Inclusive EducativeTechnologies, for people with disabilities

AM Echenique[1], JP Graffigna[1], E Pérez[1] , N López[1], D Piccinini[2], H Fernández[1], A Garcés[1].

E-mail: amechenique@gateme.unsj.edu.ar

Abstract: The conventional educational environment imposes barriers to education for people with disabilities, limiting their rights, which is a non-discriminative education. In turn, hampers their access to other rights and creates huge obstacles to realize their potential and participate effectively in their communities. In this sense Assistive Technology provides alternative solutions, in order to compensate for a lost or diminished ability. Thus the necessary assistance is provided to perform tasks, including those related to education, improving the inclusion. In this paper some researches had been made in the *Gabinete de TecnologiaMedica*, in the *Facultad de Ingenieria* of the *Universidad Nacional de San Juan* in order to solve this problem. The researchers are classified by type of disability; sensory (visual and auditory) or motor. They have been designed, developed and experienced through various prototypes that have given satisfactory results. It had been published in national and international congresses of high relevance.

Introduction

Theresearch interest in disability problems emergesfrom the statistic data of the World Health Organization (WHO) [1] which reveals that from 93 to 150 millionchildren (from 0 to 14 years) live with some disability. The global population affected by some kind of disability has many difficulties in the normal development of personal, social, educative and/or labor activities. Historically, many children and adults with disabilities have been excluded from the conventional educational opportunities. In the majority of the countries, the first efforts to provide education and professional training were undertaken, in general, through special schools, that habitually were designed for specific impairments, like the schools for the blind. These institutions assist a small proportion of those people who needed help and they were not efficient in relation with the costs: they were generally located in urban zones and they used to isolate people from their families and communities. The situation started to change just when the inclusion of the disabled into the educational system was required by law. All the countries should have as priority that people with some disability receive a good quality education in an inclusive environment. In the context of theUnited Nations Convention on the Rights of Persons with Disabilities (CRPD), the right of being included in general educational systems and receiving individual support whenneeded was recognized. Systemic changes are required to eliminate barriers and to give supporting services and reasonable adjustments in order to guarantee that disabled people are not excluded from

1 Gabinete de Tecnología Médica, Facultad de Ingeniería, Universidad Nacional de San Juan.
2 Grupo de Análisis, Desarrollos e Investigaciones Biomédicas, Fac.Regional San Nicolás, Universidad Tecnológica Nacional, Argentina.

conventional educational opportunities. It is recommended to increase access to adequate, maintainable, affordable and accessible technical assistance [1].

The general acceptance of this reality has let, in Argentina, to the creation of national and provincial laws that considers the issue of social reintegration of people with disabilities and older adults. For instance, the section 75, subsection 23 of the National Constitution, states: "the Congress is responsible for: legislate and promote positive action measures which will ensure real equality of opportunities and treatment, and full enjoyment and exercise of the rights recognized by this Constitution and existing international treaties on human rights, particularlyas regards children, women, elderly and persons with disabilities…".

A particular way of responding to this situation is through activities on research, development and technological innovation (I+D+i)promoting the search of innovative solutions for the rehabilitation of these individuals. However, the public and private institutional resources and efforts of Argentina, to confront this issue and provide real conditions of equality, are scarce.

Particularly, in the province of San Juan, there are different centers for the care of people with disabilities and the elderly. Through the collection of data of different institutions, various limitations and difficulties were revealed. The available technology is habitually unattainable because of the lack of information or inadequate economicresources that these institutions and people themselves have. These restrictions are more sharpened if it is considered that these people always need technological tools for their functional performance. That is to say, this need should be satisfied within the institutions that help to the rehabilitation and during the time remaining out of them.

In an attempt to give specific solutions to this part of the population, the *Gabinete de TecnologíaMédica*of the *Universidad de San Juan* has been working from the year 2003, in the area of *Ingeniería*and*Tecnología de Rehabilitación* (Engineering and Rehabilitation Technology). There, many human resources trained andgraduate and undergraduate about this topic, that shares its knowledge and experiences with the objective of, on the one hand, design, develop and implement innovative scientific-technologic tools, and on the other hand, adapt existent devices, aimed at satisfying specific needs of people affected by different kinds of disabilities and of the elderly. In this way, the goal of this is to provide alternative tools for the people to interact with their environment, increasing their autonomy. In this sense, the assistive technologies, properly applied, can contribute to overcome constraints in the activityimposed by the disability.

