PICTOAPRENDE: Design and evaluation of a tool that contributes to the personal autonomy of children and youth diagnosed with autism spectrum disorder in Ecuador

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Abstract

This paper presents the development and evaluation of PICTOAPRENDE, which is an interactive software designed to improve oral communication. Additionally, it contributes to the development of children and youth who are diagnosed with autism spectrum disorder (ASD) in Ecuador. To fulfill this purpose initially analyzes the intervention area where the general characteristics of people with ASD and their status in Ecuador is described. Statistical techniques used for this evaluation constitutes the basis of this study. A section that presents the development of research-based cognitive and social parameters of the area of intervention is also shown. Finally, the algorithms to obtain the measurements and experimental results along with the analysis of them are presented.

Keywords: Digital communicators, repetitive behavior, pictograms, brain disorder, autism spectrum, bootstrap, population sample, hypothesis.

1 Introduction

The Autism Spectrum Disorder(ASD), present in childhood, is identified due to a person's difficulties, changes or delays to develop social relations and communication. It also affects his/her behavior, which ends up attempting against his/her independence and ability to get into social relationships. [1]
Verbal communication is very low or almost null on these people. They present lack of attention and interest in daily activities, thus this situation becomes a great challenge for the common learning process.[2]
The most common communication methods for people diagnosed with ASD have been based on the use of pictograms - graphic representations of words or actions to learn interactively, formulate sentences or perform various routines. Daily activities are described by sequential graphics to be accomplished by these people. For example, activities such as brushing their teeth or taking a shower were proposed to be performed in their cleaning places so that the activities can be imitated.
Nowadays, mobile devices like smartphones and tablets are widely used for teaching purposes because children and adolescents diagnosed with ASD present a great deal of interest on them. These technologies allow to develop therapeutic games to stimulate and help the educational cognitive development in an enjoyable manner.[3] They also permit to assess the learning process by using statistical methods such as Bootstrap, hence realizing the Android application PICTOAPRENDE. This is an interactive software for children and young people who were diagnosed with ASD. The cognitive process is improved by using this method as well

as it helps to ensure the independence of the users.
Research for creating PICTOAPRENDE and the analysis of results was performed during a period of time of one year and six months. A sample of 20 children between 10 and 17 years old was identified for this study and they belong to the Foundation that was taken for the analysis.
This application has incorporated pictograms by taking advantage of the wide spread use of electronic communication media through a series of messages and sounds that ease the daily interaction with this segment of population, which has been historically invisible.
The development of this application is very important due to the lack of such tools that contain requirements and parameters within the Ecuadorian region such as lexicon, the use of images known by them, valid emergency numbers, data base containing telephone numbers. [4]
The use of the Ecuadorian dialect within the application is very important to consider since the utilization of countless words and phrases typical of the region are present. Foreign dialects bewilders and fool the learning process for people that suffer this kind of disorder. [5]
The results obtained by the use of this tool were analyzed through the application of statistical techniques such as bootstrap, hypothesis validation, confidence interval and descriptive statistics, obtaining satisfactory results.

2 Intervention area

2.1 General characteristics of people diagnosed with Autism Spectrum Disorder.

Within the characteristics of autistic children, it is not odd that it comes accompanied with a certain mental retard degree, which consists of the existence of a great difficulty towards oral communication when expressing their feelings and needs.
Children and young people with autism have an inflexible behavior. In other words they do not take the changes in routine, sudden facts or last time modifications adequately. [6]
Another feature of these children is the fact that they are obsessed with a certain behavior or one of their objects (toys). This added up to their lack of capacity of communication could result in a really difficult behavior and even somewhat aggressive when integrating the toddler with the rest of society. [7]
Eye contact and attention are deficient. They are not often able to use gestures as a manner of communication. They speak aloud or like automatons or robots. Commonly, they do not pay attention when other people speak, they are not receptive and cannot even respond to their own names.
It is possible that they spend too much time sorting things before they can pay attention or they have to say the same phrase over and over again to calm down. It seems somehow that they are in their “own world”. [8]
Particularly in Ecuador, there are no formal statistics of people diagnosed with autism and neither there are devices or applications to treat this problem.

2.2 Status of ASD in Ecuador.

The status of ASD in the country regarding the attention to autism can be summarized as follows:

- It is estimated that there are about 180 thousand children with autism in Ecuador and there are few institutions dedicated to tackle this problem, since the Government has made visible this segment of people. Therefore, there are no public institutions specialized for care of the autistic population in Ecuador. [9]

- Inclusion of people with ASD into formal schools or institutions that are not properly equipped to treat them. This integration is not considered adequate because people with ASD requires a biological and psycho-educational intervention that is far from that required by persons with mental retardation or other mental disabilities. This difficulty leads to halt the growth of people with ASD.

- The cost for diagnosis and treatment of ASD is very high. It is only a matter of considering the access to the essential services, not only for diagnosis but also for the long and intense treatment to realize that this leads to affect any familyÂ´s budget. Families cannot access to these resources because there are not specialized public schools available in Ecuador. [10]

3 Statistical techniques for data evaluation

3.1 Descriptive Statistics.

Records or observations provide a series of data which necessarily must be ordered and presented in an intelligible manner. Descriptive statistics develops a set of techniques which aim is to present and reduce the different observed data.
The presentation of data is realized by sorting tables, process called tabulation, and subsequent graphical representation by using histograms, bars, pie charts, and others. Using this statistical average allows to share different sets of data obtained from different observations. [9]

3.2 Bootstrap.

It is the most versatile and well-known sampling technique. The basic idea is to treat samples as they were population and extract with replacement a large number of resamples of size n. Thus, although each resample has the same number of elements as the original sample, each one could include some of the original data more than once. As a result each resample will probably be different from the original sample; whereby a statistical x, calculated from one of those resamples will take a different value from the one that produces another resample. The fundamental affirmation of bootstrap is that a frequency distribution of statistics calculated from the resamples is an estimate of the sampling distribution of population.[11]
Three practical applications are derived as a result of this process:

- Assess bias and sampling error of a statistic calculated from a sample.
- Establish a confidence interval for an estimated parameter.
- Testing hypotheses for one or more population parameters.

4 Application development.

4.1 Research of cognitive and social parameters.

PICTOAPRENDE is an interactive software oriented to children and young people with autism spectrum disorder. It aims to improve the verbal process and interaction with the environment. [1]
This study was performed in Quito - Ecuador thanks to the proposed requirements by a number of foundations dedicated to the treatment of this disorder as follows:

- The generation of an interactive application.
- An application based on pictograms.
- The application must use clear icons, limited language and evident gestures.
- The predominant color in the application should be blue or dark blue.
- It should focus positively on education and treatment of autism.
- Provide means to communicate by the use of movements, gestures, signs and sounds.
- Avoid overuse of images, colors and specially noisy, complex and hyper-stimulant environments.
- The application must be made in full Ecuadorian dialect.

