility, and on the other hand, children with ASD. The scope of the research includes the analysis, design and implementation of software that uses augmented reality in a playful environment with the aim of reinforcing educational aspects of children diagnosed with ASD, it is in a stage of development and research, currently working on a proof of concept through the implementation of a prototype, the previous studies have been worked for a period of 4 years where aspects related to DCU were considered in a particular way,

Keywords: Accessibility · AR · Autism · User centered design · HCI · Prototype · TIC · ASD

1 Introduction

Autism Spectrum Disorder from now on ASD is a complex neurological disorder [1] which usually lasts a lifetime. Autism is defined as a serious disorder that affects several areas of development [2], defined by other authors as a pervasive developmental disorder [3], is detected, and is externalized through poor communication [4–6]. Difficulty establishing social relationships with their environment [7], and limitation in language, additionally they present problems with the imagination [8] and flexibility of thought [9].

On the other hand, augmented reality, hereinafter RA, is a technology that allows the user to interact with the physical and real world that surrounds him. [10], is the combination of virtual objects, such as 3D graphics or animations, with real environments [11–15].

M. Antona and C. Stephanidis (Eds.): HCII 2022, LNCS 13309, pp. 277–290, 2022.
https://doi.org/10.1007/978-3-031-05039-8_20

When we talk about ASD, we glimpse a particular world, complex and difficult to access [16], there are many scientific questions that remain unanswered. In the last 10 years, researchers have carried out studies aimed at improving the living conditions of children diagnosed with ASD [17], through the use of new technologies known as emerging technologies in this particular case we refer to augmented reality [18–21].

AR is used in teaching-learning processes at different levels from preschool to university [22], Gavilanes who considers that AR revolutionizes educational processes at all academic levels due to its high level of motivation and innovation[17]in conjunction with Jaramillo who defines that augmented reality systems enrich real environments with additional information generated by computer [23] due to the unique characteristics that it presents and the motivation that the experience of new learning represents for the students [24, 25].

This study is structured as follows: Sect. 2 explains the project called Esperanza. Section 3 explains the materials and methods that were used in the execution of the investigation. Section 4 presents the results of the study, finally Sect. 5 establishes the conclusions reached from the current execution of the work framed within the doctoral research.

2 Project Hope Motivation

After the studies carried out for this project, there is documentary evidence that AR is a tool that allows improving teaching-learning processes in children with autism. [26–29], of the studies analyzed after a systematic review [30, 31] there are still aspects that have not been addressed in depth, especially focused on experimental work with children with ASD, there is no documented evidence that the construction of software products has implicit at least a minimum percentage of techniques based on user-centered design henceforth HCI [32–34].

On the other hand, the Esperanza Project is developed in the LINTI New Computer Technologies Research Laboratory, of the Computer Science Faculty of the National University of La Plata, Argentina. This project aims to: analyze, investigate, develop, implement and experiment by creating a prototype that makes use of AR to complement educational activities in children diagnosed with ASD, it seeks to know if augmented reality facilitates teaching-learning processes.

The Esperanza project has an approximate development time of 4 years, of which the stated objectives have been successfully completed, such as: The analysis, design and implementation of a software product, through a method to reinforce certain teaching-learning processes of children with TORCH. Figure 1 shows the different phases:

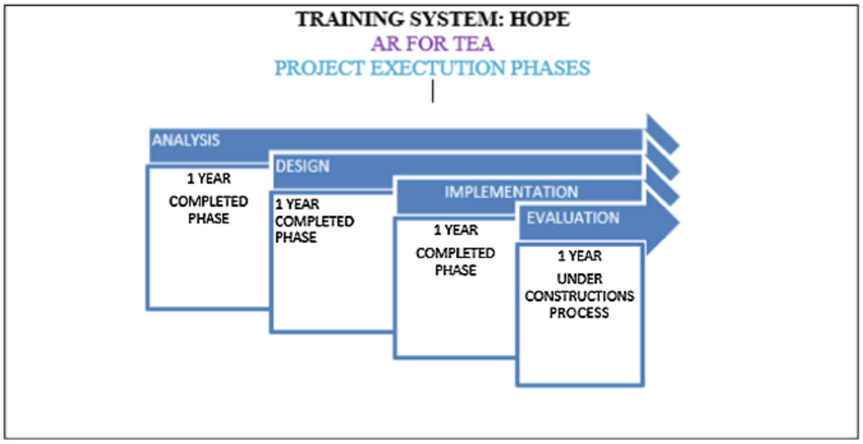

Fig. 1. Design process of the Esperanza project.

