Design of interfaces for Dyslexia and Dyscalculia Applications

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ABSTRACT

In the field of Human-Computer interaction, one of the decisive factors is the graphical interface; especially in applications in which the user has specific conditions that limit its operation and performance. This is the case of the "Gabarato" application, which facilitates the treatment of children diagnosed with dyslexia and dyscalculia. During the development phase of the application, it was determined that there is a complexity to achieve specific usability interactions such as "ease of use", "memorability" and "effectiveness", especially with users who cannot operate hardware because their physical or cognitive difficulties to manipulate a conventional interface. The present work presents a new interface proposal and some parameters to consider measuring usability interactions in children who present specific conditions or disabilities.

Keywords: Interfaces, Usability, User Experience, Disabilities

INTRODUCTION

Dyslexia is classified as one of the specific learning difficulties and is known as a basic disorder that involves oral and written comprehension of language; it is mainly defined around the deficit of phonological, auditory, or visual language processing. People who manifest this disorder, especially in school stages, present difficulties with both precision and speed in understanding the language (Galaburda, A. M., & Cestnick, L., 2003) On the other hand, according to different authors, dyscalculia can manifest itself as a difficulty in the ability to perform calculations or operations that involve numbers; Among other difficulties in the basic training stage, students may have difficulties to use the language, use graphs or understand problems that involve geometry or arithmetic operations (Andalusian Dyslexia Association, 2010)

Contemporary educational systems, developing countries, have significant limitations at the budget level to acquire technological tools that effectively contribute to the learning of children with conditions such as dyslexia and dyscalculia; these problems that in developed countries have adequate protocols and instruments for treatment and diagnosis; In countries like Ecuador, they have become a cause for school dropouts, because added to the lack of tools, there is a low level of application and control regarding the educational adaptations that children require in the different stages of cognitive development in basic education.

THERAPIES USING MOBILE APP

Several experts have pointed out that one of the alternatives to face these learning difficulties would be the use of specialized applications that can be used as a complement to specific therapies. Applications such as For Dyslexia, Children’s day map, ABC Kit Letters, Newsela, Rave-o and Detective, present interesting functions that range from exercises that allow identifying if a child has dyslexia to specific exercises that use didactic strategies that range from the use of questions, guided readings and small games that can be used during the school stage (Quishpe, Bernal, & Gilva, 2017).

Gabarato

The Gabarato application, designed and produced by students and teachers of the Indoamérica University of Ecuador (Cobos & Piedra, 2019). Gabarato was tested in a group of students receiving therapy at the Sinsoluka Foundation, which welcomes children of different ages who are in a condition of poverty, neglect, or with special educational needs, who for various reasons do not receive state benefits for their treatments. For its production, we worked with psychologists, speech therapists, and experts in psycho rehabilitation, who participated as consultants during the Project.

It consists of two clearly defined sections, the first is oriented as support material for the treatment of dyslexia, provides reinforcement regarding the acquisition of skills to understand written language, and through audible support, facilitates the reading process from the decoding of graphemes and phonemes that make up words. For Dyscalculia, the development team chose to facilitate the recognition of mathematical signs and propose operations based on mathematical logical reasoning.

Table 1: Activities included in las primeras pruebas de UX

Dyslexia Section		
Field	**Definition**	**Activity**
Visual discrimination	Develop the skills that allow distinguishing the details and differences that exist in the signs of written language.	Identify the same letters Paint the letter with the corresponding color
Visual organization	Integrate writing symbols	Complete the word. Identify silhouettes
Visual Memory	Recall visual information, remember the spelling, and store perceptual information	Memorize letters Remember the order of the words
Auditive Perception	Properly process sound stimulation	Listening exercises Phonological exercises
Auditive decoding	Develop fine discrimination of sounds	Listen and complete words Spanish syllables separation
Auditive Memory	Retain and organize sounds	Hear and remember words Listen and remember sentences
Dyscalculia Section		
Number line	Consolidate mental number line	Place the numbers in order
Play Models	Develop logical thinking and motor skills	Play Models - Cubes
Spatial sense	Reinforce spatial coordinates	Play models – arrows

The validation of the product was developed with instruments that made it possible to determine the factors that influence the use of the application, through a specific study to determine the requirements derived from the abilities of the children in the use of the tool. The results of this work were presented at the 4th International Conference on Human Systems Engineering and Design: Future Trends and Applications (IHSED 2021) in Croatia in September 2021.