4.2 Generation of the application

Due to the delay or partial lack of oral language that children with autism possess, the need to compensate this deficiency is generated through alternative modes of communication such as pictograms - systems that allow represent a real object or figure schematically, thus developing their social and communication skills.
PICTOAPRENDE has seven options available, as shown in Figure 1. These help to learn daily sequences, common and basic phrases that express basic needs. It also teaches digits, sounds that are associated with different pets, and the correct pronunciation of vowels.
Through logic and memory game, it teaches emergency numbers and allows users to send e-mails and text messages expressing needs and possibly emergency.

This application incorporates lexicon and Ecuadorian dialect deployed into an amicable voice for users as well as the integration of images and clear symbols, thus making it attractive for children and young people with Autism Spectrum Disorder.[1]

Figure 1: PICTOAPRENDE main menu

- **PictoActions:** They teach sequences of daily personal care such as going to the bathroom, bathing, teeth brushing and doing the bed. These activities are represented by pictograms, method that encourages most people with autism in a variety of situations, including both expressive communication as well as the use of schedules and other visual aids [12]. See figure 2.

Figure 2: Sequence for making the bed

- **PictoSentences:** They help to reduce the lack of oral communication with the deployment of daily phrases such as I want to go home and I am hungry or sleepy. Simple and well-known sentences that are fundamental towards interaction and proper development of children and young people diagnosed with ASD. See Figure 3

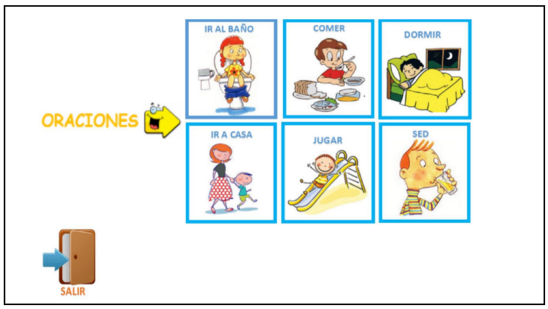

Figure 3: PictoSentences menu

- **PictoNumbers:** It is an option that teaches natural numbers from 0 to 9 along with their pronunciation in Spanish. Taking into account that they are the basis to do math operations.
  This alternative aims to help memorization and through repetition seeks to achieve the identification of each number as well as its correct pronunciation as shown in Figure 4.

Figure 4: Screen of PictoNumbers

- **PictoVowels:** Vowels are an integral part of the learning process for reading and writing. Since children and young people with ASD possess limited oral abilities, they do not achieve an interaction between vowels and consonants, therefore articulating words and phrases becomes difficult.
  For this reason the option PictoVowels was created as shown in Figure 5. It reproduces the sound of each vowel including an illustrative image.

Figure 5: Screen PictoVowels

- **PictoAnimals:** A research developed by the Institute of Neurosciences of Castilla and Leon has shown the importance of exposing children to certain sounds in order to stimulate their hearing sensitivity and facilitate the learning process. [12] Therefore, the PictoAnimals option was created to encourage children and young people with ASD.
  The sounds produced by animals can be relatively fun and even more if you learn in an easy and enjoyable manner. This application includes 10 different pet sounds and they are reproduced by touching the screen. See Figure 6.

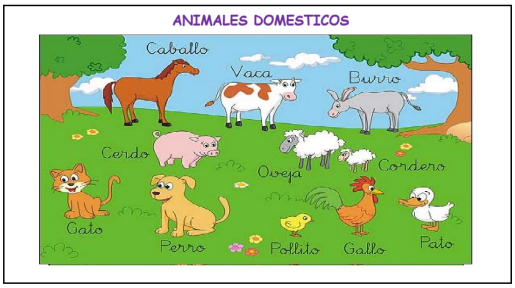

Figure 6: Screen PictoAnimals

- **PictoMessages:** This is one of the most representative options of the application, since it allows the user to communicate with family members, teachers or people who are in charge of their care and education.
  Raise warnings of the need or existence of any kind of emergency that the user might be involved.
  The user can ask for help by sending pre-stablished text messages or emails. See Figure 7.

Figure 7: Menu to send a text message or an e-mail

- **Emergency numbers:** This teaches the users the most important phone numbers that can help in the case there is a problem or emergency in Ecuador. All this through an interactive game.
  First of all, the 911, police phone number, is thought as well as Red Cross and fire station contacts. The user is expected to repeat the number correctly, when this happens a sound showing approval will be activated, otherwise the sound will warn the user that something is not correct.
  When dealing with children that are not able to maintain verbal communication, it is necessary to teach them what to do in the case an emergency arises.
  It is relevant to consider that calling to the phone numbers mentioned above without facing a real emergency is consider a felony; this according to the organic code article 396. People who fail to do this could end up receiving a punishment between 15 and 30 days in prison. For example, individuals who make false warn calls to the Safety Integrated System ECU 911 can fall in this case.
  This is consider a fourth class violation, which was incorporated in the legislation due to a high rate of malicious calls. The third part of this article states that the penalty applies to "any person who improperly makes de use of the emergency number to give false warnings of emergencies, and this involves displacement, mobilization or unnecessary use of resources of the emergency institutions." [13]
  Thus, this option allows the user to get trained without making any call. See Figure 8.

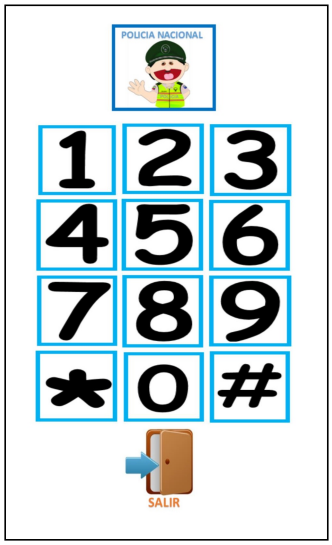

Figure 8: Screen of the number of the national policel

5 Algorithms to measure the results

PICTOAPRENDE was tested on the target population for six months through monthly evaluation on each option of the application.
A scale of skills assessment was utilized; this consisted of the tabulation of 10 tries in each option. The assessment was applied before and after using the tool so that it can be seen how the aptitudes of the population sample changed.
Finally, the results were analyzed by using the following algorithms:

5.1 Algorithm using descriptive statistics

This algorithm uses polygonal graphs and pie charts according to the learning data obtained at the end of the evaluation process for each of the options. The following steps were applied:

1. Definition of variables (variables which values are under study): learning percentage in each option of the PICTOAPRENDE tool.
2. Selection of the sample to be studied: twenty children and young people ranging from 10 to 17 years old diagnosed with ASD were chosen.
3. Data collection: results obtained from the assessments that were applied to the sample by the use of the proposed scale of skills.
4. Tabulation of results: Obtained data from the test was sorted through the utilization of tables. It was assumed that the user effectively learnt when he/she scored more or equal to 6 out of 10 in the step 3.
5. Graphic representation: use of pie charts presenting the results after the evaluation process.