3 Methodology

The present work proposes the design of software created from a DCU perspective for children with ASD, the research is presented in the opposite direction to what our knowledge in computer science generally indicates, even though it is a project focused on the construction of a software product - a strongly technological component, we changed this paradigm, and The research began with a study of the end user and their relationship with the environment (children with ASD), for this purpose the particularities of the user were studied, in a broad sense the research was framed in the disorder and in the pedagogical strategies adopted, how and when it is detected, how it is diagnosed, its characteristics, what is important or what are the premises for a child with ASD to learn, how technology affects these children, after this first approach, we understood the child, affections, family, fears.

We begin a new stage, where with the previous information it is sought to establish which technology is better for these children, the use of emerging technology was determined: two of the technologies were analyzed: virtual reality and augmented reality, choosing the latter since one of the problems that virtual reality presented is the immersion that it causes in the user, which was an inconvenience detected by the multidisciplinary team that participated as an expert judgment in the investigation, since a reflection was made and it was indicated that one of the problems detected in a child with ASD is the lack of connection with the present with reality, with the professionals that surround him and that virtual reality, far from helping us, could deteriorate this condition, Thus, the use of AR was chosen, which was focused on educational use, including it in certain teaching-learning processes through software with playful characteristics.

The first step was to know how these children learn, unlike other users, a child with ASD is not alone, since he is highly dependent on his family circle (father/mother), and support (teachers, therapists, medical personnel), this made us rethink the original approach since if we wanted the experience to be truly purposeful, our user had to be seen from a new perspective where the needs grow based on the fact that these children are not independent and generally need constant accompaniment.

The investigative process is defined as exploratory, descriptive. and experimental, the project defined several stages to fulfill its purpose where experimental approaches involving users were carried out, from 2017 to February 2021, with the participation of 300 people related to the TEA, some of them providing qualitative information and others qualitative, several studies of various types have been generated that have helped to reinforce the present investigation, it is important to indicate that this process was worked with the accompaniment, support and constant guidance of an academic team from the UNLP -and even more so with a research laboratory focused on new LINTI technologies, together with a multidisciplinary team: parents of children with ASD, accompanying teachers of children with ASD,

The evaluation process of the interaction of a child with ASD consisted of an intrinsic hardware component to bring it closer to the software product, in our case we tested technological devices such as: laptop, smartphone, virtual reality headset, 3D glasses, Kinect) in a progressive process. We show it in Fig. 2 where the four interactions that have been worked on around the project are shown.

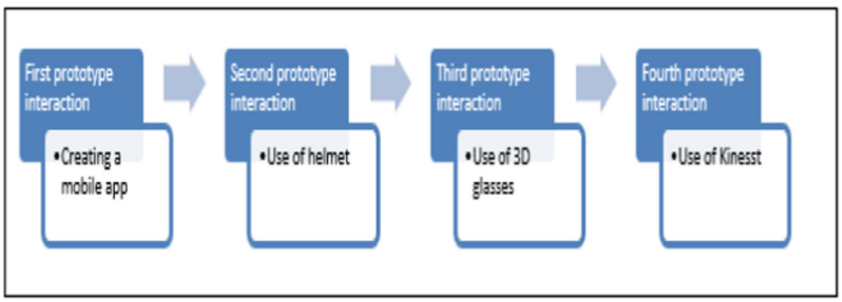

Fig. 2. Prototype designs – Esperanza Project iterations.

3.1 Test of Concept

In this context, concept tests were planned based on different iterations that allowed us to build the prototype of the Esperanza project.

The stages where the original ideas of a product development prototype were defined and conceptualized are defined below, the same ones that have evolved over time, the product has been built from a user-centered approach and in an interactive way, expressed Otherwise, we can indicate that, as we carry out concept tests, the prototype has been fed back, seeking to satisfy the needs of a user that has specific characteristics, in each interaction we verify particular details, so the software design was many times modified, and has been conceived through countless approaches, tests and with the participation of children with ASD supported by a multidisciplinary team.

