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Didactic module for teaching reading and writing to visually impaired children

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ABSTRACT

Educational models and laws in most countries have promoted the inclusion of people with disabilities in the school system. In the case of Ecuador, the development of teaching and learning methods and tools for people with visual impairment is a priority. However, teachers lack didactic tools to facilitate the teaching-learning process, particularly with regard to reading and writing for people with severe visual impairment. Therefore, the aim of the research was to develop a didactic module that can include improvements and strategies for teaching people with visual impairment with state-of-the-art technologies. Methodologically, the research consists of three phases; the first, design using SolidWorks software, the second, assembly, through elements printed under 3D technology and configured in a free and friendly programming language called RANMAN and the third, validation of the module. This last phase sought to evaluate the degree of acceptance of the device by teachers and students with visual disabilities. The results show that the didactic module optimizes the learning process of reading-writing skills in children with total disability, by merging Braille language with Raspberry technology for the design of the device that reduces the cost. In addition, the system has been accepted by teachers and students included in the pilot test.

PALABRAS CLAVE / KEYWORDS: Learning, disability, validation, programming, technology, students.

1. Introduction

According to the World Health Organization (WHO), the number of people suffering from visual impairment has increased in recent years, which means greater investment in education, rehabilitation and integration into society of people with this disability. Particularly, in families with limited economic resources, as well as those

living in communities and countries under poverty (WHO, 2018).

Visual impairment is a condition with multifactorial consequences on health, social development, educational processes, family relationships, and economic development. Along with this condition, in many cases there are problems of nonconformity, adaptation crises, emotional imbalance and the decline in the development of capacities and intelligence, which can have severe psychosocial consequences, when these manifest themselves at school age, mainly during childhood and adolescence (Arteaga et al. , 2019; German, 2020). It affects between 1% and 4% of the population of Latin American countries. This means an important figure for the countries of the region, considering that most of them are developing countries. Its impact is seen when 2% to 8% of the population ceases to have the work, taking into account that a large part of these people require the help of at least one member of their household who must also stop working to dedicate themselves to caring for the person with disabilities. (WHO, 2018), Munera et al. (2016) in a study conducted in Colombia, indicate that 39% of disability is due to ophthalmological causes and 37% due to neuro-ophthalmological or neurological causes. The registration and characterization of this population are fundamental for the design of rehabilitation programs and mitigate the social and psychological effects caused by this condition.

In the case of Ecuador, the development of teaching and learning methods and tools for people with visual impairments is a priority. According to the National Institute of Standardization (INEN, 2019) there are 54,437 people with visual disabilities, of which 85.06% are adults, 12.12% young people and 2.82% children, which represents a significant number of people of school age, given the cultural, social and psychological effects especially in people of school age, strategies have been established to guarantee the rights to education of children and adolescents (Llamazares et al., 2019), including at the level of university education (De la Cruz Flores., 2017).

At the academic level, one of the main problems observed is the lack of teaching-learning methodologies and instruments to develop the skills and abilities of people with severe visual impairment, particularly with regard to the reading and writing process. For this, there is the so-called Braille method, which is a system of raised points that allows people with visual impairment to read and write by touch (Marcet and Lara., 2016), this system combined with technological development such as 3D applications have allowed the development of resources to facilitate the inclusion of students with visual disabilities (Betún et al, , 2020).

From the pedagogical point of view, the Braille system is slow and impractical, which is due to the absence of an adequate teaching tool. However, by using existing computer technology, their potential can be improved. Improving methodology and technique, it is possible that reading performance can be significantly optimized (Romero et al., 2018), this technique includes audio-based systems such as podcasts (Terán et al., 2017) and tactile resources (Ospina and Rodríguez, 2018).

At present there are a variety of free operating systems that can be applicable to different platforms such as: Raspbian, Kali, Pidora, Ubuntu, Risc Os and Sarpi, and basic and low-cost platforms such as Raspberry Pi, which has been successfully used in fuzzy logic programming systems, in the mobility of people within mass transport systems or other activities of high concurrence of people (Camargo et al., 2017; Cardona and Vásquez, 2019).