The aim of the present work is to present different assistive technologies developed in the *Gabinete de TecnologíaMédica* (GATEME), with the objective of giving alternatives of help to people who have sensory or motor disabilities, in the access to the inclusive education.

1. AssistiveTechnology

The fundamental objective of a rehabilitation device is to improve the independence of the person with a disability; that is why the design and development of these devices is based not only on the user skills (that is, it should focus on the other functions of the affectedpeople and not on the lost functions), but also on the activity to what is designated, and the context or environment where it will be used[2].Paying attention to these concepts, a system of assistive technology is defined as that integral system resulting from the interaction between the assistive device, the human operator with some disability and context where the functional activity will be done (Figure 1).

The man-machine interface is the component of major importance in the assistive technological systems. An interface may be defined [3] as the boundary shared by the components that interact in a system through the communication or informationexchange on both sides through the boundary. Consequently, there are endless interfaces, in all the application areas.

The man-machine interfaces may then be defined as the boundary between the person and any device through which the information exchange is produced. This exchange is bidirectional and includes the interface from the person to the device to control it and the interface that gives information with reference to the environment or to the operation if the device. The information exchange that exists in an input way for being able to operate the device is done through a control interface between the user and the device. This control interface varies depending on the needs of the user, the task to be performed and the device to be used. Furthermore, the information exchange from the device to the person is done through visual, audible and tactile signs, and these play an important role in the feedback to the user.

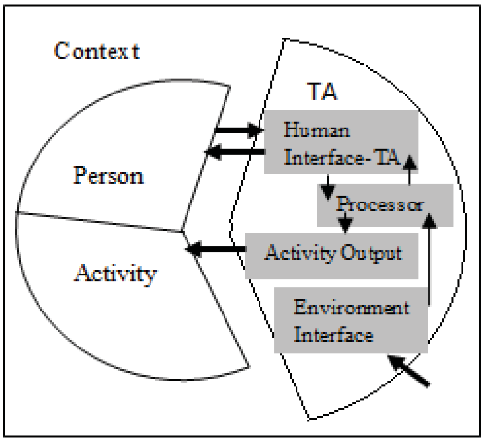

Figure 1. Analysis of the role of Assistive Technologies in the HAAT(Human Activity Assistive Technology)model taken from [2].

2. Developed Interfaces

This section presents the development of different interfaces applied in systems of assistive technologies, like alternative tools for people with neuromotor and sensorial disabilities. These interfaces have as objective giving different solutions for educational purposes. Interfaces based on biological signals and artificial vision are developed for neuromotor disabilities, and for people with sensorial disabilities, the developed interfaces are based on tactile stimulation and augmentative systems. These systems may be defined as speech therapy and educational instruments for people with various communication and/or language disorders, and its goal is the teaching of a structured set of non-vowel codes that allow functions of representation, using specific procedures of instruction.

2.1. Neuromotor Disabilities

2.1.1. Interfaces based on Biological Signals

The biological signals often used in these applications are electroencephalogram (EEG), electromyogram (EMG) and electrooculography (EOG), because they have already demonstrated to greater or lesser degrees, a skill of classification and discernment of the volunteer’s intentionality.

The electrooculography (EOG) is employed in the case of people with severe motor disabilities, where the damage is at brain or spinal level and they are not able of doing voluntary movements with their extremities.To recognize the signs sent by visual fluctuations, a system of electrodes is employed, one placed near the muscles of the eyes. In this way, the visual fluctuations produce variations in the field current, that is reflected in a more positive potential when the eye turns to the electrode, and less positive, when it turns in the opposite direction [4]. These interfaces end in the production of control commands for peripheral devices, computers, among others, with the aim of improving the communication of the user with the surroundings and allowing the access to various educational, recreational and visual environment computer systems[5], [6], [7].

The signals EOG were employed in the commandof the mouse through an Accessibility Interface for **Control of the Mouse Pointer** [8], of a personal computer and potentially of other devices.

The communication between the circuit of acquisition and the PC is implemented wirelessly. A circuit of acquisition and conditioning of electrooculographic and electromyographic signals has been designed accompanied by a processing software of the signals with which the user may move the mouse pointer and click in any personal computer.

These signals are acquired through superficial electrodes in the face of the patient, Figure 2, and then expanded and filtered in a conditioning circuit.

