

Evaluation of the usability and accessibility of applications for mobile devices of pictograms in students with autism spectrum disorder of CAM Tehuacan

Evaluación de la usabilidad y accesibilidad de las aplicaciones para dispositivos móviles de pictogramas en los alumnos con trastorno del espectro autista del CAM Tehuacan

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Abstract

The objective of this research was to analyze two applications that use pictograms installed on a mobile device with the Android operating system, through surveys applied to teachers, family members and students with autism spectrum disorder (ASD) to evaluate the criteria of usability, functionality, and accessibility. The Omega coefficient was used to evaluate the reliability of the applied instruments so as not to depend on the number of items, the acceptable value should range between 0.70 and 0.90. The evaluations obtained in each one of the surveys were: for teachers of the Multiple Attention Center (CAM) of Tehuacán 0.707 and for parents 0.705, demonstrating that the reliability of the instrument that was applied is adequate. With the results of this analysis, areas for improvement were detected focused on the development of a new mobile application adapted to the needs of students with ASD from the Tehuacán CAM, and as a contribution of a Mexican development in this segment.

Mobile, Usability, Autism

Resumen

El objetivo de la presente investigación fue analizar dos aplicaciones que utilizan pictogramas instaladas en un dispositivo móvil con sistema operativo Android, por medio de encuestas aplicadas a profesores, familiares y alumnos con trastorno del espectro autista (TEA) para evaluar los criterios de usabilidad, funcionalidad, y accesibilidad. Se utilizó el coeficiente Omega para evaluar la confiabilidad de los instrumentos aplicados para no depender del número de ítems, el valor aceptable debe oscilar entre 0.70 y 0.90. Las valoraciones obtenidas en cada una de las encuestas fueron: para maestros del Centro de Atención Múltiple (CAM) de Tehuacán 0.707 y para padres de familia 0.705, demostrando que la confiabilidad del instrumento que se aplicó es el adecuado. Con los resultados de este análisis se detectaron áreas de mejora enfocadas al desarrollo de una nueva aplicación móvil adaptada a las necesidades de los alumnos con TEA del CAM de Tehuacán, y como una aportación de un desarrollo mexicano en este segmento.

Móviles, Usabilidad, Autismo

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1. Introduction

The first contributions on autistic traits were developed in 1926 with child psychiatrist Grunya Efimovna Sukhareva who published a detailed description of autistic traits in several children in a German scientific journal of psychiatry and neurology (Manouilenko *et al.*, 2015). "Autism affects 1 in 160 children worldwide and is the most prevalent condition in the psychiatric field. Mexico lacks STI (Science technology and innovation) policies that articulate the needs of this population" (Anzaldo *et al.*, 2019, p. 13).

As defined by the World Health Organization (WHO, 2022), "Approximately one in every 100 children has autism. Evidence-based psychosocial interventions can improve communication and social skills, with a positive impact on the well-being and quality of life of both autistic individuals and their caregivers."

In the State of Puebla there are 49 CAMs, whose mission is to offer initial and basic education and job training to children and adolescents with multiple disabilities and pervasive developmental disorder, with the aim of eliminating or reducing barriers to learning and participation in school, classroom, socio-family and work contexts.

Autism is a lifelong neurodevelopmental condition that interferes with a person's ability to communicate and relate to others (Elsabbagh *et al.*, 2012). The Mexican Autism Clinic estimates that, in Mexico the incidence of autism is 1 child per 115 (CLIMA, 2021). Considering that the population size of Mexico is 126 million, according to INEGI (2020), there are about 94,800 people with ASD in ages 0 to 4 years and 298,000 people with ASD, in the age range of 5 to 19 years (Fombonne *et al.*, 2016).

In the City of Tehuacán, 2 CAMs operate that serve children and adolescents with multiple disabilities and pervasive developmental disorders, including students with autism. The use of applications for people with ASD is important as García, Garrote and Jiménez (2016) state, "ICTs and specifically mobile applications are booming and educationally speaking, they can be a great resource for children diagnosed as ASD as they can improve communication, language, emotions, social intervention and vocabulary".

The number of ICT-based tools for the intervention of people with ASD has experienced significant growth, so much so that people with ASD have been included as a priority target in what has been called Affective Computing (Cuesta, 2012, p. 18).

"Many authors have pointed out the need to develop software and hardware that, combined with specific technology, will increase the vocabulary and communication skills of people with ASD" (Heredia & Navas, 2019, p. 46). This allows students with ASD to use another tool to be able to function in their environment.