In addition to the operating systems for the design of prototypes for the assistance of people with visual disabilities, there are design programs such as Solidworks, which allows creating, simulating, publishing and managing 3D models, which has complex simulation functions to help users test the performance of the product in real circumstances, this program together with 3D printing can provide people with visual impairment the development of digital models for application for didactic purposes (Gual et al., 2018; Martin-Blas, 2019).

Consequently, based on the advantages of the Braille system, the didactics can be optimized and thus facilitate the literacy process by taking

advantage of applications such as 3D printing accompanied by technical supports. However, these didactic resources are expensive, which has hindered their massification, so it is necessary to seek the design of low-cost didactic resources (Saorin, et al., 2016; Olguín et al., 2019).

Despite this reality, the development of a didactic module that includes improvements for teaching people with total visual impairment with cutting-edge technologies, would facilitate their interrelation with the environment. It should be noted that currently most curricular programs have developed strategies for the inclusion of students with different abilities in the educational system, so that changes to the ordinary curriculum must respond to the individualities of each student, depending on their characteristics, personal and educational history, motivation and interest, pace and learning style (Mora et al., 2016; Sanchez, 2018).

In this sense, the objective of this research was to develop this didactic module that can include improvements and strategies for teaching people with total visual impairment with cutting-edge technologies, for which a prototype was designed and validated based on a user-friendly programming language, called RAHMAN. Additionally, the prototype is easy to use, since it has an interface which has basic programs for the development and management of the same that integrates a small application where a child can learn basic topics, its design was made through the SolidWorks program, which allows the edition of materials for 3D printing, Once the device was designed and configured, its use and degree of acceptance were validated through pilot tests carried out on a group of teachers and students in a school for the care of visually impaired schoolchildren, located in the province of Pichincha, Ecuador.

2. Method

The methodological design of the research consists of three stages, which were prototype design, assembly and validation, each of these stages is described below:

2.1. Design of the prototype.

Its design was carried out using the Solidworks software (Clavijo and Morales., 2016; Montijo, 2019), which presented a better printing of the materials in 3D, through the use of PLA technology (printing filament), the measurements of the prototype were designed according to the electronic materials that are components of the didactic model, among which stand out: the Raspberry Pi, keyboard, speakers, housings and bases.

2.2. Assembly of the prototype

Once the prototype was designed, it was assembled. This was done in software, in such a way to match the established measures. It consists among its components of speakers with their respective housings; support bases (left and right), Qwerty keyboard modified for use in Braille language.

2.3. Didactic module

As previously mentioned for the operation of the didactic module requires the integration of the following components: Raspberry Pi, QWERTY keyboard, speaker, which are described below:

2.3.1. Microprocessor

Called Raspbery Pi (Upton and Halfacree, 2014), which is a micro-computer that has the following technical specifications: CPU + GPU: Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz; RAM: 1GB LPDDR2 SDRAM; Wi-Fi + Bluetooth: 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac,Bluetooth 4.2, BLE 38; Ethernet: Gigabit Ethernet over USB 2.0 (300 Mbps); 40-pin GPIO; HDMI; USB 2.0 ports; CSI port for connecting a camera; DSI port for connecting a touchscreen; Stereo audio and composite video output; Micro-SD; Power-over-Ethernet (PoE).

2.3.2. Qwerty keyboard

This keyboard modified in Braille language has a total of 78 keys, its use is fundamental for the fulfillment of the writing functions, the

characteristics of the keyboard are observed in Figura 1.

Figure 1. Qwerty keyboard used to control the operation of the didactic module

2.3.3. Speakers

Sound system that delivers clear, crisp sound and allows typing functions to be performed.

2.3.4. 3D printing

Having their designs proceeds to the execution of the printing code, after a few hours each of the prints were developed according to the measurements of the program. After executing the design and acquisition of electronic elements, we proceed to the installation of Debian Software (Abate and Di Cosmo, 2017) and execution of each of its menus and submenus meeting the needs of visually impaired children.

