Application of Assistive Technologies in Rehabilitation of the Visually Impaired

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Abstract. This article brings together studies aimed at the use of assistive technologies during the rehabilitation and/or support processes of people with total and/or partial visual impairments (whether congenital or acquired) and how the difficulties and limitations arising from this framework can be overcome through the recognition and exploration of the individual abilities and skills to perform tasks, through the use of AT. The methodological processes adopted in the research were conducted through observations and systematic comparative analyzes to recognize the patterns of behavior of individuals with visual impairment during the execution of their activities. The data analysis was performed to identify and compare the factors that contribute to the difficulties and successes in the application of assistive technologies for the rehabilitation of visually impaired people. It's hoped that, at the end of these studies, their results may explain how AT contribute to improve quality of life to people with disabilities.

Keywords: Assistive technologies · Rehabilitation · Visual impairment

1 Introduction

In Brazil, according to the Census conducted by the Brazilian Institute of Geography and Statistics (IBGE) [1] in 2010 , about 35.7 million people declared themselves to be visually impaired, and may be partial or total. Still for the IBGE, in 2013, as seen in the EBC Portal [2], the visual deficiency is the one that affects more Brazilians, representing 3.6% of the population and 16% of these visually impaired people have limitations that prevent the accomplishment of habitual tasks like go to work, go to school or even play. In World Health Organization (WHO) [3] reports in 2011, about 285 million people worldwide have some type of disability and 39 million have some form of visual impairment, 90% of this population living in low-income environments. According to data provided by the Lions Club International Foundation [4], about 6 million school-aged children have some type of visual impairment and less than one in ten have access to education. According to the same source, the unemployment rate in this group is between 75–90% (approximately 5 times that of the general population).

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According to Galvão Filho [5], although society is increasingly considering diversity, there are still no concrete initiatives that can, in fact, reduce the inequalities in opportunities for people with disabilities. It is necessary to create, then, a culture of valuing diversity, at school, in companies and in society in general. Only in this way will one point towards true inclusive development.

In this sense, this article has an important role to gather four works in a summarized way that seek for inclusion solutions for people with visual disabilities in a leisure, education and technology field.

2 The Use of Didactic Games as a Rehabilitative Aid for Visually Impaired Children

Children with visual impairments (both partially or totally, either congenital or acquired) present a number of difficulties during their physical, cognitive and sensorial development, especially due to the lack of materials specifically produced for the improvement of these attributes. In such situations, the use of didactic games as a form of rehabilitative assistance to the child seems to be effective, since they present both educational and playful characteristics, which are necessary for rehabilitation processes.

The various obstacles faced by visually impaired children may de-motivate and even make it impossible for them to stay in their own educational. In the midst of such problems (which include issues such as transportation, infrastructure, professional preparation and adaptation of diverse activities), it is observed the importance and, at the same time, lack of specific didactics that integrate general values of learning and development of the skills considered essential for the student ‘s adaptation to their condition, according to Decree 6,571 [4] (State Interventions) and also according to the requirements elaborated and documented by ABNT - NBR 9050 (referring to the standards of the physical adaptations for students with disabilities).

Blindness in children is something that goes way beyond the mere lack of vision, but the assistance of parents, teachers and caregivers during the stimulation of their potential can lead them to have a normal life, acquiring characteristics and skills inherent to their full development [7]. Among the several theoretical principles and different approaches aimed at teaching children, Jean Piaget’s Genetic Epistemology, which is based on intelligence to elucidate how the fundamental processes and stages that occur during the construction of knowledge, stands out [8]. The preset of age groups attributed to the various types of games is also a way to facilitate their choice to better meet the playful and didactic needs of children and other users [9].

Considering this context and presented data, it was sought, as a general objective, to identify the needs of users related to the problem, which is, how to assist visually impaired children to adapt to lack or loss of vision (total and/or partial) through Development and training of their remaining physical, cognitive and sensory abilities. This research also points out the stages through which the studies were submitted during its course, including bibliographical and field analyzes that enabled the understanding of theoretical and practical knowledge, aiming to provide informational assistance to professionals, tutors and even family members involved in child rehabilitation processes.

2.1 Methodology

The research was performed through systematic observations to recognize the behavior patterns of the children during the execution of diversed tasks, attending to their difficulties and successes. Interviews were also conducted in the form of semi-structured qualitative questionnaires to teachers, specialists and other professionals [10]. Finally, data analyzes (from the surveys) were carried out to compare and identify the main aspects related to the use of educational games as a rehabilitation aid for visually impaired children.

The data collection used to formulate both the questionnaire inquiries and the activities perceived in the observations was done according to the theoretical principles addressed in the bibliographies and other references mentioned throughout the research itself.