The acquisition circuit consists of three channels, one for the acquisition of signals from the eye vertical movements, another for the acquisition of horizontal movements, and the third for the acquisition of electromiographic signals. In the second stage, the signals from the three channels are digitalized and wirelessly sent to the PC, to provide the actions to the mouse pointer (horizontal, vertical and diagonal pointer movements, and click).

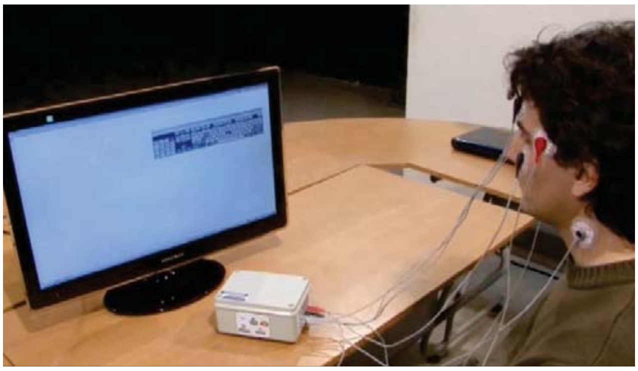

Figure 2. Accessibility Interface for the Mouse Pointer Control.

2.1.2. Vision-BasedInterface

The Vision-*B*ased Interfaces(VBIs) are perceptive interfaces that use the vision as a channel of communication from the user to the computer. The Vision-based Interfaces havecameras as constituent parts that are non-invasive entry tools*,* one standard computer to process the images, control and obtain drive commands. The module of image processor consists of the monitoring or recognition of the region or portion of the object of study, to bring the parameters that enter to the control module, where the events are generated. These are the entries to the action command module that generate the actions for some specific task.

The Vision-Based Interface: an alternative tool for Children with Cerebral Palsy [9]; develop, detect and follow hand or foot movements of the user. This interface consists of a webcam that captures the image of the zone to be sensed and applying image processing algorithms it detects the movements of these regions. The movements detected in Figure 3, are translated into cursor movements in the computer screen through which different PC utilities are commanded. This accessibility tool uses the residual abilities and it has been successfully tested by people with severe motor disabilities.

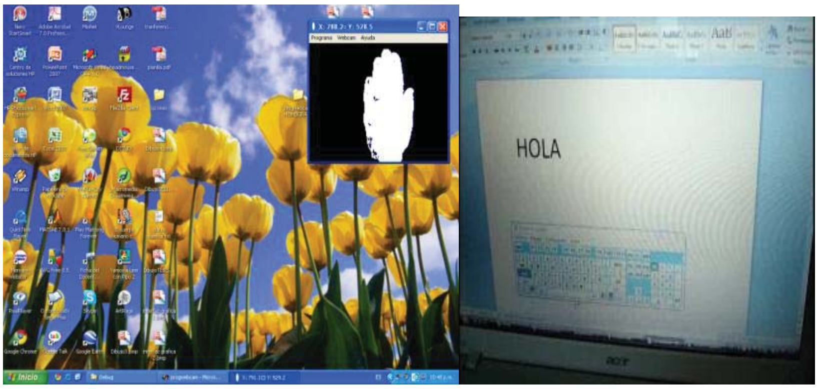

Figure 3. Vision-Based Interface

2.2. Sensorial Disability

2.2.1. Visual Disability

One of the major problems that people with visual disabilities confront regarding educational activities is the access to reading material. In this sense, the Braille system for literacy is widely used by blind and deaf-blind people; and it is characterized by its universality and relative simplicity.

In the case of blind people, where the augmentative devices are inadequate, the use of other sense is required, like the touch or audition sense [10]. The touch presents series of advantages as regards auditory stimulation that at the same timeliberates the channel for communication. In this aspect, the “Touch Display” [11] can be mentioned. It is the equivalent for a visual “display” where the information is perceived by the contact with the skin. These devices use various means of achievingthat stimulus, for example: temperature, electricity, compressed air or mechanical variation (of pressure or vibration). The heat as stimulation medium raises the problem of thermal inertia. The mechanical devices have difficulties related to the deterioration, fatigue, heat, size and production, etc. The electrical stimulation needs to supress the sense of electrical shock and an adequate electrode-skin interface. It presents less manufacturing and maintenance problems than mechanical devices;it costs are lower, and it gives more robustness and useful life to the system [12].