2.3.5. Software

As an operating system, the free access program "Debian" was used, which has high reliability and is easy to use by the user. As a screen reader, a free access program called Orca was used, for the management of the didactic module the system has a quick access menu which is described below (Figure 2).

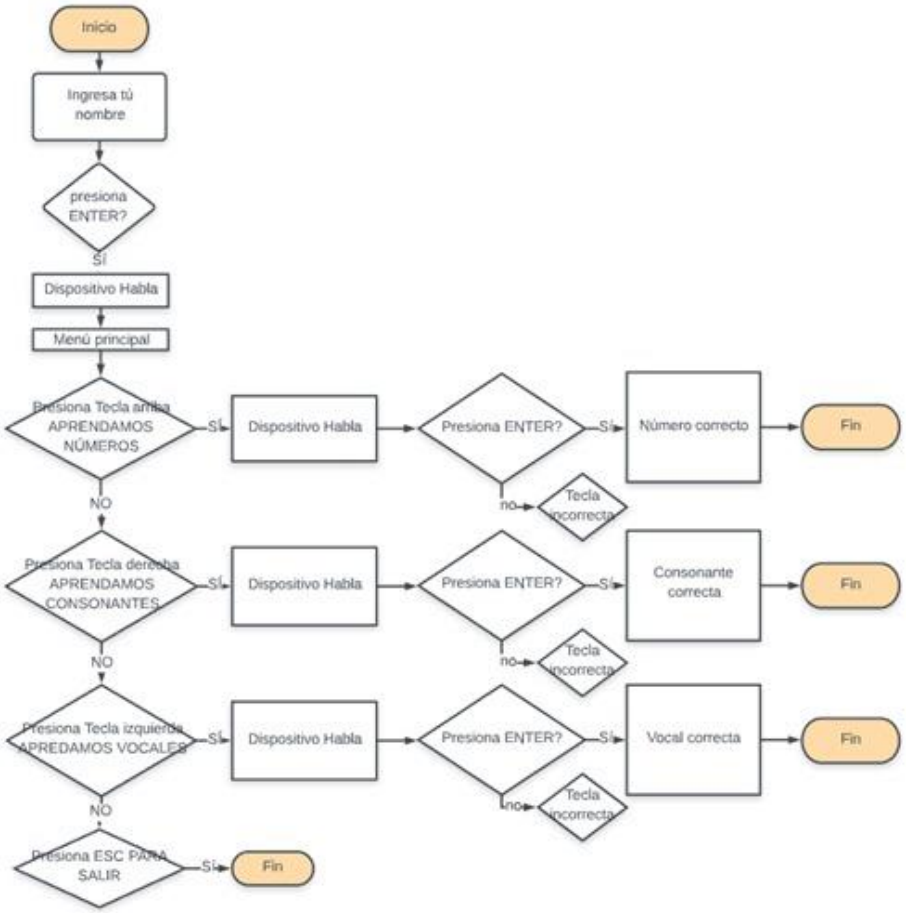

Figure 2. Quick access menu for the writing, reading and math functions of the teaching module

The didactic module in turn has two menus for access to skills related to the area of literacy and another referred to the learning tools associated with writing, which are described below, the writing module is designed for the introduction of vowels and consonants and the handling of words fromhilligal monkeys to pentasyllables.

In relation to the reading module, it has the function of listening to the writing of the selected text through the speaker system, so that the student can then read it, depending on the compression of it.

2.4. Validation of the Didactic Module

The objective of the validation of the didactic module was to evaluate the degree of acceptance by children with severe visual impairment and their teachers. According to data from the National Institute of Standardization (INEN, 2019) there are 54,437 people with visual disabilities, of which 2.82% are children, that is, approximately 1535 of the total population of school-age young people in Ecuador. For the study, a sample(s) of 307 students was calculated. For the selection of special education educational centers and to locate the study subjects, an intentional sampling was used, because the educational units were selected according to the proximity to the module construction laboratory at the University of the Armed Forces (ESPE), located in Latacunga, in the canton of Quito. province of Pichincha.