2.2 Results

After completing the field surveys (interviews and observations), it is concluded that it is possible to establish relationships between the elements worked on the child and the functional characteristics that the educational games present, making the rehabilitation process even more effective. It is also possible to perceive that the method, that is, the order of steps to be followed in the process, is of equal importance, since it considers the evolution of the child in the game during different sessions (and also different days of the week/month), clarifying more precisely the benefits that the use of educational games provide in short, medium and long terms.

The following is a list of relationships between the physical, cognitive and sensory aspects of the child and their recommended matching games (based on the results obtained in the observations and inquiries):

- Cognition - puzzles, memory games (with different formats or high/low reliefs) and tic-tac-toe games;
- Hearing - games with sound stimulation (rattles or whistles, for example) and activities in which there are sounds that vary according to the distance of their emission;
- Tact - games in which there are varied surface textures (high/low reliefs, cloths with different types of weft and softness, tactile mats, fabrics and flaps);
- Synesthesia - games that require orientation, mobility and positioning associated with sounds, smells, notions of space and distances traveled.

2.3 Conclusion

At the end of these studies, it was found that the use of didactic games for the rehabilitation of visually impaired children is done according to theoretical foundations approached by many of the authors who deal with the subject. Despite the marketing and financial limitations to which this process is most often submitted, it is possible to affirm that the contribution of didactic games is indispensable for the increase of autonomy and consequent improvement in the quality of life of visually impaired children.

3 Tactile Color Systems for People with Visual Impairment: Advantages and Limitations

Visual impairment is a type of sensory impairment that compromises the acquisition of information through vision, since the affected sensory channels are those of vision. To relate to the outside world, blind people use non-visual sensory stimuli such as touch and hearing. For Ochaita and Rosa [17], (p. 1) "[…]. Tact, […] is the meaning that allows the blind the sensory knowledge of the animate and inanimate objects that make up the environment". The haptic system is considered the most important preserved system for a visually impaired person and is closely linked to sensory stimuli. Through active touch, many properties of the surrounding environment can be perceived in the absence of vision [18] (p. 477).

For Minardi [19] (p. 3) there is a need for simple unit symbols to be applied to everything from maps to clothing. There is also a need for symbols that can be engraved on photographs to provide contour, shape and color to the illustrated elements. Still for Minardi [19] (p. 3), color "[…] is widely used within our language as a means of communicating not only the colors of objects, but also as coding in maps, graphs and other visual displays. Color is an important aspect in communication for people with visual impairment that can often be under-explored.

In theory of forms, according to the author Gomes Filho [20], (p. 17), art is based on the principle of form pregnancies, that is, in the formation of images, the factors of balance, clarity and visual harmony are considered indispensable. According to Kepes [21] (p. 18) "[…] the important thing is to perceive the form by itself; to see it as structured "all", the result of relationships."

According to the website Acessibilidade Brasil [22], today the reproduction of graphics, drawings or images is made by textures, that can be of manual form or digital with the Brazilian program Monet. The legend in Braille uses the name of the color and/or the information to identify that the texture may be of any given color. This program is compatible as Braille Fácil, another Brazilian program, used for texts. Both programs are available for free download. This texture system is flawed in need as the choice of an object by color, such as the purchase of a shirt, for example.

3.1 Methodology

The method used to support the study development was the systematic review of three patents that presented color-coded solutions for visually impaired people, such as Braille for reading. The three systems were chosen were Feelipa [23] NOGUEIRA (Colour code for visually impaired people (WO 2013137757 A1, 2013)), Minardi (Tactile symbols for colour recognition (US 5286204A, 1994)), and Vankrinkelveldt [24] (Tactile symbols for colour recognition by blind or visually impaired persons (EP 1318494 A1, 2003)).

3.2 Results

Feelipa and Minardi are the most similar of the three systems. Although Vankrinkelveldt presents geometric solutions like the others, it differs in a creation of new colors. The Feelipa system presents the three basic shapes representing the primary colors, just like the Minardi. In the combination of two primary forms, a new shape and a new color are created, following the same pattern of the chromatic circle, being primary colors forming secondary colors and a primary color with a secondary color forming a tertiary color. The Minardi system also presents the solution for colors that can not be obtained by combining the colors of the chromatic circle. The author presents eight geometric shapes representing complex colors. In the Vankrinkelveldt system, although it is also based on geometric forms, it uses a system like Braille, with the creation of basic shapes using dots. The author also presents a solution for complex colors, but the question of the forms union for the creation of a new color is not clear. The Feelipa system does not provide a solution to these complex colors. The Vankrinkelveldt and Feelipa system offer a solution for light and dark tones of the same color. The Minardi presents only the prediction for light tones changing the relief type.