These meetings were planned to carry out the following stages:

Initial Stage: Call, conditioning, presentation of the prototype.

User research stage: a multidisciplinary team was summoned to carry out the field research.

HCI evaluation stage: in each interaction of the models defined for the prototype, usability testing was carried out observing the interaction between the children with ASD summoned and the multidisciplinary group that participates as an observer, as a guide or as a support and the device (mobile app, helmet, goggles, Kinect). In this project, three of the first prototypes were eliminated for not meeting user expectations.

Reflection and debate stage: after the practical experience, changes were made to the initial prototype, which allowed the project to be assertively consolidated.

Prototype 1: Software and Smart Phone. In the first prototype created in the Esperanza Project, we bet on the review of educational applications created for mobile phones, this proposal supported teaching-learning processes mediated through AR technology, through activities such as imitation, classification, segregation, for this purpose we used cards that allowed the visualization of images of domestic and wild animals in AR through the smartphone, a curricular plan was proposed where some objectives were defined and the evaluation carried out on the child once we carried out the intervention through several sessions It was carried out with the measurement of certain achievements of an indicative, communicational type.

The difficulties that this prototype presented was that it was limited to work at a table and the participation of the teacher, since the child felt fear, that is, he did not want to have the telephone in his hands, so therapies in this sense should necessarily be carried out in the same place, keeping in mind the treating professional who guided and performed the interaction with the hardware and software. However, we were looking for mobility and independence of the child. Figure 3 shows the therapist working with a child with ASD at a table in the children's center and with the use of the smartphone, children with ASD usually tend to stand, move constantly and find it difficult to follow the instructions required. a constant support, for this prototype, in addition to the software, a curricular plan had to be worked on,

Fig. 3. Designs of software and smartphone prototypes Proyecto Esperanza.

Prototype 2: Software and Use of HDM Helmet. In prototype two, created in the Esperanza Project, we opted for software review, we wanted to use a virtual reality headset (HMD) with the purpose of training social skills in a controlled, repeatable, and safe virtual environment. For this purpose, we used VR-HMD, we specified a curricular plan where some objectives and evaluation through achievements were defined.

The difficulties that this prototype presented was that it carried out an immersion process and the child generated little or nothing feedback with the teacher, followed by the little tolerance of using the helmet, in the planned sessions the time established by the that the work was finished earlier than planned and remained unfinished, even though we achieved the first objective, which consisted of the child's mobility and independence, the learning objectives were not achieved.

In summary, the acceptability to the child was limited, as was the practicality of its use.

Prototype 3: Software and Use of 3d Glasses. In prototype three created in the Esperanza Project, we bet on the use of 3D glasses, our intention was to train teaching-learning processes using software. For this purpose, we used Google -glass, we specified a curricular plan where some objectives and evaluation through achievements were defined.

The difficulties presented by this prototype, was the little tolerance of using the glasses, in the planned sessions the established time was not fulfilled, therefore, the work was finished before the planned and was left unfinished, after the experience with the prototype 2 and prototype 3 we understood that the children with ASD with whom we found ourselves doing the field work felt uncomfortable when trying to put the glasses on them, even when a prior knowledge process was carried out, even the teacher and treating staff used the glasses during the therapies so that it becomes an element in a certain common way, but it was not assertive, despite achieving the mobility and independence of the child, the sessions did not end and therefore the learning objectives were not achieved.

Prototype 4: Software and Kinect. In prototype 4 we bet on the use of natural user interfaces that allow the child to have mobility, freedom, we seek to provide educators with effective strategies that allow them to have greater effectiveness in the teaching-learning processes in children with ASD, so that we develop a playful software to learn certain processes, for this purpose we use a Kinect device and we develop a game called Hoope, we use adaptations to allow the model to meet expectations. For the intervention phase, strategies are proposed to carry out a playful activity mediated through technology using the Hoope system. This system allows the child to interact alone or with the help of the professional who guides the session.