In each educational unit, groups were formed with teachers and students where they were given talks about the module and its characteristics. In addition, diagnostic information was collected through the application of an instrument aimed at

teachers and students. The second stage of validation was the direct interaction of 10 students and 6 teachers with the module. From whom information and testimony was collected about their experiences in relation to confidence and satisfaction when using it. For this stage there were 5 prototypes.

An instrument was applied to 26 Special Education students in the province of Pichincha, Canton of Quito, whose ages were between 7 and 12 years, from grades 1 to 6. With a total of 57.49% boys and 42.31% girls, the data were taken from the information collected by the National Council on Disability (CONADIS, 2019), as seen in Tabla 1.

Table 1. Data corresponding to school-age students in the province of Pichincha with severe visual impairment. Sample data by course and area of knowledge

Canton	Quito	
Degree of disability	Severe: 85-100%-	
Student with disabilities	26	
Classification by gender	Male: 57.49 %	Female: 42.31%
Age rating	4-6 years: 30.77%	7-12 years: 69.23%

3. Results

The validation of the results was carried out in two stages, one to know the disposition of the student and teachers for the adoption of the module designed as a learning strategy in the area of literacy and the other to know the assessment that both students and teachers have of the importance of this tool as a teaching method for students with severe visual impairment, The results are presented below:

3.1. First stage:

The results obtained in the diagnosis presented in Tabla 2. reflect that only 56% of the students addressed have used the Braille system as a learning method and that even only 44% have done so within the scope of formal education, one of the positive aspects is that 100% of students said that it requires technological support that complements and facilitates the learning process, Expressing 100% pleasure when using the didactic module designed in this research, the students stated that the limitations for the adoption of a didactic module under computerized systems is the high cost and that the few existing ones are of imported origin, for which the elaboration of a low-cost module, would massify its use among students.

Table 2. Diagnosis on the feasibility of using the module of reading and writing by students

Using Braille for writing	
Braille system (%) 56	Other system (%) 44
Reading Learning Scope	
Formal education (%) 44	Informally (%) 56 %
Requires technological support	
Would require it (%) 100	Would not require it (%) 0
Origin of the technological device	

Imported (%) 100	National (%) 0
Cost would limit device usage	
Yes (%) 45	No (%) 55
General perception about the literacy module	
Taste (%) 100	No taste (%) 0

With regard to the perception of teachers, which is observed in Tabla 3 in relation to the adoption of the use of the literacy module, they stated that despite considering that the use of a didactic module would be very useful for the attention of students with visual disabilities, they affirmed that they had some limitations for the teaching of this system, due to weaknesses in the competences related to the use of Braille, as well as limitations of motor skills and the didactic strategies used, given that limitations in motor skills further compromise reading and writing, 88% consider that the use of technological resources as didactic support will be important to improve the learning process, which means that for most teachers it is considered to make use of technology.

Despite the importance and necessity of the use of technological devices, only 50% own an electronic device; while the other 50% do not own it. This means that half of the teachers have access to electrical devices and that these have a good acceptance of them, however 100% of the teachers approached would like to use the support of an electronic device adapted especially for children with visual impairment. As for the programming language called RAHMAN there is total acceptance by teachers to find it a friendly system. Finally, both teachers and students, the Braille system was learned through private education because the state does not have accessible study programs.

Table 3. Diagnosis on the feasibility of using the reading and writing method by teachers

Factors limiting students' writing		
Use of Braille (%) 63	Motor skills (%) 25	Didactic strategies (%) 13
Importance of the use of technological tools as a didactic resource		
Important (%) 88		Not important (%) 12
Use of technological tools as a didactic resource		
He uses it (%) 68		Not used (%) 32
Would like to use technological tools as a teaching resource		
Yes (%) 100		No (%) 0
Do you think that the use of the didactic module would be useful?		
Yes (%) 85		No (%) 15
Feasibility of using the didactic module as a learning tool		
Feasible (%) 100		Not feasible (%) 0

3.2. Second stage:

This stage was characterized by working with teachers and students for a month where they were instructed in the use of the module and application for reading and writing. The group consisted of 26 students with severe visual impairment and proficiency in Braille. Among them, 11 girls and 15 boys aged 8 to 12 years. The total number of teachers six (06). From all, testimony was collected about their direct experiences regarding confidence and satisfaction when using the module. This was assessed in relation to aspects of operation of the keyboard, audio system, access to the menu, reading system, the results of the assessment are observed in Tabla 4.