3.3 Conclusion

All three systems present a good solution for color characterization on various media types. Feelipa is the youngest of them, it is believed that the prediction for more complex colors is lacking, but the forms are good *prägnanz* and the system of the union of the forms facilitates, do not need to recognize a new geometric form with different characteristics. Although Minardi is from 1994, it presents the solution for complex colors and the union of the shapes, lacking a forecast for dark colors. Vankrinkelveldt compared to these two previous systems becomes a little complex, because it requires the learning a geometric form for each color, but is like to Braille and it could facilitate the adaptation for a blind person. It is believed that this research has generated a good discussion to determine a color system that facilitates the perception of colors by blind people.

4 Assistive Technologies Context in Special Education Use

Education is one of the main factors to promote inclusion. According to Kleina [25], all students can learn something new, regardless of their level of difficulty. Otherwise, one must think about what can be modified in teaching practice in order to favor their learning. By the way, for Oliveira and Glat [26], special education assumes the character of a set of measures to meet the special needs of students.

Hummel [27] states that AT (Assistive Technologies) resources are the work objects of teachers: the lack of specific knowledge of resources makes effective planning impossible to promote significant learning moments.

Manzini and Santos [28] describes that, in the implementation of the AT resource in school, the professional must understand the student's situation: desires, physical, psychomotor and communicative characteristics, observe the student's dynamics in the school environment, also the needs of teachers to increase student participation in the

teaching and learning process. For Valente [29], the learner has often limited his ability to learn because the appropriate tools for his own development are not offered.

AT is not a device that allows the disabled student to perform their tasks in the same way as the other students. Its function is to allow the student to carry out the activities in his own way, providing autonomy in his learning process. Many low-cost alternatives can be handcrafted to meet the needs of the school context. Bersch and Pelosi [30] consider that to develop an AT device in school, is to creatively seek an alternative for the student to perform his tasks. It is to find a strategy that values your way of doing, increasing your abilities of action and interaction from your abilities.

When AT are well employed, they play a major role throughout the teaching and learning process. According to Mercado [31], the adequate use of technologies in teaching and learning processes favors the mental representation of knowledge.

4.1 Teacher's Training

Working with AT in special education is a way to promote independent living and social inclusion. This justifies an investigation on the subject, especially regarding the process of inclusive education and the appropriate use of AT.

According to Nickel [32], in the implementation of AT, it is fundamental to provide training to teachers in order to support individual inclusion projects. Is necessary a process to support the continued teacher's formation, lectures and meetings. It is up to the managers to organize the training so that all professionals receive adequate training, including in a preparatory capacity for future educators.

Today it is perceived an underutilization of the possibilities of the AT being resources for the development of learning. That is, according to Conte and Basegio [33], AT are rarely used in class planning or inserted in teacher training. It is also perceived that the research work on the training of teachers in inclusive contexts is an almost marginal issue.

Some programs of teacher training have already been rethought and adapted to the new legislation of the educational system. However, according to Hummel [27], the proposed programs do not include sufficient knowledge for future teachers to be able to work with the inclusion of students with disabilities. Usually only a discipline on the subject is intended.

The training must return to the understanding that the school environment is composed of heterogeneous individuals, further exacerbating the need for appropriate pedagogical actions and that it is known to determine and understand the specificities/deficiencies of each student. According to Silva [34], the political pedagogical projects of various degrees bring the problematic where the insertion of the theme of special and inclusive education still has to be built.

5 Affordable Interface Assessment for Visually Impaired Users on Remote Control Emulator for Smart TV

Mobile devices have gained global prominence, both in handset marketing and application development, and in greater acceptance by the blind public. In surveys conducted in Brazil by FGV-SP, in 2010, 125 million units were marketed, approximately four times more than computers. It is estimated that in 2016 will be 168 million units marketed. The popularity of mobile devices, along with the financial factor, is also understood by the greater interactivity it promotes. Touchscreen widens and simplifies interactions with the interface, reducing response time. With this potential for interaction, in conjunction with the native accessibility tools of mobile devices, the number of disabled users has increased exponentially.

Smart TVs comprise a group of televisions that, via the Wi-Fi or cable connection, connect the basic function of the devices with the access to the web, access to personal content, installation of applications and several other items that improve the experience of use. On Smart TV, operation is carried out by remote control, since the only button on the body of the device is the on/off switch. Since remote control is the instrument of user-TV interaction, it is important to note that remote controls are designed for sighted people, using different color and button sizes for ease of handling. Due to the large number of functionalities, its interface becomes complicated even for those who are psychic. According to Universal Design, "products should be designed so that they can be used by all people in an easy way, reducing the chances of error". In the case of a blind user or low vision, the use of the TV through the control Makes the activity highly frustrating due to the lack of accessible elements for its use. However, the world's largest manufacturers of Smart TVs already offer mobile app that emulates the remote control, so the blind person can operate the TV using the accessibility features available on Smartphones.

