Recommendations for the design of inclusive apps for the treatment of autism

An approach to design focused on inclusive users

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Abstract — **This article presents the results of an investigation that, based on the literature systematic review and a case study, obtains the identification of the most relevant functional and non-functional characteristics from the software applied in the treatment of the Autism Spectrum Disorder -ASD. The study is based on the use of computational applications focused on strengthening social and emotional skills, as well as the characteristics linked to the training processes of autistic children. The project includes the exploration of the state of the art and technique on Emotional Intelligence, children with disabilities such as autism and architecture models for the design of inclusive software applications. All this is validated through qualitative and quantitative metrics and analyzes with evaluation indicators on appropriation or strengthening of emotional abilities in autistic children. The tools considered are: instruments for collecting non-invasive information, filming activities and analyzing emotions through recognition of facial expressions. Finally, the result of the heuristic evaluation of the application of inclusive computational tools within the treatment of Autism is presented, in addition to a conceptual proposal of a scheme for the design of inclusive computational applications, which could be complemented and validated in the future as a product of strengthening of expected skills (intrapersonal skills (motivation) and social skills).**

Keywords - Autism Spectrum Disorder -ASD, emotional skills, recommendations, framework, human-computer interaction.

I. INTRODUCTION

The results and impact of human activities are linked to the levels of emotional and social intelligence that have been created during childhood. This situation is more complex in cases of children with intellectual and developmental disabilities (IDD), especially those with Autism Spectrum Disorder -ASD. This disorder is a neurological and developmental condition that begins in childhood and lasts a lifetime, affects how a person behaves, how he interacts with others, how he communicates and how he learns. Those who suffer from it may have trouble talking to another person, they do not look into their eyes when they are spoken to and they may also have limited interests and repetitive behaviors.

The US Center for Disease Control and Prevention (CDC) recognizes many ways to maximize the ability of an autistic child, so that he can grow and learn new skills. Generally, these treatments fall into several categories, such as the Focus on Behavior and Communication, as a principle for the development of behavioral and communication skills. However, these treatments include behavioral and communication therapies, development of skills or medications to symptoms control, but there are very few cases in which the design of models for the use of inclusive technologies that allow to enhance their skills and competencies.

One of the current disadvantages in the treatment of children with ASD is the traditional handling of emotions by their therapists with training in aspects such as collaborative learning, social adaptation, decision making, the ability to face conflicts, that is, , emotional intelligence management [1]; but linked to this practice, it is necessary to explore alternatives related to the strengthening of skills, without applying instruments in an invasive way or the use of computational tools, which stimulate these skills in a more natural way. One of these aspects to explore is the characteristic of how most children with ASD show interest in images (pictograms), from the notion of physical representation that is then configured as an idea in the work of these people [2].

That is why, to think about the design of inclusive computational applications that allow the integration of some pictographic elements in the work processes of children with ASD, can result in an improvement in the way in which they acquire skills for emotional intelligence, and therefore, the question to be asked is to what extent the use of inclusive computational applications can facilitate the implementation of therapeutic activities that facilitate the strengthening of the levels of emotional and social intelligence in children with ASD and how this would allow us to propose a framework for the development of inclusive applications oriented to the treatment of this disorder?.

Due to the above, this project seeks to explore the best features that must have of inclusive applications applied to the treatment of autism as a framework in the computational field.

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II. ABOUT THE AUTISTIC SPECTRUM DISORDER

A. Neurological Development Disorders

Autism is part of permanent neurological development disorders, in which areas related to social interaction, communication, behavior and interest among others deteriorate [3]. According to [4] in the educational environment, the affective dimension of learning processes is given importance, however, emotional aspects in education remain a complex challenge today. Emotion consists of three components: Neurophysiological, Behavioral and Cognitive. The neurophysiological component is manifested in aspects such as breathing, sweating and hypertension, which although they are involuntary responses that the individual cannot control, clarifies that if they can be prevented by appropriate techniques. The behavioral component is related to facial expressions, nonverbal language, tone of voice and body movements, among others. Unlike the neurophysiological component, these expressions are controllable and provide fairly accurate signals about the emotional state of the person. The cognitive component is the one that relates to feelings, because fear, anguish and anger, among other emotions are expressed in this component.