5.2 Bootstrap Algorithm for Hypothesis Testing

The number of samples in the research is limited due to the size of population, thus data could be compromised. For this reason bootstrap technique was implemented to assess the difference between the initial vs final learning data; this according to the following algorithm. [14]

1. Consider that both samples, initial and final come from different populations (A, B).
2. Determine the data validation by applying null hypothesis testing, where $H : A = B$.
3. Use the media differences as statistics.
4. Combine the elements of both samples and a single set is obtained $X = [initial, final]$ consists of 40 elements.
5. Draw with replacement a resample of size $n = 40$, where the first 20 values will be called $Initial'$ and the remaining ones $final'$; these based on X.
6. For the taken sample, compute the statistics value $final' - initial'$. The hypothesis will be based on this.
7. Repeat at least 1000 times the previous steps.
8. Build the frequency distribution for the statistics $final' - initial'$.

The obtained distribution constitutes a Bootstrap estimation of the sample distribution for the media difference statistics.
If we count the number of times that the difference in Medias exceeds or equals the observed value in the original samples, we can obtain the relative frequency; this will be considered as an approximation of the probability to find, accepting the null hypothesis as true, a difference of Medias more or equal to the one observed. See equation 1:

$$Prob_H(final' - initial') \geq (final - initial) = \frac{\text{Number of times}[(final' - initial') \geq (final - initial)]}{\#repetitions} \tag{1}$$

If the result of the probability is less than 0,05 significance level, we reject the null hypothesis and it is asserted that the obtained data with the sample population is 95%.

5.3 Bootstrap algorithm for confidence intervals

Confidence intervals were implemented by the method of percentiles, which determines the more likely range of learning with the use of PICTOAPRENDE. Considering that the values can be represented visually as a normal distribution or commonly called Gaussian distribution, it is determined that according to the media value, the learning percentage is estimated.
To develop the Bootstrap confidence intervals, it was used the percentiles method where $F'(\theta')$ approximates to $F(\theta)$. The idea is that an interval with a confidence level of $1-\alpha$ includes all the values of θ' between percentiles $\alpha/2$ and $(1-\alpha/2)$ of the distribution of $F'(\theta')$. [15]
To develop the confidence intervals we will work separately with the initial and final data, obtaining thus independent results of CI for the learning media of each option of the application. The following algorithm was set as pattern:

1. Save initial data obtained from the sample of 20 children and young people with ASD in a set X.
2. Select randomly and with replacement 20 data from set X.
3. Calculate the average of the taken resample.
4. Repeat steps 2 and 3 at least 1000 times.
5. Estimate the 2.5 and 97.5 percentiles of the distribution of the media based on the mean values obtained by the previous step. These would become the limits of a bootstrap confidence interval of 95%.
6. Perform steps 1 to 5 with the final data of the sample in order to obtain the confidence interval.

6 Experimental results

The following section describes the findings along with the technical differences. All data went through hypothesis testing for validation purposes; a value of 0,05 was yielded for all options of PICTOAPRENDE, thus claiming 95% of certainty on the data. Furthermore, this allows the realization of confidence intervals to determine the most probable learning range.
Next, the results are displayed according to the classical statistics by using pie charts, which represent the final percentage of learning. Then this is compared with the results obtained by using bootstrap technique, which is based on confidence intervals. This was done for every single option of the application.

6.1 PictoActions

During the period of evaluation, visual and aural memory were improved. It has to be consider that several of this actions were realized by users with almost no difficulty, thus getting better interaction in his/her daily life.
The percentages achieved by users at the end of the learning process on each activity is presented by measuring the aptitudes on the skills performance scale set before.

- **Brush your teeth:** Of a total of 20 students, 16 of them succeeded at learning the sequence of brushing their teeth without difficulty. This corresponds to 80% of the total sample. The remaining 20% failed to learn this routine due to lack of attendance, as it is shown in Figure 9.

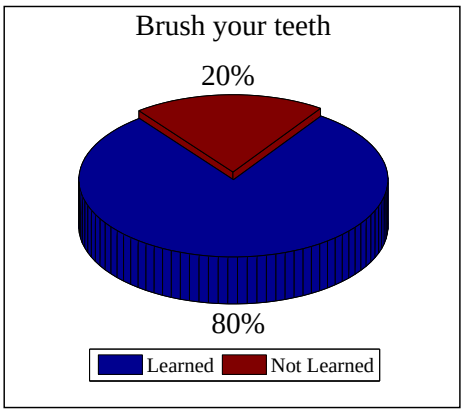

Figure 9: Analysis of brush my teeth option

- **Do the bed:** Of a total of 20 students, 18 of them succeeded at learning the sequence of making the bed without difficulty. This corresponds to 90% of the total sample. The remaining 10% do not carry out this daily activity, hence they have no need to learn it. See Figure 10.

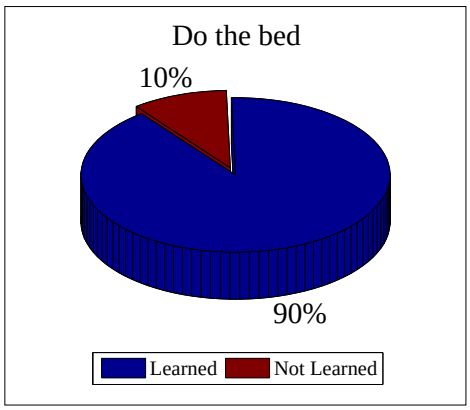

Figure 10: Analysis of making the bed option.

- **Go to the bathroom:** From a total of 20 students 19 of them succeeded in learning the sequence to go to the bathroom without difficulty, which corresponds to 60% of the total sample.

  The remaining 5% due to physiological defects may not go to the bathroom by themselves. See Figure 11.