We established and organized the educational process and the environment used for the intervention, this favors learning, understanding of situations, independence from constant reinforcements, and minimization of conflicts caused by confusion or concern. Due to the interest in visual rather than auditory perception, it is essential that each activity is visually structured in a way that promotes understanding and motivation. In Fig. 4 shown below we indicate how the proof of concept of prototype four was carried out, in the first image the staff of the Therapy center, psychologist and psych pedagogue

Fig. 4. Designs of software prototypes and Kinect Esperanza Project.

are shown, in the other photograph we observe a child with ASD who participate in the project by approaching the computer screen.

4 Results

Under the premise of man-computer iteration, the Esperanza project has allowed an approach to the characteristics and particularities of a user (child diagnosed with ASD), the intention was to know and adapt the product to the needs, this process has been carried out through several tests of concept, where as a starting point we carry out the analysis, design and implementation of prototypes that were tested in real environments in educational centers for children with special abilities, perhaps one of the heuristics reached in the investigation is the complexity that the context represents of testing children with ASD.

To date, work has been done on the analysis, design and implementation of four prototypes, the same ones that have been reviewed, used, evaluated not only by the user for whom the product is intended, in our particular case, children with ASD, but additionally other actors involved in the educational process were actively involved, authorities of the educational center who should know the project, its objective, the proposed scope and more than all the possible benefits of having the results first hand, it is imperative to indicate that For almost four years we have collected valuable information that can only be collected through field research, interacting with the study population.

As a starting point, we made a call to the users to participate in the study, the intention is to present the Hope Project, the objectives it pursues, we worked with the parents through informed consent, we also worked with the authorities of the center, and with the treating professionals, to carry out the experimentation, finally this stage ends up teaching the prototype how it works and what it does, how the interventions will be carried out and their duration.

In the second stage, defined as user research, the support of a multidisciplinary team was requested to carry out the field research, the intention is to collect the different points of view of the professionals. For example, in the educational area, a special education teacher establishes a curricular work plan and evaluates whether the learning achievements were achieved, on the other hand, the psychologist carries out the accompaniment for the experimentation with the created product and collects from the first source the behavior of the child, evaluates aspects such as visual contact, non-visual, stress, ICT professionals focus on verifying if the product meets software quality parameters, that is, it is easy to understand for the user, it is adaptable.

Student's t-Test. For the study, we carried out a statistical procedure defined as T Test, or single sample, previously we verified that the values of the sample taken met a normality parameter, (n less than 30), since it was used for the evaluation of the various group prototypes. of independent variables that did not have a specific relationship. We use an alternative hypothesis where we indicate that each of the prototypes put under consideration are different from one another and therefore in the evaluation the participants decided to qualify some variables as numerical data we evaluate the prototypes and as variable data of groups we evaluate: the device, Experimentation with ASD, and Curricular Assessment.

For this as a research team we define a:

- Null Hypothesis: which establishes that there is similarity of the prototypes.
- Alternative or researcher hypothesis: We propose that there are differences in the prototypes to be evaluated despite being measured by the same variables.

We established the level of significance $= 5\% = 0.05$, where, if P in the study would result in a higher level of significance than that established as 0.05, the null hypothesis is discarded and the alternative hypothesis is accepted. Then the most relevant value of the table corresponds to the bilateral SIg, where the estimated value of P is greater than 0.05, so the null hypothesis is discarded and the researcher's hypothesis is accepted, then it can be concluded that the prototypes are different even when have evaluated the same parameters (Table 1).

Table 1. Single sample test.

	TEST-VALUE = 0					
	you	gl	Next (2-sided)	Mean difference	Ninety-five percent confidence interval of the difference	
					Lower	Fig
Prototype I mobile app	2,199	Eleven	0.050	7.8333	−0.009	15,675
Prototype II helmet	2,182	Eleven	0.052	5,5000	−0.049	11,049
Prototype III glasses	2,195	Eleven	0.051	7.1667	−0.021	14,354
Prototype IV Kinect	2,199	Eleven	0.050	8.5000	−0.009	17,009