"In the therapeutic approach to children with autism spectrum disorder (ASD), it is essential to incorporate the construction and use of alternative and augmentative communication systems (AACs)" (Echeguia, 2016, p. 104), such as pictograms. "The images used in pictograms are not standardized according to the context, since a concept is represented by different types of pictograms" (Orellana, 2016, p. 96).

On the ARASAAC website (Portal Aragonés de Comunicación Aumentativa y Alternativa), it contains images available to facilitate communication with people with autism (García *et al.*, 2016).

The aim is for teachers to use the pictogram applications with their students with ASD in the CAM and parents at home. There are different applications for people with ASD on the market, of which two were chosen at the suggestion of those in charge of the CAM, PictogramAgenda and PictogramAgenda, of which the usability and accessibility were evaluated, proposing improvements for the development of a new mobile application, as a contribution of this research.

The methodology section presents the study carried out, the evaluation and measurement instruments used to generate the results. The results section presents in an analytical way the information collected and processed to obtain the usability and accessibility assessment of each of the applications.

Methodology

The methodological approach applied was non-experimental, since the usability, accessibility and functionality variables do not undergo descriptive modifications. The objective is to evaluate people with autism and their relationship and interaction with mobile applications. The primary source research instruments used were web surveys directed to different people directly related to CAM activities and the use of mobile device applications focused on the support of children with ASD, being the participants teachers, parents or guardians, as well as children with ASD, during the period from January to June 2022.

The applications PictogramAgenda and PictogramaAgenda were chosen at the suggestion and recommendation of Lic. Maricruz Mendoza Morales and Lic. Miguel Debas Escobar, director and psychologist of CAM Héctor Lezama Surroca, respectively, since these two applications have been used, tested and analyzed.

Teachers according to their experience and daily interaction are best suited to select appropriate apps for their students and provide suggestions to parents who express interest in educational apps (Weng, 2015).

Pictograms are graphic symbols used to facilitate language for children with some type of disability. These symbols are essential in the work done with students with ASD, since most children with learning disabilities have an easier time communicating through images, since they have a lower level of abstraction (Domínguez, 2019, p. 6).

To evaluate the mobile applications, a mixed survey with likert-type scale, open and dichotomous response was applied as an evaluation instrument, with the following indicators: learning, usability, efficiency, memorability, interaction with the application, satisfaction, and accessibility, taking as a reference that all students use a mobile device such as a cell phone with Android operating systems and the application is free.

The objective of educational mobile applications is to complement the daily activities performed by families and teachers, where all activities are oriented towards the same purpose, not exceeding its use (Gallardo Montes *et al.*, 2021, p.5).

Survey for CAM teachers

It consists of 7 items, offering different scales, 4 of the items have dichotomous answers, 1 item offers 4 non-scaled options referring to the academic level and 2 of the remaining items offer 3 options with a Likert-type scale different one from the other, the options being: 1 Very useful, 2 Not very useful, 3 Not at all useful and 1 Very beneficial, 2 Not very beneficial and 3 Not at all beneficial.

Survey for Parents

It is made up of 10 items, 9 of which offer dichotomous responses, and only 1 item has 3 options on a Likert scale, 1 Very supportive, 2 Not very supportive, 3 Not at all supportive.

Data collection survey for children with ASD

For this particular instrument, its approach only required open-ended questions, being the items focused on gathering information particular to children with ASD, information that in this case is not quantifiable within a Likert-type scale.

Next, the Omega coefficient was applied, where the acceptable value should range between 0.70 and 0.90, using the Jamovi software (www.jamovi.org) to verify the reliability of the instruments, obtaining the following results: survey for CAM teachers 0.707, survey for parents 0.705, which indicates that the instruments used are reliable.

The survey was based according to the system of indicators for the evaluation of mobile applications for users with ASD through 3 dimensions, the design/form dimension with the indicators: availability, ergonomics, usability, and accessibility; content dimension with the aspects: content, and help; pedagogical dimension with the indicators: interactivity, learning, and monitoring as proposed by (Gallardo-Montes *et al.*, 2021, p. 5).

These two mobile applications are found in the catalog of applications that develop communication with students with ASD, within the 50 applications with ratings of 80-90 PictogramAgenda and 70-80 PictogramAgenda, elaborated as a resource for teachers and families (Capel, 2021).

Also using the Google Apps database, 35 mobile apps were found and organized according to user ratings, number of downloads and updates, without excluding whether they are paid or free, with the PictogramAgenda mobile app appearing in 32nd place (García *et al.*, 2016).