Table 4. Assessment of teachers and students of the functioning of the components of the didactic module for the teaching of children with severe visual impairment

Compontes	Assessment of Students and Teachers			
Keyboard	You can interpret each of the keyboard letters by touch.			
	Students		Teachers	
	Otherwise		Otherwise	
	100%	0%	100%	0%
Speaking	Is comfortable with the graduation of the volume of the speakers			
	Otherwise		Otherwise	
	100%	0%	100%	0%
Reader	Device initiation is quick and easy to access			
	Otherwise		Otherwise	
	100%	0%	100%	0%
Accessibility	The reader is easy to understand			
	Otherwise		Otherwise	
	100%	0%	100%	0%

In the interaction with the components of the module, 100 percent of the teachers and students expressed total agreement with the components of the same, which would facilitate the incorporation of the module into the teaching and learning process in schools in the province of Pichincha and in Ecuador.

The present research allowed to validate the use of a program to improve the literacy skills of students with visual disabilities in Ecuador presenting the advantages of its accessibility and ease of use and low cost, which would enhance its massification and its use in the poorest regions of Ecuador and other countries of the region.

4. Discussion and conclusions

Robles et al (2018) affirm that the adoption of didactic modules for people with visual disabilities in developing countries is more complex due to the lack of resources of both government entities to develop investment programs in education and for families to acquire these didactic resources, which is why these authors proposed multifunctional Braille, using applications, which was low cost and the system was satisfactorily evaluated by 90% of the participants.

Romero et al. (2018) point out that there are a series of technological tools for the inclusion of people with some type of disability, including visual, whose use helps overcome the limitations of the condition, generates personalized attention, favors communication processes, promotes student autonomy, saves time and facilitates access to multiple information resources, Despite the benefits of teaching resources, especially those based integrated into artificial intelligence systems, their greatest limitation for their massification is the cost, so initiatives that promote local systems taking advantage of their own resources and the use of free software that lead to the reduction of costs, will favor their massification especially in countries located in the poorest regions (Facha, et al., 2019)

Ceballos et al. (2018) successfully evaluated the use of software for teaching English to visually impaired people, which combines auditory aspects with tactile handling, unlike other systems proposed by Terán et al. (2017), which only considers the use of postcast-based audio. Given that some weaknesses observed in teachers is their ability to handle the Braille system, authors such as Gómez et al. (2019), have proposed a global learning construction system which was successful in improving the capacities of teachers who serve students with visual impairment in the management of the Braille system, so it is necessary to improve this system in teacher training to facilitate the inclusion of people with visual disabilities (Gómez et al., 2018), which must be accompanied by the development of didactic modules that facilitate the learning process.

Esparza (2019) points out among the factors that should be considered for the adoption of a didactic module, are the size of the screen, which should be 'preferably large', accessibility to the menu, which in the case of the designed system had 100% accessibility, ergonomics, especially referred to the size of the keyboard, which also resulted in 100% acceptance by students, sign language and voice-to-data translation, which was also positively validated through the functioning of the reader and speakers. Serrano et al. (2013) point out that although students may have access to different didactic programs, the work should focus on training teachers to design learning programs and activities that allow an efficient use of it.

It is possible to merge technological elements that enable the teaching-learning process of reading and writing of visually impaired schoolchildren. With this, the response of the educational environment to the adaptation needs of children from 7 to 12 years with the indicated condition is facilitated.

In a broader context, the implemented didactic module redefines the traditional teaching-learning process for people with total disabilities, by merging Braille language and Raspberry technology into a low-cost device.

The requirements for the implementation of the didactic module for people with visual disabilities were: to be solid to avoid internal damage of the module, lightweight, and with alternatives of use to comply with the primary education program.

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