In this way, confronting the problems of accessibility observed in the use of physical remote control, and the possibility to discuss about its substitution by a emulator installed in Smartphone, the focus of the research proposed in this research was guided by the following question: the use of a remote control emulator can make the experience of a user with visual limitations more accessible?

The principles of usability are directly linked to accessibility, and should be observed as important items in the design of new products. In the digital field, accessibility promotes the adaptation of electronic devices and software developed to meet the most diverse types of physical and intellectual limitations [35].

5.1 Methodology

The World Wide Web Consortium W3C is an international body that has the initiative to assist web site developers by providing information and guidelines that bring their products to the maximum potential of accessibility. Although designed for the web, its principles can be easily applied to products developed for mobile platforms.

For practical purposes, as it is a mobile app, we will follow Google's accessibility recommendations, which are meant for projects specifically designed for the Android

operating system. In its official documentation, accessibility appears as a user interface subitem, titled Making Applications Accessible, where it guides application developers to observe four recommendations for interface design.

According to Silveira [36], "information has to be perceptible, reaching the user effectively regardless of the environment or sensory capabilities. Regarding the components of the user interface and navigation in the system, these should be easy to use and understand, according to each person's capacity and knowledge".

By discussing a problem from the perspective of observation and experimentation, which conditions this study to a hypothetical-deductive research, the object of analysis was defined as a TV remote emulator, installed and synchronized from a mobile device with a system Android operating system. The research was structured in the verification and validation of the accessibility requirements, by the use of the TalkBack accessibility feature, native to the Android operating system, which translates the graphic interface components into sound information. It was called Accessibility Analysis, which encompasses simple tasks such as changing channels and volume and more complex tasks such as accessing settings and interactive content. In this methodological process, validation was performed with a blind user, through a checklist. For Sonza [37], a checklist consists of a document with verification items and detailed monitoring, with the purpose of assisting in the documentation of manual tests done by disabled people and programmers. The reference used to construct the checklist was the Brazilian Federal Government's web accessibility test document (e-MAG, [38]), duly adapted for mobile devices.

5.2 Results

Once the verification process and validation carried out in the Accessibility Analysis process, the first observation is the effective importance of labelling the interface elements, in a more specific and more important factor, which would result in the efficiency of the service provided by the emulator, the Buttons. Basic operation buttons, such as VOLUME (±), CHANNELS (±), or the POWER button, are not labelled, being interpreted by TalkBack as a "button without a marker". In screen 2, which shows the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, LIST icon, zero, point in the 3×4 grid, only numbers are labelled but have no description of Function, being considered more like subtitles.

Screens 4, 5, and 6 present the advanced device primary settings and access to interactive content functions. All buttons here are labelled, but do not point anywhere in the emulator. The effectiveness of the actions performed are only visible on the primary device. The user validator did not find it difficult to reach the configuration functions, but when accessing them, it lost the autonomy to complete the action, since the feedback is given not through the emulator, but through the screen of the primary device, which awaits the confirmation of the action. The same happens when accessing interactive content: the emulator only has to navigate the options presented on the screen of the primary device.

5.3 Conclusion

Throughout this research it was possible to observe the importance of performing accessibility evaluation tests, and especially its validation through users with visual limitations. The accessibility recommendations for building sites and applications proposed by Google promote integration, engagement and interaction between developers and end users, and are in concord with the recommendations of the W3C document for digital inclusion.

Regarding the evaluated application, it was observed that: (1) the first recommendation (description of interface elements) was not completely achieved. Simple labeling of buttons can mean a more accessible service, given the structural limitation of the application. (2) the use of the smartphone as a mediator of accessibility and digital inclusion gains credibility and acceptance by people with visual limitations in the stride, since it increases the capacity of interaction by eliminating the use of peripherals such as keyboard or mouse. The native TalkBack feature of the Android Operating System has proved to be a robust and very effective tool in the instrumentalization of accessibility. (3) the structural limitation of the emulator makes it just a mediator tool for buttons, making it a simple virtualization of physical remote control.

The inclusion of blind users in the evaluation process brings the real possibility of fixing possible misunderstandings and predicting others, in order to promote the construction of more inclusive products, according to usability and accessibility tests.

6 Conclusion

This research aimed to analyze ways to promote inclusion through Assistive Technologies in the field of leisure, education and technology, in a way that would collaborate in improving the quality of life and could promote the concept of independent living for people with visual impairment. The studies, even if briefly, proved to be valuable and with great potential for implementation. This potential can be better structured in a future research.

What was interesting in the studies are the possible solutions to problems that are shown in the daily life, in order to favor the inclusion of blind/low vision in society and consequent promotion of citizenship.

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