The diversity of hypotheses about the nature of the autistic disorder that has occurred during the last decades, all of them focused more on the cause than on the underlying mental processes, has greatly limited the effectiveness of the different treatments applied for their "rehabilitation" [5].

Advances in this type of research, relate three (3) types of autism according to the involvement of your neurological system [6]:

1. ASD Level 1: Without intellectual development disorder and requiring assistance.
2. ASD Level 2: With affectation of verbal and nonverbal social communication or abnormal response to the social approaches of others. Requires essential support.
3. ASD Level 3: Severe deficit in verbal and nonverbal social communication skills that cause severe functional disabilities; very limited initiation of social interactions and minimal response to the social approaches of others. Requires support in a very important and constant way.

The use of technologies to improve and particularly stimulate the communication of children with ASD has increased exponentially in recent times. These tools in therapeutic contexts allow a generalization of behavior towards the child's natural contexts. Therefore, it is intended to verify in this case study whether the use of specialized software and using mobile devices allows children diagnosed with ASD level 1 to proceed with their treatment, outside the clinical setting, and can use it at home / school to communicate with your close social ties; therefore, this study is designed using human-computer interaction models.

B. Treatment alternatives

Communication is one of the most important objectives in the work process of a person with autism [7], so the development of this ability has to be present in all situations of treatment. We must take advantage of any situation to promote communication, whether in the context of academic or fun activities. The important thing is to create multiple situations to encourage the person to communicate, attending at all times to their acts and communicative reactions.

Any type of treatment that is used, analyzes the behavior of the child with ASD and in accordance with the results, the integral educational intervention program is developed. It should be taken into account that a person with ASD generally manifests profound and complex alterations in the area of communication, both verbal and nonverbal, presenting an absence of communicative intention or alterations in the use of language [8]. Therefore, within nonverbal communication, we must distinguish between instrumental acts, natural gestures and Alternative Communication Systems (ACS). For this project, we focus exclusively on alternative communication systems, which are the emotional and social intelligence skills that are intended to be analyzed and for which a subsequent solution based on human-computer interaction would be developed.

One of the most successful treatment alternatives is the TEACCH ("Treatment and Education of Autistic and related Communication Handicapped Children") program that provides different services for both people with autism and associated disorders, as well as their families [9]. The use of TEACCH as a treatment model, seeks to ensure that, through the application of prepared activities, the child with ASD achieves an improvement in their autonomy, while avoiding communication and language comprehension difficulties [3].

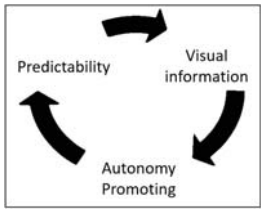

Figure 1. TEACCH Model.

An alternative to TEACH has been the use of software applications with NFC ("Near Field Communication") technology for children with functional diversity who, through their use on mobile devices, use animated pictograms to represent a person's daily activities, with which seeks to promote communication, allow planning, organizing and anticipating certain activities [10].

It is expected to validate whether these tools contribute to conventional therapies and favor better social interaction. The activities of the applications are designed to be developed in a tripartite manner, that is, the interaction between the child, new technologies and the professional or tutor will be encouraged and it is aimed at being transferable to different areas of reference of the child, mainly family and the educational center in which it is located [11]. For this purpose, the need to analyze the characteristics, functional and non-functional, that an inclusive computational application that is used effectively in the treatment of autism should be considered.

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III. THE INVESTIGATION PROBLEM

Taking into account that emotional and social management is very complex in cases of children with Autism Spectrum Disorder, where each case is different from the others, the computational developments and implementations to support their treatments have been experienced in isolation from the treatments specialized clinicians [12].

Generally, these treatments are divided into several categories, including the Approach to Behavior and Communication as the main framework for the development of behavior and communication skills. However, these treatments include behavioral and communication therapies, development of skills or medications to control symptoms, but there are very few cases in which the design of models for the use of inclusive technologies that allow to enhance their skills and competitions [13]. Based on the above, we must think about the design of inclusive computational applications that allow the integration of some pictographic elements in the work processes of children with ASD, so that we can obtain a significant improvement in the way in which they acquire intelligence skills emotional. This is why we ask as an investigative question to what extent the use of inclusive computer applications can facilitate the implementation of therapeutic activities that facilitate the strengthening of emotional and social intelligence levels in children with ASD and how this allows us to propose a framework for the development of inclusive applications aimed at treating this disorder?