3. Results

1. Selecting the sample population.

In the city of Tehuacán there are 2 Multiple Attention Centers that serve children with ASD, where aspects such as ease of access to a mobile device, familiarity with the use of a mobile device and willingness to participate in the study were analyzed. Thus, 19 students who regularly attend the CAM Héctor Lezama Surroca were selected.

Ten instructors who work at the CAM performing activities directly related to students with ASD were selected.

Of the 22 people possible for the study, only 14 were able to participate, of which 12 are directly related to the student, 1 is a therapist and 1 is a shadow teacher, who is a permanent companion of the student, subsidized by the parents themselves.

2. Collection of information

An initial survey was applied to collect information related to the conditions and level of intensity of support for children with ASD. In the CAM 89.4% of the students are male and 10.6% are female. The age distribution of children with ASD is summarized in Table 1.

Age	Children
Less than 7	4
7 a 12	8
13 a 18	5
19 a 24	2

Table 1 Ages of children with ASD

Source: Own Elaboration

Table 2 shows the distribution of the years of stay of students with ASD in the CAM.

Time	Number of students
Less than one year	2
1 to 2 years	6
More than 2 years and up to 3 years	5
More than 3 years	6

Table 2 Years of stay in the CAM

Source: Own Elaboration

There are 18 students with a medical record and only 1 does not have one, since his parents did not consider it necessary. According to the level of studies, 1 is in early education, 4 in preschool, 7 in elementary school, 5 in high school and 2 received job training.

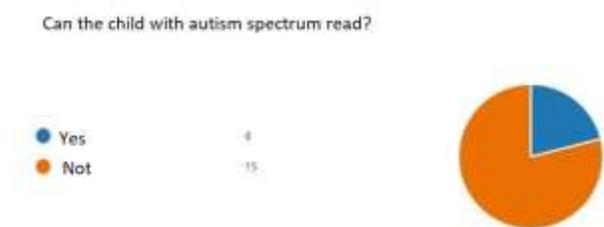
Of the 19 students, 8 are not able to establish stable communication with others or communicate in any way, but 11 of them are able to communicate by means of words that are understandable, not being able to complete a sentence (Graphic 1).



Graphic 1 Graph of communication through speech

Source: Own Elaboration

The students who can communicate by reading are 4 and 15 have difficulty reading (Graphic 2).



Graphic 2 Graph of communication through reading

Source: Own Elaboration

Students with ASD use different ways to communicate, either through signs, gestures, oral or written expression. The survey showed that 17 express themselves through signs, 7 communicate through oral expression and 6 use pictograms that they know and use in their daily lives (Graphic 3).



Graphic 3 Communication through other elements different from oral language
 Source: Own Elaboration



Graphic 4 Has its own cell phone for the child
 Source: Own Elaboration

3. CAM Instructor Survey

Initial surveys were applied to instructors to collect data on the knowledge and acceptance of mobile devices, the following results are shown below:

At the time of the application of the instrument, 10 instructors were found, of which 9 have a degree in Special Education, Bachelor's Degree in Psychology or related to the activities developed in the CAM, and 1 teacher does not have a related career.

All the teachers have access to their own cell phones, only 50% of the teachers know of any application focused on people with autism spectrum disorders. 90% of the teachers consider that the use of mobile applications for students with ASD is beneficial for the student and useful for the teacher's own activities. 100% of the teachers are in the best disposition to use a mobile application designed for students with ASD.

Survey for parents, therapist or caregiver.

This survey is aimed at detecting how often a child with ASD uses or is familiar with the use of a mobile device. The results obtained are summarized as follows:

Of the respondents 71.4% consider that the use of a mobile application is of great help for the integration and communication of the student with his/her environment, 9 respondents comment that the student uses the mobile device and 5 do not use it.

Another result that should be highlighted is that a minimum percentage have a mobile device for their children, using the cell phone of their parents or a relative, regularly to play, observing the interaction of the student with the device, it is concluded that he/she loses interest very quickly (Graphic 4).

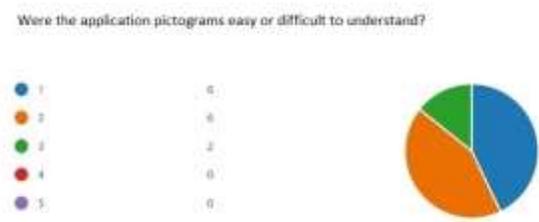
100% of the respondents are willing to use and evaluate a mobile application based on pictograms to be used with the student with ASD.

At the end of the surveys, some parents expressed that they are willing to be trained and include some technological tool that helps them with the development of learning and skills of their children, which is accessible, since they do not have the economic resources to acquire an application that involves an expense.