New questions arise in User Experience UX testing

The application user experience tests during the validation phase included tests of usability interactions related to experience, learnability, and ease. Although the tests, in general, obtained a 77% performance on average, it was found that not all the main users, who are children with different educational needs or physical disabilities, could complete the tests satisfactorily. For this reason, the development team opted for a more in-depth study that revealed details about the skills that children with disabilities require to use the teaching materials correctly.

This new study was carried out individually with the children, under the supervision of the psycho-rehabilitation specialist and the Project specialist; Several of the user experience tests that were carried out during the first phase were repeated, but for this group, time was considered as one of the crucial factors. The experiment was recorded on video, which was reviewed for details such as concentration, stress level, precision, and fatigue. The tests were initially planned for a single day, however not all the evaluations could be completed due to the level of stress they generated. It was necessary to increase the number of participants and the sessions; finally, reliable user experience data were obtained from only 15 children between 8 and 12 years old.

The results were not as expected

In the user tests carried out with children with a lower degree of physical disability, it was not possible to demonstrate in the first round of tests that there were problems when moving around the main interface; This was detected in users with a greater range of disability who had a 60% effectiveness in operating the sliding components, 33.3% presented serious inconveniences to perform the task. Another of the proposed actions consisted of extracting an object that was between two other objects, in this case, 20% had difficulties and 7% could not complete it. As the tests became more difficult, such as dragging an object to raise or lower it on the interface, some users even used both hands, affecting their posture and the performance of the application. Another of the activities that attracted attention had to do with coloring an image, in which they must select the color and place it in a section of the image where the spaces are not regular, in this case, 46.7% presented difficulties while 13 % gave up the task. Table 2 summarizes the study considering the level of success or effectiveness of the participants, the level of intervention or assistance from the specialist that was required, an estimate of the level of frustration, and the perception of speed in which they developed the activity.

Table 2: UX Test – Users with more severe physical or cognitive disabilities

Activity	Success	Attendance	Frustration	Time
Select an object	60%	high	medium	low
Select objects that are scrolled	73%	low	low	medium
Select one object out of three	73%	low	low	medium
Click and drag from A to B	60%	high	high	high
Click and drag along a path	7%	high	high	high
Predict the trajectory	53.3%	medium	medium	high
Locate objects by size	40%	medium	high	high

The 66.7% of the users developed the tasks considering themselves "slow" while on average 13% of the participants did not complete one or more activities. The level of frustration is high, for the users of the application with higher levels of disability, especially those who present physical or cognitive problems in which their attention span is compromised. These inconveniences are not necessarily connected to the problem of dyslexia or dyscalculia; however, it is a factor that must be considered when making improvements to the application, from the main interface to how the activities are presented and evaluated.

IMPROVING INTERFACES

Concepts used

As a complementary concept for the visual aspect, the User Experience Design UXD was used, defined as a set of methods applied to the design of interactive experiences (Lewis, J. R., & Sauro, J., 2021) it is the ability to synchronize the elements that favor the experience of the different senses of the user, to influence their perceptions and behaviors.

For the gameplay concepts, we worked around the Interaction Design (Oulasvirta, A., Kristensson, P., 2018), which is responsible for generating a response to the specific actions of the user, which can be simple or complex. There are four principles to facilitate the interaction process between the person and the device, raised by Donald Norman, who explained that all objects must be well designed with elements that are easy to interpret and that guarantee better operation for users.

For functional and aesthetic improvements, concepts such as the User Interface Design were used (Bødker, S., 2021), understood from how the user can communicate with the device, which allows user interaction through visual means and graphic objects that provide information and actions available in the interface, allowing the use of the device to be easy to use and learn. As an approach to aesthetics, the constructive model of the Gestalt Prototyping Framework (Ripalda, D., Guevara, C., & Garrido, A., 2021) effectively links the basic notions of the Nielsen Heuristics with Gestalt principles, providing theoretical and visual references to understand how these models are integrated during the development of a GUI. Usability experts, designers, and developers of mobile applications have used these concepts to adapt, improve, or correct the prototypes of interfaces in projects, without interfering with the development methodology they have decided to use.

RESULTS

Based on the evaluation of the user experience carried out on children with more severe disabilities, the team decided to make improvements in the content presentation dynamics of the Gabarato mobile application, through modifications in the visual components of the interface. The components that were modified were related to the parameters established in the Gestalt Prototyping Framework.

Reducing frustration

One of the main problems detected was the precision of the participants, which affects the time they spend to develop an action and is the determining factor to increase the levels of frustration of the users, in the face of this reality, as can be seen in Figure 1, some interfaces had a significant amount of information, which was removed depending on the user profile of the application; for example, it was proposed that the text blocks containing explanations of the exercises would only be available to therapists, while for the child interfaces, simplified versions of the instructions would be available (Dix, A, Finlay, J., Abowd, G. D., and Beale, R., 2004).