In the third stage of evaluation of the HCI: considered one of the most important for our project, it was framed in a testing process and user interactions with the product, in this stage usability testing was carried out observing the interaction between the children with ASD summoned and the multidisciplinary group that participates as a direct observer, the teacher or therapist as a guide or support, in the technological field we have two factors: software and hardware, the device (smartphone + mobile app, helmet, glasses, Kinect). In the evaluation process, three dimensions were considered, encompassed in the following aspects: 1) Device or hardware used for the proof of concept, in our case several characteristics are defined to evaluate the use of the device: attractive, functional, aesthetic,

The following were taken into account: 2) Experimentation of the child with ASD, we seek to determine some aspects inherent to the user versus the use, experience with the product and the reaction that is generated, we seek through direct observation to collect the impressions in the experimentation of the software in the sessions planned for this purpose, the visual communication maintained by the child, verbal communication, eye contact and their level of stress of each of the prototypes were evaluated.

Finally, and no less important, we focus on the teaching-learning processes that can be reinforced through the use of AR, 3) Learning process of the child with ASD, we seek to determine some aspects inherent to the user how much he learns, if he is able to specify certain actions, through the software, these previously planned actions are measured through cognitive, procedural or communicational indicators, experience with the product and the assertiveness it generates, for the measurement of the prototypes the Likert scale was used evaluating the device, the experience of the use of the device by a child with ASD, and finally to curricular evaluation the results obtained can be seen in Table 2.

Table 2. Evaluation of built prototypes

User centered design	Characteristic to evaluate	Prototype I: mobile application	Prototype II: helmet	Prototype III: glasses	Prototype IV: kinect
Device	Attractive	4	3	4	5
	Functionality	4	4	3	4
	Esthetic	4	3	4	4
	Information	4	4	4	5
Child experimentation TEA	Verbal communication	4	3	4	4
	Non-verbal communication	5	2	2	5
	Eye contact	4	0	4	5
	stress level	4	3	5	5
Curriculum evaluation	Cognitive indicator	5	4	4	5
	Procedural indicator	4	4	5	4
	Communicative indicator	5	3	4	5
Final weighting		47	33	43	**51**

As a result of all this multidisciplinary and cooperation work, a phase of reflection and debate is concluded, where after the practical experience, changes were made to the initial prototype, which allowed the project to be assertively consolidated.

This is how, according to the results we show in Fig. 3, on the X axis we have entered those characteristics that were evaluated through the proof of concept of each of the prototypes, in terms of the device, the experimentation carried out and finally the curricular evaluation, the scale in terms of the measurement carried out goes from 1 to 5, the first being the lowest of the qualifications and 5 the maximum, the final weighting process can be carried out with a number less than or equal to 55, which represents our 100% for the qualification obtained from each of the prototypes built in the investigative process.

It is important to indicate that prototypes 2 and 3 are the ones that received the least reception, since the child with ASD did not want to use superimposed elements on his body, the fact of using the glasses was not an easy idea, despite the fact that as a team we carried out some strategies teachers and therapists used the same prior to the intervention during regular therapies, exposure sessions were held, trying to find a possible adaptation, but these strategies simply at the time of experimentation did not give a favorable result, in the same way prototype 2 where a virtual reality headset was used, it turned out to be even more invasive, causing the child to increase his stress levels and want to leave the therapy session immediately. Figure 5 shows the scores collected by each prototype evaluated according to the variables defined in each of the characteristics analyzed, each prototype is determined with a color, blue for the prototype that uses a smartphone, in red for the prototype that uses the helmet, in green the prototype that uses 3D glasses, in lilac the prototype referring to the use of Kinect.