Based in these considerations, an **Electrodermal Braille System**[13] was developed. This allows that any digital text (books, documents, Internet information, etc.) could be loaded in a PC and subsequently read in the belt through the Braille code. It is a platform of electrodes that simulates 32 characters or Braille engramsby electrostimulation.

The feelings to receive these characters are generated by the electrostimulation of the skin receptors of the fingertips and replace the sheet of paper, generating feelings of pressure similar to raised dots of traditional texts in Braille. Blind people have experienced it with satisfactory results (Figure 4).

Following with the assistive technologies to the blind, a Mobility device to help blind skaters [14] has been developed. The device facilitates the mobility and orientation of people with severe visual disabilities in leisure and entertainment activities. Particularly it consists of a communication system to gives information to a person who goes figure skating through a wireless connection and a touch display based on vibratingmotors. There are devices that use actuators from different parts of the body, but there is not a specific application to the presented problem.

Figure 4. Electrodermal Braille Belt Experimentation

As the activity requires high mobility and attention from the skater, vibrating mechanical stimulation has been used. The vibrating motors are powerful actuators that can give clear and defined stimulus while the person is performing the choreography. Through the touch display is expected transmit the necessary information to orientate in the rink, preventing collisions and allowing the skating in a team. The device is composed of three parts: transmitter, receiver and touch display (see Figure 5). The transmitter receives the events indicated by the coach and sends the information to the receiver wirelessly. The receptor receives the information and activates the touch display to notify the skater. The coach gives information through four channels that correspond to four vibrating motors placed on a vest of elastic bands that are put on the body of the skater and allow the modification of its path through a command set establishedpreviously. The purpose of the elastic band is that it fits and shapes the body of the user and finally achieves a more direct contact. The transmitter is made up of four keys, indicator lights and the antenna.

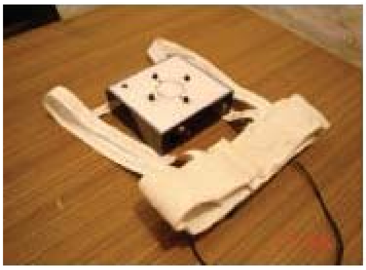

Figure 5. Vest and Receptor

The device has been tested in the training track and in the competition track too with highly satisfactory results. In Figure 6, both situations can be observed.

The developed device meets the requirements proposed by the coach and the skater. Both the transmitter used by the coach and the receiver used by the skater are compact. The touch display is comfortable and aesthetically covered by the clothing. The functioning is perfect because it achieves the objective, enabling an adequate performance and a continuous use during the training and public exposures. The implemented tool gives to the skater the possibility of listening to the music played in the choreography and receivingthe coach feedback for the mobility and orientation through touch. Moreover, it offers the opportunity of participate in professional competences and do group choreographies. The coach and the trainer have said that the development has significantly improved in the performance and security during the skating.

Figure 6. Experimentation in the training and competition track.

2.2.2. Auditory disability

In this subline, it has been designed and developed a ***cheap wireless communication device for the education of the hearing-impaired***[15]. The communication system consists of a transmitter and one or more receivers for hearing-impaired users. The signal is transmitted from the sender directly to the ear of the user by transmission of wireless signals moduled in FM, in the range of frequiencies that goes from 88 MHz to 108MHz.

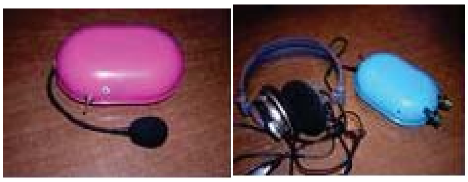

Figure 7. Wireless transmitter and receiver.

The main difference between this device and a conventional wireless hearing aid is that this minimizes the negative effects of the background noise and distance, and is very convenient in the educational context. The developed hardware (Figure 7) is being used in the “Escuela de Educación Especial paraSordos José A. Terry”, with children with pure hearing loss and in cases related to other disabilities, with successful outcomes.

In order to optimize the developed prototype, a new prototype design has been started that could adapt the audio signals with the specific needs of the user. That is, according to the audiometric response of each user, it will adjust the receiver in its response in frequency. To do that, there is a stage of programmable amplification and filtering in the receiverwith individual audio output connected to each speaker of the headphones. The receiver also has a potentiometer to modify the volume levels, fine adjustment of frequency and a power indicator led (see Figures 8 and 9).

The device is portable, small and light, which allows the teacher and students mobility, offering more “natural” school situations for the hearing impaired learners.