IV. METHODOLOGY

This is an interdisciplinary project with a mixed methodological approach and that included a quasi-experimental study through a case study. The activities were organized in three phases: A first one to define the type of study, a second one for design and methodological development and finally a third one for validation and design of recommendations for inclusive design for autism-oriented software.

*A. **Previous activities carried out***

In general, the activities were oriented as follows:

1. Theoretical support and systematic literature review.

   As it is an exploratory investigation of a mixed nature, we opt for a systematic review for the collection of information of interest in the topics considered important. This methodology has been selected because it has all the necessary elements to carry out the search for information on the proposed topic. The importance of the mapping of the systematic review is found in the structure and steps it proposes to carry out the searches in an organized and methodological way, which helps to generate reliable results in the research [14].

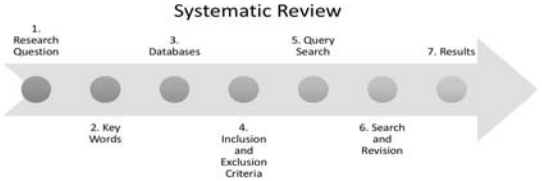

Figure 2. Process for systematic review.

A. Research questions

- RQ1: What current treatments have been more accepted and used by the international therapeutic community for the treatment of Autism Spectrum Disorder?
- RQ2: What models of computational applications and especially HCI have been used for the treatment of Autism Spectrum Disorder?
- RQ3: How does the use of HCI facilitate the design of computational applications that improve the current treatments of Autism Spectrum Disorder?

The concepts of skills of emotional intelligence were explored, especially Self-Knowledge and Social Skills; the most relevant characteristics of Autism Spectrum Disorder; what treatment and education programs exist and their level of effectiveness; notions of User Centered Design (UCD) and Accessibility; Typology of existing mobile applications for the treatment of autism; and finally the Metrics and Heuristics that may exist to evaluate the usability of inclusive applications [14].

This phase included the search, exploration of functional characteristics and selection of inclusive apps with pictogram management for autistic children, the definition of usability standards in software engineering, and the search for a measurement tool (non-invasive) of emotional changes and software usability.

2. Exploration of inclusive applications for ASD

   For this, an app search was conducted in the Apple Store and Play Store bases about software that was based on knowledge of autism and also presented treatment alternatives based on the management of pictograms for the construction of communication structures. After this collection, there was relevant information for each app such as the type of licensing, a description of the functionality of the application and an explanation of why it was selected [15].

   The inclusion criteria for the selection of the apps were: Applications that preferably had an open licensing (free) to facilitate their use by the selected analysis units (children with ASD), whose management was based on the management of pictograms , that was easy to use on mobile devices (mobile phone or tablet), adequate management for the realization of therapies based on image management and construction of graphic narratives. Exclusion criteria were based on whether your license was proprietary (requires a payment), operating system other than IOS or Android, and management of therapy other than the use of pictograms.

3. Definition of heuristic evaluation metrics

   Considering the selection criteria of mobile applications, we sought to evaluate each of the selected apps in relation to their importance in the treatment of ASD. For this reason, the usability criteria are defined to be applied in the evaluation by experts for compiled software.

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In this stage, the usability criteria that inclusive applications should apply to the interior of autism treatment were defined [12]. These criteria were:

- Easy to use
- App Documentation
- Esthetic
- Operability
- Easy access to the tool

With the criteria already defined, an instrument was built to allow heuristic evaluation, based on the criteria of experts, to be applied to the list of apps selected in the previous activity.

TABLE I. HEURISTIC EVALUATION FORMAT

Usability Criteria For Inclusive Applications For ASD	
1. Easy to use	**Value**
1.1. The representations in the interface are analogous to real-world aspects.	
1.2. Words, phrases and concepts are familiar and appropriate for the child with ASD.	
1.3. The information appears in a logical and natural order.	
1.4. The use of images that do not generate correspondence with the real world and do not contribute to learning (development of emotional or social skills) is avoided.	
1.5. Consistent and intuitive handling is evident in all phases of the application.	
2. App Documentation	
2.1. The application presents its own documentation or consultation links aimed at facilitators, therapists, teachers or parents and relatives of children with ASD.	
2.2. Contact information for application developers is presented.	
3. Esthetic	
3.1. The colors of the application have good contrast and are pleasing to the view of different users.	
3.2. The quality of the figures and graphic representations presented are similar to real-world homologous objects.	
4. Operability	
4.1. The application is easy to use by children with ASD according to their motor skills (use of buttons, links, navigation arrows, etc.)	
5. Access to the tool	
5.1. The software tool is easily accessible through application repositories for mobile devices.	
5.2. The application has no cost to download, at least in its basic version that allows low-cost work in homes and educational institutions.	