The PictogramAgenda and PictogramAgenda applications were used for two months, integrating them into the activities carried out at the CAM. After using them, a survey was applied to parents, therapists, and shadow teachers, obtaining the following results:

a) Learning to use the application.

86% considered it very easy to use the application, and considering the size of the cell phone screens it is easy to access, as well as to select an option in the application, they also considered that the pictograms of the application were very easy to understand (Graphic 5).



Graphic 5 Learning how to use the application
 Source: Own Elaboration

b) Usability of the application

During 2 months, 50% of the instructors tested and used the application with their students, concluding that the students need constant adult supervision to take advantage of the features of the mobile application. Even so, when questioned regarding how they would rate the usability of the application, 6 of them considered the application very useful for children with ASD.

c) Efficiency of the application

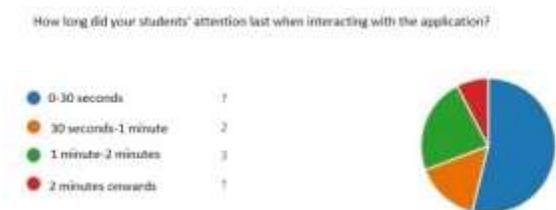
The features that were evaluated and their percentage of efficiency are summarized in Table 3 below:

Characteristic	Percentage
Efficiency of application use	72%
Clear and understandable graphics	86%
Easy to prepare a day's agenda	71%

Table 3 Efficiency of the application

Source: Own Elaboration

It was observed that the time that the students were interested in using the application was in the range of 0 to 30 seconds in the majority, the rest of the students managed to maintain their attention in a time of up to 3 minutes (Graphic 6).

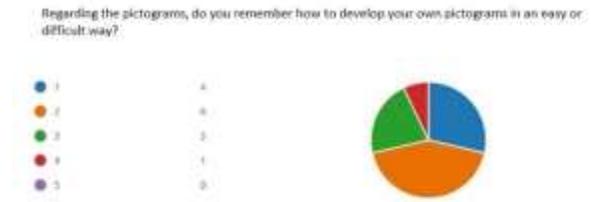


Graphic 6 Graph of student attention time to the application

Source: Own Elaboration

d) Memorabilidad

For the development of their own pictograms, such as pictures representing objects, places, things or known people, 28% consider it difficult, 43% regular and only 29% easy. After using the application, 85% considered it easy to remember each of the options (Figure 7).



Graphic 7 Graph regarding the development of own pictograms

Source: Own Elaboration

e) Interaction with the application

29% of the respondents consider the installation easy and 71% not very easy, 14% needed to uninstall some application due to lack of storage space of the mobile device. 72% consider the application useful in daily life and 28% consider it not very useful. 43% considered the interaction with the application buttons easy (Graphic 8).



Graphic 8 Graph of interaction with the application

Source: Own Elaboration

Regarding the continuity of the application management it was obtained that only 1 teacher does not consider continuing to use the application since it does not represent any benefit in their interaction with students with ASD, 2 teachers are undecided, 10 teachers consider very likely to continue using the application in their daily activities in the CAM.

f) Satisfaction

When using the application to create pictograms, more than 70% of the respondents expressed feeling comfortable developing the day's agenda and using the other components of the application. Once the agenda of the day was created the students showed a higher percentage of confidence to interact on their own.

g) Accessibility

Once the accessibility conditions were evaluated for possible physical, visual, auditory or other limitations of the users, it was determined that none of the 2 applications had these characteristics.

The test time was short due to the gradual return to the classrooms after the pandemic and that teachers did not have electric power to work with their students for a whole day, so the interaction process was little, however, the use of this sample application allowed to further increase the interest of teachers in the use of a support application for children with ASD.

Annexes

CAM Initial Teacher Survey:
<https://forms.office.com/r/ArXqgZcvEt>

Initial Survey for Children:
<https://forms.office.com/r/9PRFdgBr2W>

Final Teacher Survey:
<https://forms.office.com/r/1pzKcVUFEi>

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5. Conclusions

Once the analysis of all the results obtained through the surveys and the usability and accessibility analysis has been carried out, we can conclude that the PictoAgenda and PictogramAgenda applications do not have error correction and feedback, in the progress control of the daily agenda, they do not provide a score achieved or a message indicating that the activity has been completed, the navigation through the application is simple, there is no online help in manuals or tutorials that help to understand the operation of the application. The design of an attractive interface should be sought to attract the child's attention, language and pictograms contextualized to the country.

With this analysis we have the necessary elements to start the design and development of a new application considering improving the criteria listed above in order to achieve a more robust application with a more efficient usability and accessibility level.

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