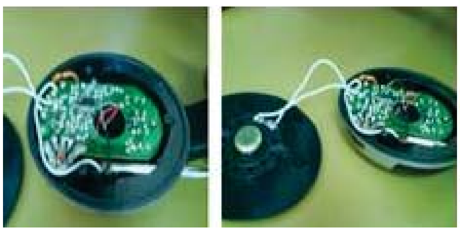

Figure 8. Headphones for the Receiver. **Figure 9**. User with the Receiver.

2.3. Mild Cognitive Impairment in Infants

Autism Spectrum Disorders (ASD) or Pervasive Development Disorders (PDD) are a group of diseases that have the following characteristics in common: social interaction affection, little imaginative activity, verbal and non-verbal communication disrupted, and stereotyped and repetitive behaviors. This deterioration generates problems in the adaptation to the family, school and community life. According to Autism and Developmental Disorders Monitoring (ADDM), in the year 2008, the ASD have a prevalence of 11.3 in a thousand, what means 88 childrenborn, one has this disorder. Due to technological advances it is possible to help children with autism to communicate and interact in their environment.

2.3.1. SicaaKids System

A platform with a specific design for children with ASDis presented, and it is evaluated. The software was developed and designed according to the needs stated by professionals of the service of pediatric speech therapy in the Hospital Guillermo Rawson, hospital of the province of San Juan, Argentina [16]. These professionals state that software is required with a window showing different useful activities to work with the child to stimulate the communication. The objective of this work is to evaluate the designed graphic interface, to know if its design is simple and easy to access for these patients.

To evaluate this software it was used a calculating performance TP which is based in the Fitt's Law, and can be used to compare the user efficiency in specific tasks.Then, to obtain the opinion of the users they were surveyed following the model of the SUS (ScaleUsabilitySystem) questionnaire.

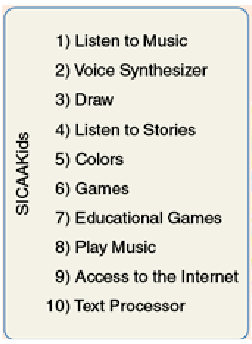

Figure 10. Software functions. **Figure 11.**The main panel of the SICAAKidssystem.

The design is simple and attractive, with representative pictures that relate the icons with the underlying functions.The scenario chosen is a child's room, with the aim of relating the pictures. All the embedded programs (music, educational games, and others) are public license. The system covers the entire screen, not to distract the user with other images. Each numbered object on the screen (figure 11) of the main panel of the SicaaKids can be associated with the list in figure 10.

These functions are implemented according to the needs and activities developed by the phonoaudiological service of the Hospital.

The techniques for the quantitative evaluation of the software use that were employed were the TP and SUS scale, for more details see [4]. The evaluation has been done with children that do phonoaudiological therapies in the abovementioned hospital. The software evaluation involves the work with underage youth users, and that's why it was needed that the parents or tutors were engaged in the evaluation and signed the informed consent. The sample consisted of 8 patients, divided into two groups, group 1: subjects A, B, C, and D that use the computer frequently. They

are 10, 8 and 7 years old respectively and the ASD diagnostic is mild. Group 2: subjects E, F, G and H who do not use the computer, of 5, 7, 8 and 7 years respectively and ASD moderate diagnostic.
The experiment has been done in two phases, one phase in aWindows® desktop environment and the other in the SicaaKids environment. The TP has been calculated for each selected icon in the Sicaa environment and in the Windows®, too. To do this the time that the user lasts in arriving to the indicated icon has been calculated. The TP values have been higher in the SiccaKids environment than in Windows, owing to the better relation that is obtained between the movement precision and the speed to do that. The survey shows that the software has had a great acceptability of the subjects and the majority of the volunteers think that the accessibility of the activities was easily with SiccaKids.

2.4. Uses of existent technology

Another important aspect to emphasize is the assistive technology, the capacity of using existent devices to potentiate institutional capacities. The research team has been working with that aim in the implementation of procedures that allow having the technological resources out of the University to potentiate the accessibility of the students to higher education. In that sense, the following aspects have been examined:

- Braille impression of school notes: through a university volunteer project, the University gave a high-speed Braille printer to the AsociaciónSanjuaninaparaCiegos.
- Magnetic rings: from some years ago the team has been created human resources to the development of magnetic rings, from an initiative in some classrooms with the requirement of academic units.
- Basic accessibility and specific technology: the research team advises on the technology acquisition to improve academic environments of students with disabilities (adapted chairs, specific software, etc.)