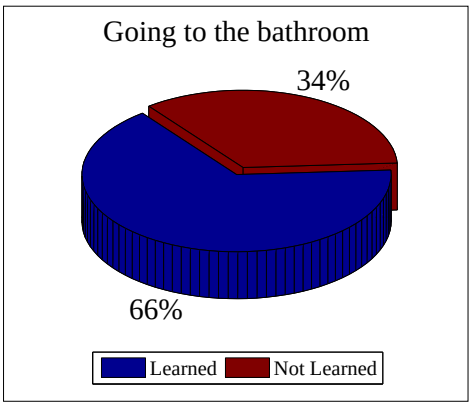

Figure 11: Analysis of the option of going to the bathroom

- **Bathing:** From a total of 20 students, 12 of them succeeded in learning the bathing sequence without any difficulty. This corresponds to 60% of the total sample, and the remaining 40% cannot bathe by themselves due to motor disabilities, since help and supervision are needed.

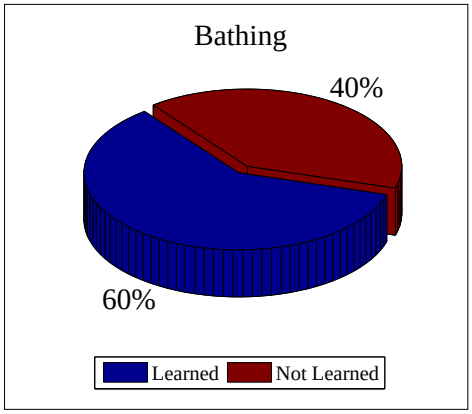

Figure 12: Analysis of the take a shower option

Figure 13 shows the confidence interval of the population sampling. It ranges from 23.5 to 30.5 percent; this shows a deficient knowledge before the use of PICTOAPRENDE because the starting point corresponds to 27% of the knowledge, which was acquired by using traditional methods.

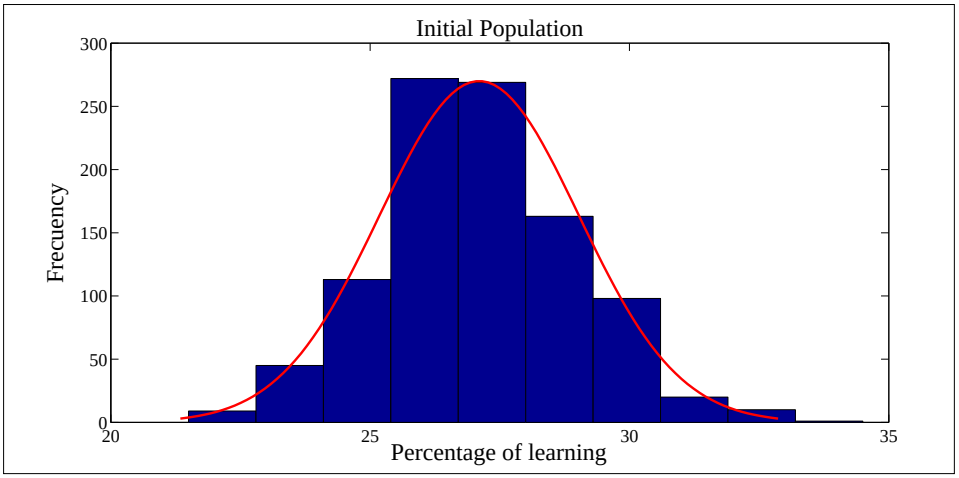

Figure 13: Normal distribution with initial data of PictoActions

Figure 14 presents the learning evolution within the population, since the media has a value of 69%. Additionally, this percentage determines an optimal learning average, which is taken with this option and considering that the learning percentage for hygiene sequences was raised by 42%. The confidence interval was obtained as 62-75 percent. This range guarantees 95% of certainty for the learning process of the sequences. A slow improvement was reflected, consequently the target was not achieved with some of the users, and this could be visualized through non-verbal communication, eye contact, facial expression, and social interaction regulatory gestures.[16]

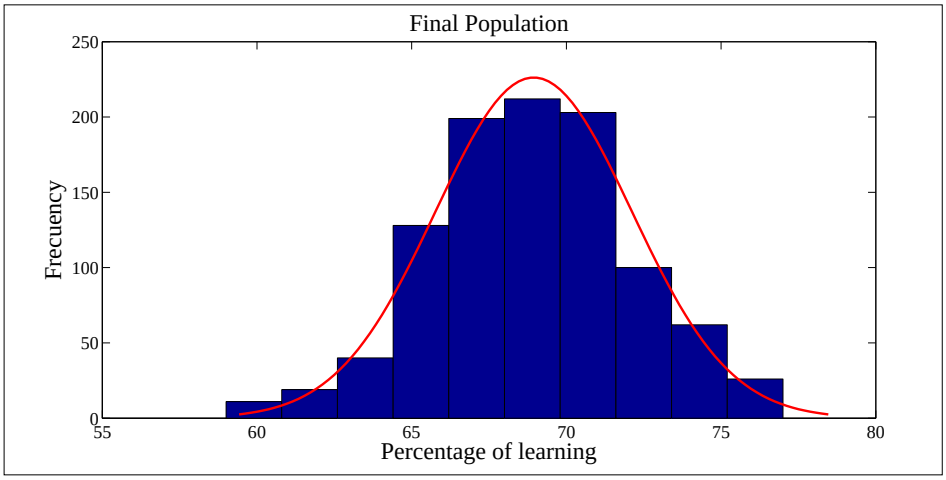

Figure 14: Normal distribution with final data of PictoAcciones

6.2 PictoSentences.

It is an option that provides users with phrases that are used daily such as I want to go to the bathroom, I am hungry, I am thirsty and others. This options helps to encourage people's attention and concentration as well as their bond with the surrounding environment. Vocalization of words through repletion is also stimulated.

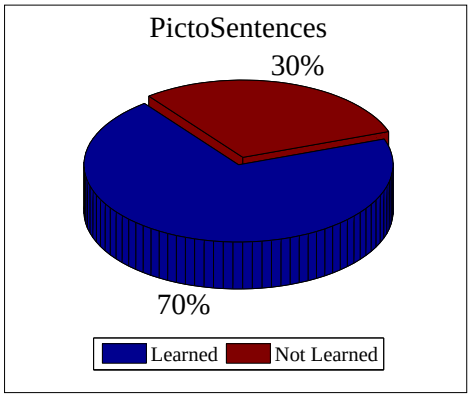

Figure 15: Analysis of the PictoSentences option

Figure 15 shows that 70% of beneficiaries got to pronounce phrases formed by two or three words. This represents a big step ahead due to the users of this application were monosyllables at the beginning and in some cases they were non-verbal.
The use of bootstrap initially yields a confidence interval of 3-19.25 percent; this shows a low concatenation of words to form phrases as it can be seen in Figure 16, where the corresponding media is 10.5 %.