Figure 1. Interfaces of the first version of the Gabarato application

During user experience testing it was determined that one of the most frustrating factors was the operation of some controls that had to be selected and dragged across the interface; To increase the precision, it was proposed that this type of activators be larger, and the displacement distances are reduced. To further reduce the level of frustration, it was decided to modify the visual, auditory, and haptic feedback, for more constant and pleasant reinforcements and stimuli; For example, the elimination of the sound of alerts in the event of failures was proposed and it was replaced by interpretive messages with random phrases with a low level of repetition.

Require less assistance and provide more autonomy

The team posits that for therapy to be more effective, children should feel progressively fewer interventions from the therapist; To achieve this, some settings must be removed from the interfaces that can generate unexpected exits and regressions, the button to "request help" will only appear after the user has repeated a certain number of failures. Increasing autonomy means that children with more severe disabilities can work with the application on their own, this forces the System to improve the prediction to adjust the level of complexity of activity; In other words, the most difficult levels for a child with good motor skills must be available for users with more severe physical or cognitive conditions, but they must have adjustments and complexity selectors adaptable to their condition. This is effectively achieved by reducing the number of repetitions or interactions. For example, in the game of painting a figure, dragging the colors, which turned out to be one of the games that generated the most assistance, time, and frustration in users with severe disabilities, in the difficulty selector there is the option to reduce the color palette from 8 to 2 options and that the illustrations show spaces that appear previously colored. As can be seen in Figure 2, the difficulty selector must also be placed in the child's interface so that they can adjust the complexity of the activity by themselves according to their progress and level of motivation.

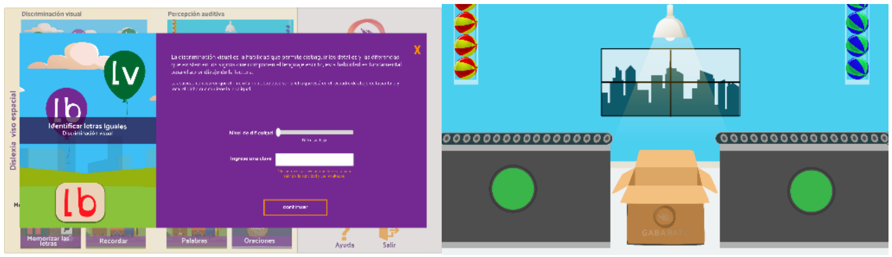

Figure 2. Interfaces related to the selection of difficulty Gabarato App

Improving speed

According to the conceptual framework, there are different factors to increase the speed in the development of therapeutic activities; the first factor arises precisely from the Usability Heuristics (Nielsen, 1992), which determine the need to modify the interactions that facilitate the memorization of the dynamics of using an interface. To achieve this, the user is required to have an induction on the location and operation of the basic mechanisms. The second factor that must be considered is that the speed in the development of a task in the Gabarato application is a relative result and depends closely on the perception of ease of use, ease of learning, and the ability of each user to complete it effectively (Baker, S., Au, F., Dobbie, G., & Warren, I., 2008). Unlike operational and commercial applications, a therapeutic application such as Gabarato will not be evaluated as fast by the speed with which it processes information, but by the effectiveness with which a user completes a task; that is, if a child completes an activity with lower levels of frustration and with less intervention from the therapist, he will not only evaluate the application as fast but will also perceive himself as fast. It is precisely this factor that specialists in the treatment of these learning conditions consider necessary, that the person being treated can perceive that they are improving, that they can stay in therapy all the time, that they perceive it as easy, and feel that they are making effective (Ljilja & Sanfod, 2017).

CONCLUSIONS AND FUTURE WORK

From the review of the results of the user experience tests, the link with people who have severe physical disabilities, the review of the videos, and the in-depth evaluation of the results by different experts and professionals who made up the development team It was seen that experience tests and prototypes can quite easily give us "false positives", causing us experts in user experience to fall into the fallacy of underestimating the results of real user tests. The metrics and instruments to determine usability factors, due to social responsibility, must meet the standards and cover the particularities of the focus groups, especially in products that focus on sensitive issues such as therapy, since within a group that requires attention, people who require special attention or specific adjustments could be involuntarily left out of the tests. The Gabarato development team is currently making the functional and visual modifications that are required to address the treatment of dyslexia and dyscalculia more effectively, the next step is to carry out comparative tests with similar applications so that improvements can be determined. at the level of content, procedures, and management of results. In parallel, work is being done to measure the progress that the children of the Sinsoluka Foundation are making from the use of the application.

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