3. Conclusions

In this work, is has been address the issue of inclusive education for people with sensor, motor and mild cognitive disabilities, taking into account the more relevant problems and necessities of the affected people to bring technological solutions. Considering the strengths of the investigation group technical helps has been proposed, applying Assistive Technologies with the aim of restoring or substituting partially or totally the auditory, visual or motor functions, improving the realization of normal or habitual actions of people with special abilities.

To resolve the problems identified, it has been designed and develops devices and systems to care for specific disabilities considering utilities, costs and needs. Some of these technologies have been transferred to different institutions that are involved in the attention of people with special abilities. It is worth stressing that these institutions have been helping actively in the evaluation of the developed technologies.

4. References

[1] Informe Mundial sobre Discapacidad. OMS 2011

[2] AM Cook, SM.Hussey “Assistive Technologies: Principles and Practice”, 2° edition. United States of America, Mosby Inc. Editions, 2003.

[3] RW. Bailey. “Human Performance Engineering”, 2º ed., New York, Englewood Cliffs, Prentice Hall, 1989.

[4] C. R Cassemiro. y C.G Arce, "Comunicación visual por computador en la esclerosis lateral amiotrófica", Archivos Brasileños de Oftalmología, 2004, Vol. 67, No. 2, pp. 295.300.

[5] M. Johnson "Recent trends in robot-assisted therapy environments to improve real-life functional performance after stroke", 2006.Journal of NeuroEngineering and Rehabilitation.

[6] H. Krebs, N. Hogan "Therapeutic Robotics: A Technology Push", 2006. Proceedings of the IEEE.Vol. 94, No. 9.

[7] M. Matarić, J. Eriksson, D. Feil-Seifer, C. Winstein "Socially assistive robotics for post-stroke rehabilitation", 2007. Journal of NeuroEngineering and Rehabilitation, 4:5.

[8] Sergio Bajinay, Roberto Zanetti, Eugenio Orosco, Natalia M. López. "Equipo inalámbrico de adquisición de señales biológicas para el comando del mouse". XVIII Congreso Argentino de Bioingeniería, VI Jornadas de Ingeniería Clínica. 28 al 30 de septiembre del 2011. Mar del Plata, Argentina.

[9] M. González, D. Mulet, E. Perez, C. Soria & V. Mut. "Vision Based Interface: an Alternative Tool for Children with Cerebral Palsy" 32nd Annual International Conference of the IEEE EMBS Buenos Aires, Argentina, August 31 - September 4, 2010. ISBN: 978-1-4244-4124-21995.

[10] C. Lenay, O. Gapenne y S. Hanneton: Sensory Substitution: Limits And Perspectives. Université de Technologie de Compiègne. 2003.

[11] F. Vidal-Verdú, y M. Hafes: Graphical Tactile Displays for Visually-Impaired People. IEEE Trans Neural S and Rehab Eng, V15, N1, 2007..

[12] H. Kajimoto, K. Naoki, M. Taro, T. Susumu "Tactile Feeling Display using Functional Electrical Stimulation", In Proc. of The 9th Int. Conf. on Artificial reality and Telexistence, pp.107-114, 1999.

[13] A. M Echenique, J. P Graffigna, and V. Mut "Electrocutaneous Stimulation System for Braille Reading". 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, (EMBC 2010), 31/8 al 4/09/2010.4 pp 5827-5830 ISBN 978-1-4244-4124-2: ISSN: 1557-170X

[14] Acerbi A, Graffigna JP, Polimeni G, Fernández HH: "Dispositivo de ayuda a la movilidad de patinadores ciegos". XVI Congreso Argentino de Bioingeniería & V Jornadas de Ingeniería Clínica, 2007 ISBN: 978-950-605-505-9.

[15] A. Garcés, H. Polimeni, H. Fernández (2007). "Educación de Hipoacúsicos, Equipo de bajo Coste de comunicación inalámbrica", Mundo Electrónico, nº 389, Barcelona. ISSN: 0300-3787 Pág.: 52-59., Apr. 1965.

[16] E. Perez, D. Piccinini, N. López, S. Ponce. Evaluación de plataforma de Accesibilidad para Niños con Trastornos del Espectro Autista. VI Congreso Latinoamericano de Ingeniería Biomédica. CLAIB 2014. Paraná, Entre Ríos, Argentina. ISBN 978-950-698-343-7