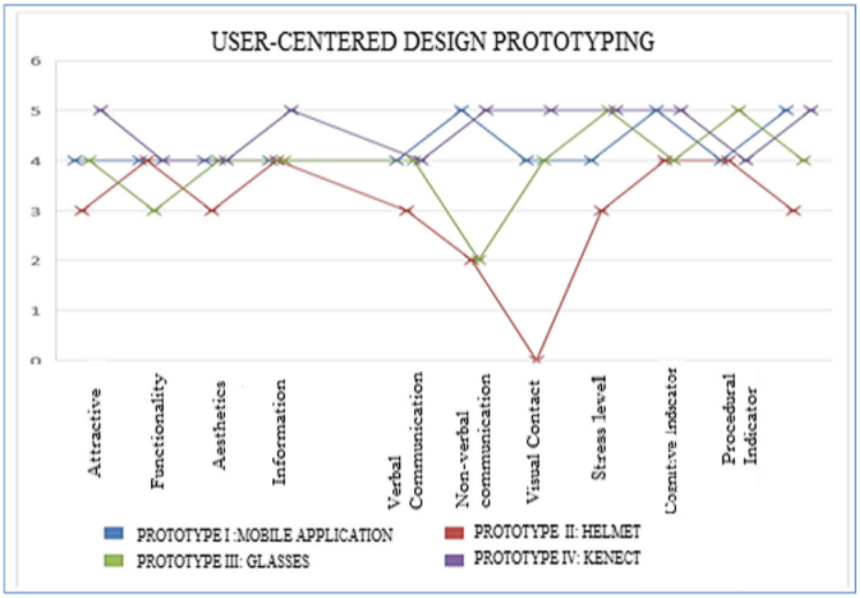

Fig. 5. Weightings achieved by the prototypes made for the Esperanza Project

5 Discussion and Conclusion

In the present investigative work, a study of techniques related to user-centered design DCU in children with ASD has been carried out, a space little studied due to the complexity of planning for the execution of usability tests, additionally exploring usability and accessibility in a software product.

The methodology is a heuristic that created and adapted where a series of phases proposed that allow an adequate DCU to be conducted, certainly these processes are necessary to bring exceptionally reliable products to the market and that have been perceived from a multidisciplinary field trying to have feedback. of the end user, through the analysis, design and subsequent implementation of software tools that seek, from an innovative and simple proposal, to improve the quality of life of children diagnosed with ASD.

So far, four prototypes have created for the Esperanza project. This, far from discouraging us, tells us that we are on the right track, since the product or prototype that obtained the best rating in the evaluation will be accepted and will serve to reinforce some important aspects of the project. teaching learning. The tool, and a plan has been developed for its validation in therapy centers.

The iterations (prototypes) that were carried out in the conception of this research began with the analysis, design and implementation of an app (mobile applications), this prototype was assertive in several aspects, but it avoided the mobility and independence of the child already for to be used he needed to be at a desk accompanied by his teacher, it was observed that the child was afraid to take the smartphone in his hands, so the multidisciplinary team decided to look for a new alternative.

In the second interaction, it was sought that the child will use a helmet where the child would be provided with the mobility that was not obtained with prototype one, however, the helmet turned out to be invasive and moved away from the original conceptualization in terms of augmented reality. the feeling of immersion so this prototype after a proof of concept was discarded.

In the third interaction we decided to bet on the glasses (Google Glass) that allow the deployment of augmented reality and at the same time allow the mobility of the child with ASD, however, when carrying out the experimentation the child could not bear the use of glasses for more than two minutes, which did not allow the established sessions (22 min) to be carried out for the development and intervention of the work plan. After a meeting with the multidisciplinary team, this prototype was discarded.

Finally, the perspectives of the multidisciplinary team are fulfilled in terms of fulfilling characteristics such as mobility that has been provided through prototype four, this is how the use of a Kinect that allows the use of natural user interfaces, and the use of augmented reality was evaluated. Therefore, the system was accepted immediately, currently several tests have been conducted on this prototype that have been satisfactory and it is desired to expand the sample to users with ASD of various conditions to evaluate the result.

We thank the National Secretary of Higher Education Science and Technology SENESCYT-Ecuador for the support provided, as well as the Research Laboratory of New Computer Technologies - LINTI of the Faculty of Computer Science, National University of La Plata.

References

1. Enríquez Pigazo, I.: Trastornos del Espectro Autista: estudio de un caso y propuesta de intervención logopédica (2018)
2. Bleuler, E., Minkowski, E., Manual, S.: El trastorno del espectro autista: aspectos etiológicos, diagnósticos y terapéuticos. Revista Médica del Instituto Mexicano del Seguro Social **55**(2), 214–222 (2017)
3. Contini, L.E., Astorino, F., Manni, D.C.: Estimación de la prevalencia temprana de Trastornos del Espectro Autista. Santa Fe-Argentina. Boletín Técnico **13**, 12–13 (2017)
4. Guzman, G.B., et al.: Introducción a la neurobiolog ' ia y neurofisiolog ' ia del Trastorno del Espectro Autista Introducción a la neurobiología y neurofisiología del Trastorno del Espectro Autista Introduction to the neubiology and neurofisiology of the Autism Spectrum Disord (2016). https://doi.org/10.5839/rcnp.2016.11.02.05
5. Hervás Zúñiga, A., Balmaña, N., Salgado, M.: Los trastornos del espectro autista: aportes convergentes. Pediatr. Aten. Primaria **XXI**(2), 92–108 (2017)