The instrument built for heuristic evaluation applies a formula to calculate the percentage of usability (PU) of each of the analyzed applications.

$$PU = \frac{\sum_{i=1}^{i=ncc}(vc * re)}{\sum_{i=1}^{i=ncc}(cc * rc)} * 100$$

Where:

vc: Criterion Value; re: Evaluation Relevance (Desirable above value 4); rc: Criterion Relevance; cc: Number of criteria evaluated

This activity determined the four mobile applications with the best result of the heuristic evaluation carried out by one (1) expert in User Centered Design and HCI, one (1) software developer and one (1) graphic designer.

4. Exploration of inclusive computer application design models

   The state of the art allowed to identify models of design of inclusive applications that could be applied or adapted for the development of applications focused on the treatment of autism [15]. In this sense, there are some generic models that can be used for this purpose and another that was created exclusively for inclusive developments. The methods explored were:

   - MDA Method: It contains the necessary steps to define the Mechanics, Dynamics and Aesthetics of a user-centered development [16].
   - 6D Method: Organized in stages of generic design of computer applications that can be adapted to inclusive development through the stages of problem Description, solution Definition, solution Design, solution Development, Debugging and testing and finally the Documentation [17].
   - MPIu+a Method: It is the only method contemplated that was created for the design of inclusive applications. Its stages are: Requirements Analysis, Design, Prototype Implementation, Launch and Evaluation [18] [19].
   - Gamification Method: Of great value to add playful features to inclusive development. In this case, Gamification Canvas or Octalisys models and instruments could be used to design activities [20] [21].

B. Case Study Design

The purpose of the case study is to verify through the application of human-computer interaction models if the use of specialized software, and through mobile devices, allows progress in the results of the treatment of children with Autism Spectrum Disorder –ASD developing some emotional and social skills such as children's self-recognition and social performance.

In this step, the case study was designed for two (2) units of analysis, corresponding to seven-year-old girls who have been previously diagnosed with level 1 autism and who are accompanied by professionals in speech therapy and physiotherapy. During this activity, the best physical distribution of the technological elements and equipment to be used during the study had to be designed, so that during the experimental activities with the autistic girls they could use the inclusive apps while we could register their emotional changes through facial recognition.

The selected distribution of the elements was:

1. Worktable: On which a digital or cellular tablet is located where the applications selected for the study have been previously loaded.

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2. Chairs: Where the child with ASD and the person who directs the activity is located. An additional chair can also be available for the person who collects the information (observation sheets).
3. Filming camera: For the capture of the child's facial expressions during the development of the activity and the identification of expressed emotional changes.

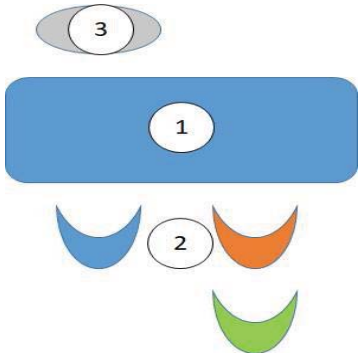

Figure 3. Distribution of artifacts in physical space.

1) Recognition of emotional changes

For this, the E-motion computational application is used that allows the identification of emotions expressed by a person's face through the facial recognition technique. The algorithm contained in E-motion allows us to recognize the type of emotion expressed by validating movements in the muscles of the face. In our case, the emotion expressed by autistic girls was validated during each type of activity carried out with the inclusive apps that were selected for the case study.

Figure 4. Facial recognition technique.

2) Identification of predominant emotions during the case study

Then to carry out several experimentation sessions with the autistic girls where the inclusive applications selected for this stage of the project were used in the context of the treatment based on pictogram management, a relationship was obtained between the Activity carried out and the predominant Emotion that originated (See following table).