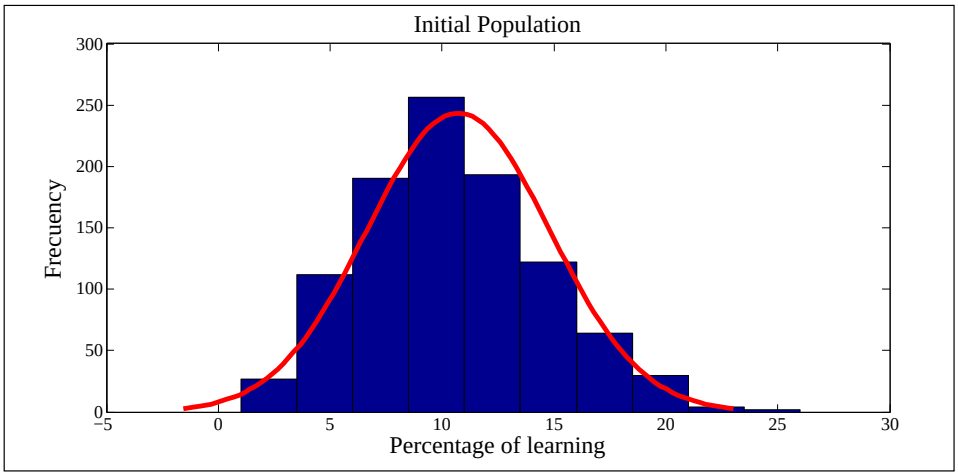

Figure 16: Normal distribution with initial data of PictoSentences

Figure 17 shows an average of 53% and a confidence interval of 40.5 - 64 percent; range in which we can state a significant advance in oral communication of children and young people with ASD. The obtained results were very close compared to the ones gotten with descriptive statistics.

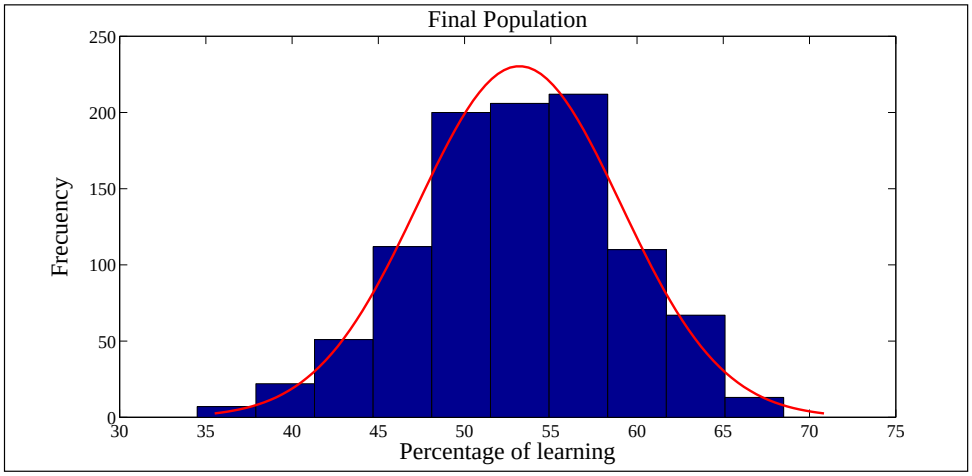

Figure 17: Normal distribution with final data of PictoSentences

6.3 PictoNumbers

Memorization and repetition exercises were realized by the use of this option. Thus, getting the right pronunciation and identification of the natural numbers, which shows the numbers from 0 to 9 along with their pronunciation in Spanish.

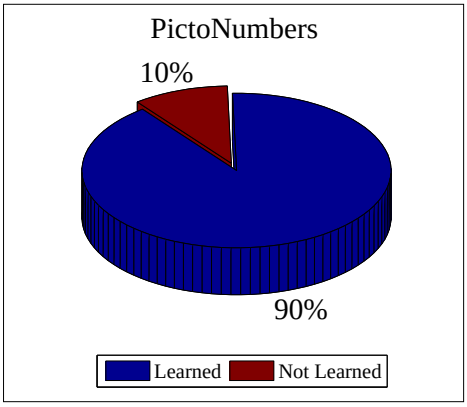

Figure 18: Analysis of the PictoNumbers option

A high percentage was gotten by using pictonumbers, as shown in Figure 18. This was achieved due to the majority of children and young people already had a basic knowledge about digits, thus getting reinforcement and sound knowledge on this topic.
Utilizing bootstrap allowed to determine that people already had a prior knowledge about this actions, hence obtaining a media of 45% and a confidence interval of 36-54 percent. This shows an acceptable knowledge of the numbers from 1 to 9 before running the PICTOAPRENDE study. See Figure 19.

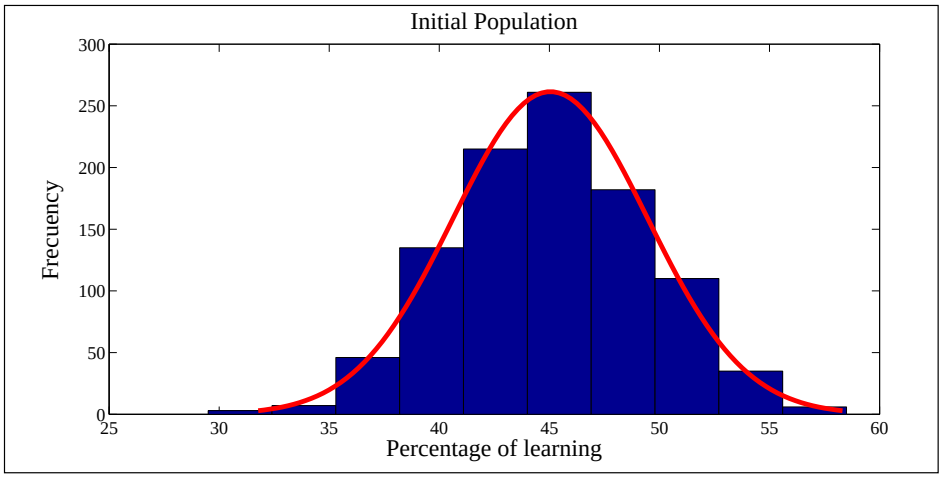

Figure 19: Normal distribution with initial data of PictoNumbers

Using the final data, a media of 75% was obtained. This shows that the population under study possesses a good knowledge about this topic. The confidence interval ranges from 64 to 84 percent; this range guarantee the learning process with a certainty of 95%. See Figure 20.