6. Hervás Zúñiga, A.: Un autismo, varios autismos. Variabilidad fenotípica en los trastornos del espectro autista. Rev. Neurol. **62**(S01), 9 (2016). https://doi.org/10.33588/rn.62s01.2016068
7. Rodríguez Medina, J.: Mediacion entre iguales, competencia social y percepcion interpersonal de los ninos con TEA en el entorno escolar (2019). https://doi.org/10.35376/10324/39475
8. Sagarzazu Sacristán, M.: ¿Por qué pinto así? La expresión plástica y artística en adolescentes con Síndrome de Asperger, Autismo de Alto Funcionamiento y/o Trastornos del Espectro Autista, vol. 2017, no. cc, p. 1 (2017)
9. Tsai, L.Y.: Impact of DSM-5 on epidemiology of autism spectrum disorder. Res. Autism Spectr. Disord. **8**(11), 1454–1470 (2014). https://doi.org/10.1016/j.rasd.2014.07.016
10. Aumentada, R., Las, U.N.A.E.D.E.: Aplicaciones de los dispositivos móviles augmented reality, an evolution of theapplication. Rev. medios y Educ. pp. 57 (2012)
11. Sánchez, A.: Evaluación de la tecnología de realidad aumentada móvil en entornos educativos del ámbito de la arquitectura y la edificación. Univ. Politécnica Calalunya, no. Ega Ii, p. 339 (2013)
12. Espinosa, C.P.: Realidad aumentada y educación: análisis de experiencias prácticas augmented reality and education: analysis of practical experiencies. Pixel – Bit. Rev. Medios y Educ. 187–203 (2015). https://doi.org/10.12795/pixelbit.2015.i46.12
13. Fracchia, C., Alonso, A., Martins, A.: Realidad Aumentada aplicada a la enseñanza de Ciencias Naturales. Rev. Iberoam. Educ. en Tecnol. y Tecnol. en Educ. (2015)
14. Rovira, U., Rovira, U., Rovira, U.: El papel de las tecnologías digitales en la intervención educativa de niños con trastorno del espectro autista autism spectrum disorder José-Luis Lázaro-Cantabrana Mercè Gisbert-Cervera, no. 4, pp. 41–54 (2018)
15. Herrera, G., et al.: Pictogram Room: Aplicación de tecnologías de interacción natural para el desarrollo del niño con autismo. Anu. Psicol. clínica y la salud = Annu. Clin. Heal. Psychol. **8**, 41–46 (2012)
16. Medina Rivilla, A., Rodríguez Serna, C.: Potenciar las capacidades de las personas. Modelo para facilitar la comunicación con estudiantes del espectro autista. Rev. Educ. Inclusiva **9**(1), 1–12 (2016)
17. Gavilanes, W., Abásolo Guerrero, M., Cuji, B.: Resumen de revisiones sobre Realidad Aumentada en educación. Rev. Espac. **39** (2018)
18. García Guillén, S., Garrote Rojas, D., Jiménez Fernández, S.: Uso de las TIC en el Trastorno de Espectro Autista: aplicaciones. Edmetic **5**(2), 134 (2016). https://doi.org/10.21071/edmetic.v5i2.5780
19. Basogain, X., Olabe, M., Espinosa, K., Rouèche, C., Olabe, J.C.: Realidad Aumentada en la Educación: una tecnología emergente. Basogain, X., Olabe, M., Espinosa, K., Rouèche, C., & Olabe, J. C. (n.d.). Realidad Aumentada en la Educación: una tecnología emergente. Rev. Mex. Tecnol. 2(3), 14 (2000). http://multimedia.ehu.es
20. Yuen, S.C.-Y., Yaoyuneyong, G., Johnson, E.: Augmented reality: an overview and five directions for AR in education. J. Educ. Technol. Dev. Exch. **4**(1), 119–140 (2011). https://doi.org/10.18785/jetde.0401.10
21. Andrés Roqueta, C., Benedito, I., Soria Izquierdo, E.: Uso de aplicaciones móviles para la evaluación de la comprensión emocional en niños y niñas con dificultades del Desarrollo. Rev. Psicol. y Educ. **12**(1), 7–18 (2017)
22. Lasheras Díaz, C.: La realidad aumentada como recurso educativo en la enseñanza de Español como lengua extranjera. Propuesta de intervención a partir de un manual, p. 63 (2018)
23. Jaramillo Henao, A.M., Silva Bolívar, G.J., Adarve Gómez, C.A., Velásquez Restrepo, S.M., Páramo Velásquez, C.A., Gómez Echeverri, L.L.: Aplicaciones de Realidad Aumentada en educación para mejorar los procesos de enseñanza-aprendizaje: una revisión sistemática Augmented Reality applications in education to improve teaching-learning processes: a systematic review Contenido. Espacios **39**(49), 15 (2018)