TABLE II. EXPRESSIONS GENERATED IN CASE STUDY

Activity	Predominant emotion
Display pictograms and listen pronunciation.	Surprise
Organize sentences based on pictograms.	Sad
Recognize parts of your body expressed graphically.	Surprise
Possibility of expressing feelings, desires and activities to perform.	Happy
Play with characters and complete task.	Happy

C. Inclusive app design recommendations for ASD

The framework of recommendations for the design of inclusive applications that are valid for use in the treatment of autism is the result of the review of existing literature, the exploration and validation of applications designed for treatment purposes based on the use of pictograms and the analysis of the existing inclusive software architecture.

With all the previous elements highlighted, the project defines a logical process of designing inclusive applications that serves as support for the treatment of autism. These stages are as follows:

1. **System Functionalities:** This phase must define the quality attributes that are required to have the inclusive software to be developed, especially since compliance with ISO / IEC 25010 Standards and its characteristics: Functional adequacy, Performance efficiency, Compatibility, Usability, Reliability , Security, Maintainability and Portability.
2. **Interaction context:** Where the gameplay of the app to be built (gamification) is defined, in addition to the design method of the inclusive development model (analyzed in section A4 of this article). In this sense, it is recommended to use the MPIu+a Model to define the stages and the Classic Gamification Model (ARCS) for the functional characteristics of the application to be designed.
3. **Design of activities:** Where the design of the application is defined from Usability. Subsequently, the use of an agile computational application development model is recommended for the implementation of this.
4. **Information design:** This is where the verification of the information attributes contemplated in the app and the verification of its functionality is recommended. In this regard, some existing design patterns such as the Facade Pattern and the Feedback Pattern can be used to ensure software functionality.

V. RESULTS

The project obtains as a more relevant results a list of validated computational tools for formal linking to clinical treatment processes of autism spectrum disorder; Likewise, a user-centered design recommendations base for inclusive applications is achieved, including the design process, a gamification model and a software architecture proposal. Finally, the project facilitated the generation of new knowledge related to the area of human-computer interaction applied in clinical contexts. The requirements engineering models for the case of inclusive applications aimed at the treatment of autism add new factors to take into account, which should guarantee the development of applications with a much better degree from the

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functional point of view, that is, from their usability and its accessibility for children with ASD.

During the development of a computational application, the design of the activity and the design of the information continue as the main activities that make up the overall design process of said interaction. In addition to this, the quality attributes mentioned by ISO 25010 and the playability characteristics required for gamified applications must be taken into account, therefore, an evaluation cycle (or improvement) of the application to be developed must be included within its architectural definition. This is where the MPIu + model would be integrated and the MDA or 6D design frameworks mentioned to ensure that functional and non-functional requirements are achieved from the beginning of the design of the applications and not until the end of the tests with children who are immersed in an ASD treatment.

In order to define usability criteria, the cognitive abilities of the children are taken into account, the same ones that are specified in each of the phases of development of the agile methodology Extreme Programming (XP), where each one throws a product which is used as input for the following definition, thus generating specific and different criteria. The software development can be framed in the use of the Facade, Usability and Feedback design patterns that guarantee stability and use of the final application.

VI. CONCLUSIONS

The study of the characteristics (functional and non-functional) of computational tools focused on the specific use of children with autism, if it allowed the determination of user-centered design alternatives for inclusive applications as support for the development of emotional and social skills within the current therapeutic conditions of ASD intervention. With the above, the hypothesis raised at the beginning of the investigation is validated. Likewise, the design of computer applications focused on clinical treatments such as ASD must be adjusted to existing quality standards. Likewise, one could experiment with the use of game techniques (Gamification) that can result in a motivating factor for interactivity between the autistic child and software applications that are used as therapeutic support.

It is possible to formulate a framework that seeks the parameterization of the design of computer applications that support the treatment of children with ASD, especially for the development of some specific predefined skills. A framework for the design of inclusive computational applications for the treatment of ASD can be based on the use of established software architecture patterns; however, these must be adjusted to the extent that the therapeutic and technical conditions require. The MPIu+a Model continues to be a guide for the usability and accessibility engineering process par excellence, however, in particular cases of disability it may require some methodological adjustment for the achievement of particular desired objectives.

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