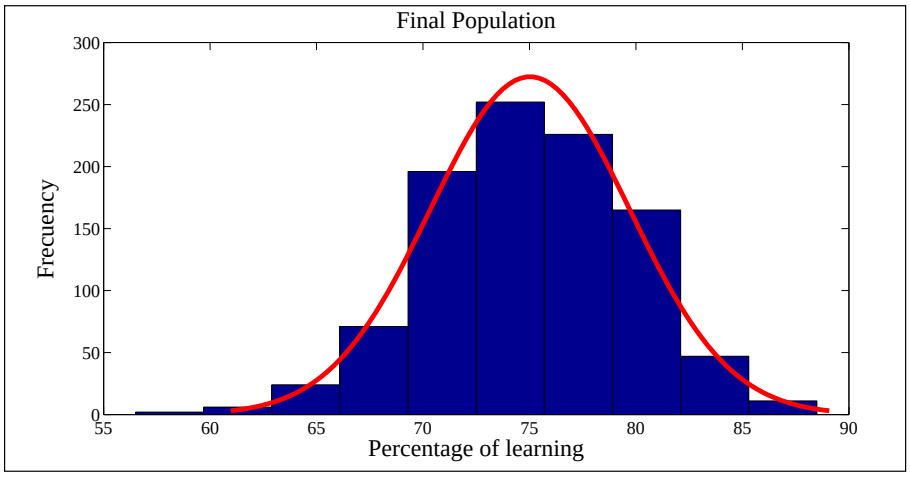

Figure 20: Normal distribution with final data of PictoNumbers

6.4 PictoVowels

By the deployment of didactic methods for learning embedded in the PICTOAPRENDE application, the five Spanish vowels were recognized in the 90% of users as shown in Figure 21.

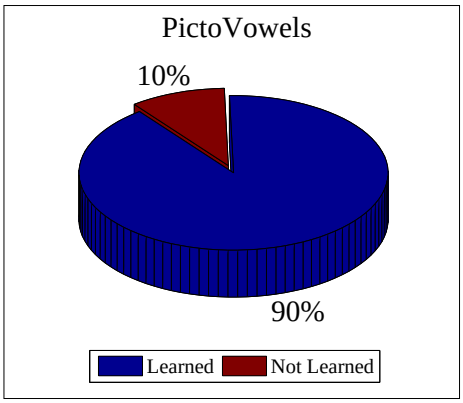

Figure 21: Analysis of the PictoVowels option

Because of the previous job realized by the foundation when learning vowels, the obtained results regarding reinforcement and learning are considered optimum.
The 10% left are consider cases of severe autism, where a verbal auditory agnosia exists accompanied by a phonological language code. In this cases children and young are able of learning through visual language (gestures, signs, writing).
The bootstrap technique as well as the one aforementioned showed a high percentage of knowledge, and this was also considered before working with the application. A media of 44% as shown in Figure 22.

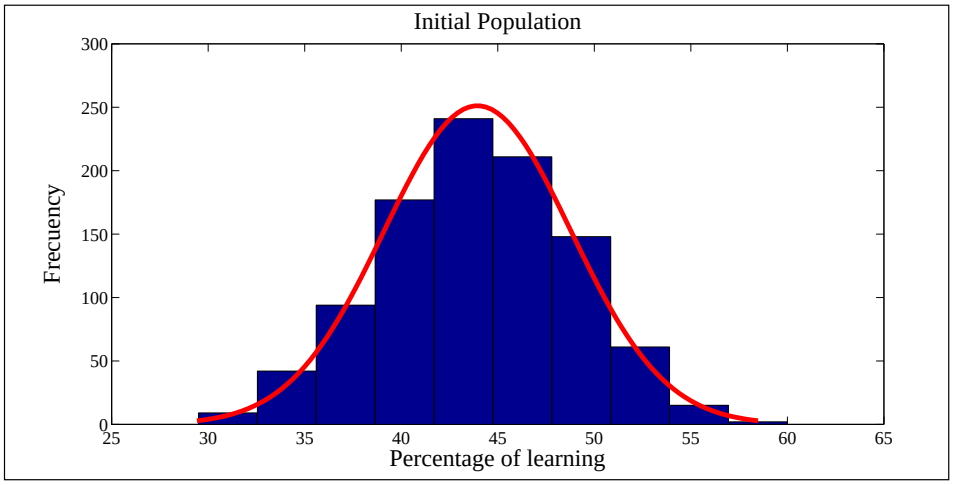

Figure 22: Normal distribution with initial data of PictoVowels

Once the learning process was finished, this option was mastered and it is confirmed by the utilization of bootstrap from where the confidence interval, 65 - 86.5 percent, is expected to receive the 95% of the population under study. The obtained media is 77%. See Figure 23

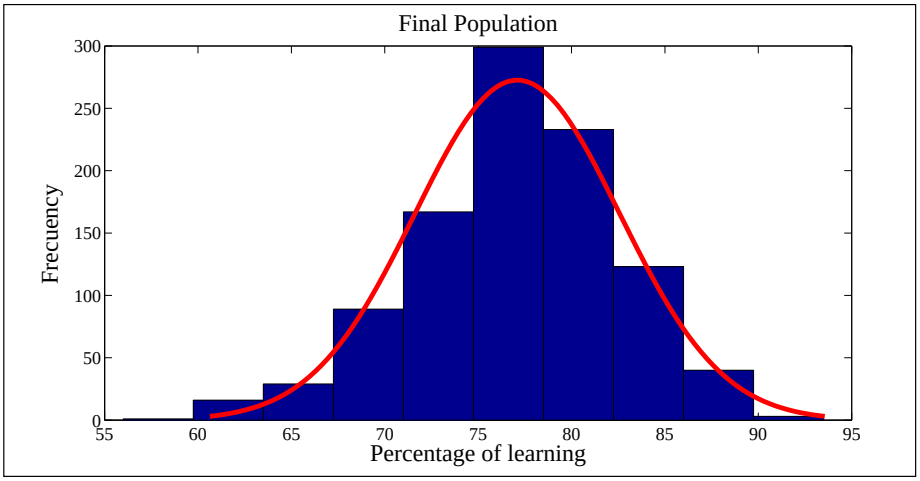

Figure 23: Normal distribution with final data of PictoVowels

6.5 Emergency Numbers

PictoAprende was used to perform memorization and repetition exercises so that children can get trained with the available emergency numbers in Ecuador, this in the case a real event may happen.
The application includes Police Station, Firefighters Department, Red Cross and emergency numbers. It also teaches in an interactive and didactic way, thus getting a permanent attention during the learning process. As result 8 out of 20 users recognize and are able to use the application in the case an emergency arises. See Figure 24.