24. Gómez, B.D.: La necesidad de nuevas estrategias metodológicas en la educación inclusiva del alumnado autista [The need for new methodological strategies in inclusive education of autistic students]. Ensayos **28**(1), 15–23 (2013). https://doi.org/10.18239/ensayos.v28i0.345
25. Sánchez Bolado, J.: El potencial de la realidad aumentada en la enseñanza de español como lengua extranjera. Edmetic **6**(1), 62 (2016). https://doi.org/10.21071/edmetic.v6i1.5808
26. Romero, M., Harari, I.: Uso de nuevas tecnologías TICS -realidad aumentada para tratamiento de niños TEA un diagnóstico inicial. CienciAmérica **6**(3), 131–137 (2017)
27. Romero, M., Macas, E., Harari, I., Diaz, J.: Eje integrador educativo de las TICS: Caso de Estudio Niños con trastorno del espectro autista. SAEI, Simp. Argentino Educ. en Informática Eje, pp. 171–188 (2019)
28. Romero, M.R., Macas, E., Harari, I., Diaz, J.: Is it possible to improve the learning of children with ASD through augmented reality mobile applications? In: Botto-Tobar, M., Zambrano Vizuete, M., Torres-Carrión, P., Montes León, S., Pizarro Vásquez, G., Durakovic, B. (eds.) ICAT 2019. CCIS, vol. 1194, pp. 560–571. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-42520-3_44
29. Romero, M.R., Diaz, J., Harari, I.: Impact of information and communication technologies on teaching-learning processes in children with special needs autism spectrum disorder, pp. 342–353 (2017)
30. Marín-Díaz, V., Cabero-Almenara, J., Gallego-Pérez, O.M.: Motivación y realidad aumentada: Alumnos como consumidores y productores de objetos de aprendizaje. Motivation and augmented reality: students as consumers and producers of learning objects. Aula Abierta **47**(3), 337 (2018). https://doi.org/10.17811/aula_abierta.47.3.2018.337
31. Láinez, B., Chocarro de Luis, E., Sancirián, J.H.B., López Benito, J.R.: Aportaciones de la Realidad Aumentada en la inclusión en el aula de estudiantes con Trastorno del Espectro Autista contributions of augmented reality in inclusive education with students with autism spectrum disorders. Rev. Educ. Mediática y TIC **7**(2), 120–134 (2018). https://doi.org/10.21071/edmetic.v7i2.10134
32. Almazán Tepliski, F.: Las claves de la usabilidad, los gurúes Nielsen y Krug. Serv. Digit. Bibl. del Congr. Nac. Chile (2005)
33. Macías Morales, M.G., Aguirre Intriago, K.E.: Propuesta tecnológica para el diseño de una página WEB usando los principios de usabilidad de Jakob Nielsen para optimizar el proceso embarque de la empresa TUCHOK S.A. (2017)
34. Sánchez, W.: La usabilidad en Ingeniería de Software: definición y características. Ingnovación. Rep. Investig. **2**, 7–21 (2011)