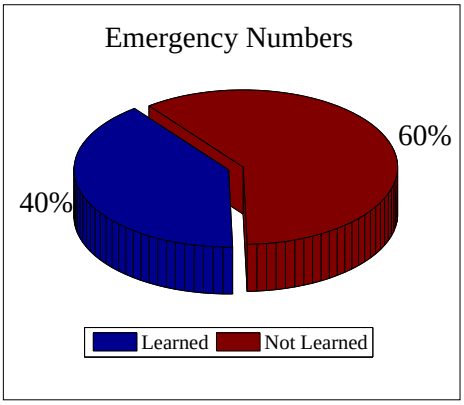

Figure 24: Analysis of option emergency numbers

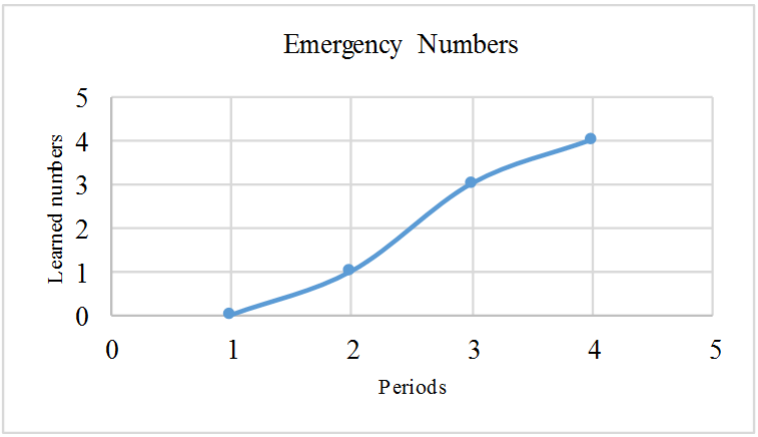

Figure 25: Analysis of the trend of learning of emergency numbers

From a sample of 8 children, who learned to manage correctly the emergency numbers application, a gradual progress is showed. It has to be considered that a familiarization stage was done at the beginning as well.
During the second stage, one of the emergency numbers which corresponds to 911 was memorized.
During the last two stages, 100% of the proposed numbers was learned. See Figure 25.
This process was carried out over a long period of time and a low overall rate in user performance.
The memory is not affected by these disorders although this accompanied by a mental retard, it edges the use of the semantic memory, which is in charge of coding and storing general and specific information in a very structured way. [17]
In order to establish a 95% certainty for the results, confidence intervals were obtained at the beginning as well as the end of the use of this option, thus determining a 9% media before the use of PICTOAPRENDE. See Figure 26.

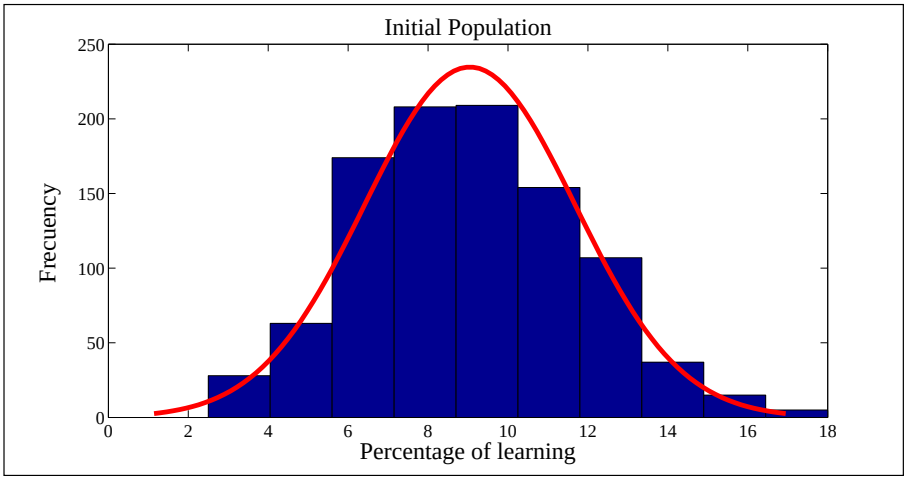

Figure 26: Normal distribution with initial data of Emergency Numbers

Upon completion of the training process, an average of 39%. Although this do not represents an important improvement, it determines a pattern for a next stage of learning, since the confidence interval is between 27.5% and 51.25% as shown in Figure 27.

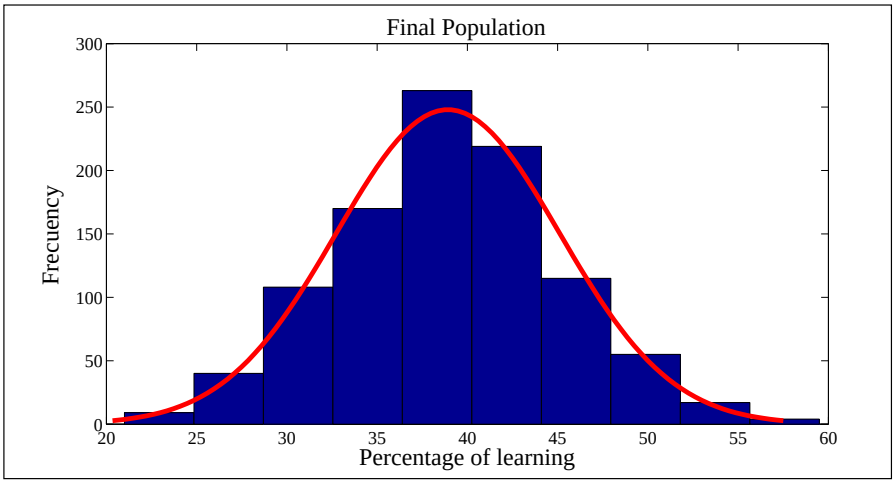

Figure 27: Normal distribution with final data of Emergency Numbers

6.6 PictoMessages

By using PictoMessages, users were able to interact with their surrounding environment and showing their needs and emergencies by sending text messages and emails.

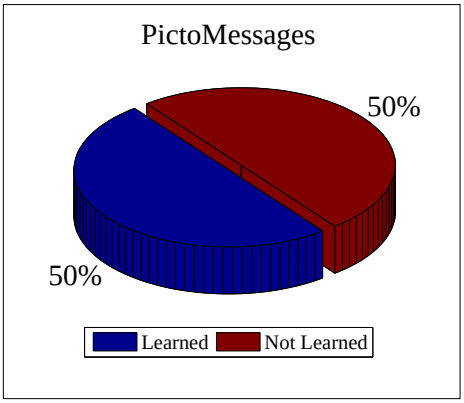

Figure 28: Analysis of the PictoMessages option

As it can be seen in Figure 28, 50% of the sample was able to understand the functioning of this option and the remaining 50% did not achieve the desired results because they did not realized that at selecting a different option, a message is sent to family's pre-established phone number.
The study showed null knowledge before the use of this application. This due to this option is uniquely presented in PICTOAPRENDE. An initial media of 1.5% was determined by using bootstrap technique. See figure 29.

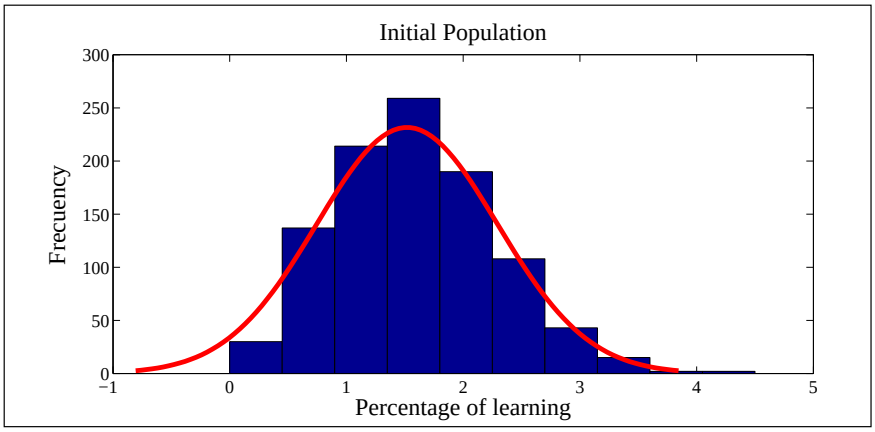

Figure 29: Normal distribution with initial data of PictoMessages

Once completed the learning period, a average of 43% was obtained, thus determining a confidence interval of 30.5% to 54.5%. This range guarantees the learning with 95% certainty. See Figure 30.
Because of the percentages obtained by the two techniques, a progressive advancement and a good reaction towards this option were demonstrated. Therefore, it is recommended to perform studies and test for longer periods of time.

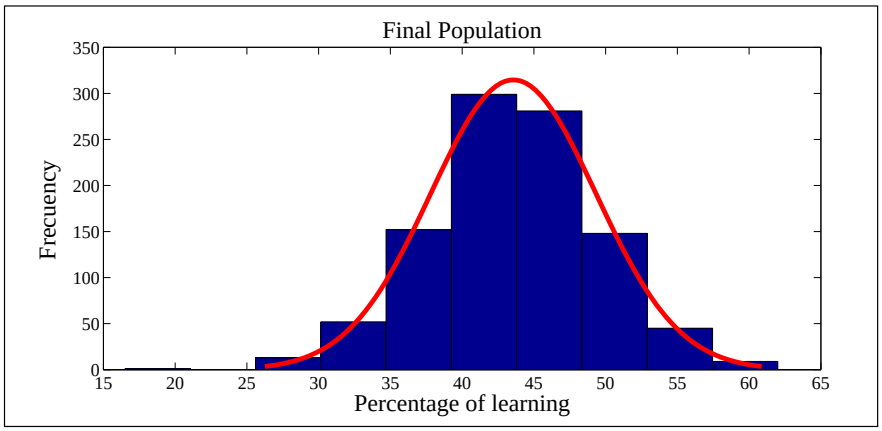

Figure 30: Normal distribution with final data of PictoMessages

7 Analysis of results

As it was determined in the former paragraph, the learning results, obtained with the PICTOAPRENDE tool, were satisfactory. This considering that the data was validated through statistical techniques such as descriptive statistics and bootstrap. The first one tries to summarize the data in a quantitative manner, thus getting learning percentages after the study of the tabulated data once the tool was utilized. The second one is applied to support the learning affirmations as well as make decisions and come up with conclusions from the collected data of the population. It has to be considered that the earning process of the population with ASD is closer to reality, since a great number of random samples is generated, hence emulating a wider population sample.
Table 1 shows the obtained results after processing the information. For instance, considering the PictoActions option and descriptive statistics, it can be observed that 14 out of 20 children learnt this option.

Additionally, through the use of confidence intervals, it can be assured that the learning process of the users would be placed in a range between 62 and 72% with a certainty of 95%. Based on this, it can be reflected that between 2 and 3 out of 4 actions were mastered by using this option and this after the continuous use of the tool for at least six months.
Grounded on the yielded results with PICTOAPRENDE, it can be said that the application is versatile and usefulness for people diagnosed with ASD; this considering that in modern times people are opting for "mobile learning". Furthermore, it has to be mentioned that this tendency is modifying the educational habits. Technological breakthroughs during the last decades are making possible the development of studying methods that are more dynamic, complementary, and interactive; they are usually wireless, therefore catching the attention of children and people with ASD. [18]
A drawback of this tools is the fact that it cannot be assured that the user is able to alert when an emergency situation may arise. This due to the low learning indexes shown with the PictoMessages and Emergency numbers options. Also, users tend to develop a tendency to depend on the device, consequently they end up in a lack of concentration and attention of their surrounding environment. This fool the objective of the tool, which is the insertion of the user into society. As a contrast this would foster the lack of capacity to communicate and develop social interaction skills. This application shall be used under the supervision and responsibility of adults.

Analysis of data/Options	**Learning outcomes of descriptive statistics %**	**Trust intervals**			
		Initial media %	**Initial confidence interval %**	**Final media %**	**Final confidence interval %**
PictoActions	81	27	23,5 - 30.5	69	62 - 75
PictoSentences	70	10.5	3 - 19.25	53	40.5 - 64
PictoNumbers	90	45	36 - 54	75	64 - 84
PictoVowels	90	44	34,5 - 53.5	77	65 - 86.5
PictoMessages	50	1.5	2,5 - 10	43	30.5 - 54.5
Emergency numbers	40	9	4,5 - 14.5	39	27.5 - 51.25

Table 1: Results obtained

8 Conclusions

PICTOAPRENDE is an interactive application which is oriented to children and young people diagnosed with moderate ASD in Ecuador. The application counts with a series of options that aims to help people during the learning process. This helps to people's reinsertion into society by improving their communication skills. PICTOAPRENDE can be run in electronic devices such as tablets and cell phones, since technology arises interest on children and young people with ASD, this has allowed to obtain satisfactory results. Therefore, it can be also concluded that specialized education since a very early stage in life helps to achieve significant indexes of independence on people diagnosed with ASD. After the study, it can be asserted with a 95% certainty that users are able to achieve high memorizing rates. However, although good results are obtained after the evaluation, it is recommended to realize more trials and studies for longer periods of time.

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