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Review of the Literature

ICTs in Inclusive Education for Sensory and Physical Disabilities

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ABSTRACT

The current paper examines the role of Information and Communication Technologies (ICTs) in the inclusion of students with sensory and physical disabilities. Our main goal is to present the importance of ICTs and highlight their contribution to the smooth and equal inclusion of these children in the educational system and society. Thus, the research team of this paper presents specific examples of ICTs that aid children with visual and hearing impairments and physical disabilities. We followed the method of bibliographic review of articles, focusing on articles from the last five years. However, we considered it necessary to include also some older articles for a more complete and accurate review of the topic. According to the results of the research, ICTs provide an attractive and supportive environment for the students with special needs as well as equal opportunities regarding their inclusion. Since we live in the world of information and the digital revolution, we have to adapt to modern reality and prioritize the use of ICTs in education. Lastly, ICTs help the students with sensory and physical disabilities to overcome the barriers that exist in traditional educational systems which would lead to the reduction of social exclusion.

Introduction

Information and Communication Technologies (ICTs) concern the study, design, development, implementation, and support of computer information systems, especially computer software applications. ICTs use electronic devices and software for the conversation, storage, protection, processing, transmission, and secure retrieval of information [1]. The right to education concerns all children without exception and is essential for the personal development of every human being. ICTs give opportunities to students with special educational needs to achieve equality in education. For the above reasons, teachers need to acquire the appropriate knowledge on how new technologies can be used properly according to the culture, needs, and economic situation of their country [2].

Article 1 of the United Nations defines children with disabilities as those up to the age of 18 who have long-term physical, mental, intellectual, or sensory-motor disorders which, in interaction with various barriers, may impede their full and effective participation in society on equal terms with the others. Various scholars, policymakers, and activists are working to reform children's rights to be compatible with the digital age [3]. The global goal of the 21st century is for people with disabilities to have more opportunities to participate in education. Also, in the health sector, with the help of ICTs, efforts are being made that people with disabilities receive a better quality of health services that respect their needs, peculiarities, and rights [4]. In our research, we focus on people with sensory and physical disabilities and how the use of ICTs can improve the quality of their lives and help them participate equally in the educational process and, thus, society.

Technology aids students with disabilities to improve their independence in the academic and work field and their participation in-class activities and discussions. ICTs (Information and Communication Technologies), make learning possible anywhere and at any time by allowing the students to have access to information and knowledge wherever and whenever they want. The use of ICTs in education is inevitable. Students spend many hours of their daily life using technology, so it is reasonable not to be attracted by environments where technology is not been used.

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The use of available technologies is considered as the main tool for the implementation of inclusion and participation. Technology can be divided into three categories: assistive technology, accessibility technology, and universal design. Assistive technology, in particular, is any device that helps a student with a disability to complete a daily task. It is more than an educational tool as it is a fundamental work tool comparable to pencil and paper for students without disabilities [5].

Digital inclusion is widely regarded as a phenomenon in which marginalized people, such as people with disabilities, have access and participate in education, social and political activities, and employment opportunities equally as others through the use of digital technologies. The focus of digital inclusion is to help people with disabilities increase their access to technology and their ability to use it [6]. ICTs promote the adaptation of the educational process to the characteristics, interests, and needs of the students by helping them participate actively to achieve their learning goals. Teachers seem to have a positive attitude towards the use of ICTs and in the last years, they have gained more knowledge in this field. However, it is necessary to adapt the curriculum and develop teaching strategies, so that ICTs can be integrated into the educational process. Besides, teachers need further training to be able to support the proper use of ICTs [7].

According to Turner-Cmuchal M. & Aitken S., nowadays the contribution of ICTs has been recognized worldwide as they improve the quality of life of people with disabilities, they reduce social exclusion, and strengthen their participation in society [8]. According to the Council of the European Union, many European countries have adopted policies that include the use of ICTs, to promote equality in education and the inclusion of people with disabilities in the information society. The UN Convention on the Rights of Persons with Disabilities ensures their access to ICTs and knowledge.

Except for the attractiveness factor, there is also the efficiency of the use of technology. For instance, digital textbooks offer a better alternative than traditional textbooks because they are interactive and they provide instant feedback [9]. ICTs support students with hearing and vision problems, as they provide access to educational material through audiovisual media [10]. Below there are presented a few examples of ICTs and their contribution to the inclusion of students with visual and hearing impairments and physical disabilities.

ICTs in Sensory Disabilities

I Visual Impairment and Blindness

The educational material that is designed for not visually impaired students is often inappropriate for the visually impaired, except if it is modified to suit their needs. This requires efforts to develop content in accessible formats or to use software to convert ordinary content to accessible formats [11]. According to Kim *et al.*, the number of visually impaired people is constantly increasing worldwide, so ICTs have been designed to help them in their daily lives [12]. In particular, there are special devices that convert the optics into an audible or tactile stimulus such as screen readers, Braille keyboards, Braille printers, or special screens used in Braille. Also, mobile phones can use the camera to identify objects and via GPS, the location and inform the visually impaired people with a voice message. One of the needs of man in the 21st century is to 'save' the favorite moments and beautiful places in photos. For this reason, an attempt was made to design an original function of the mobile phones that used the 'TalkBack' screen reading software [12].

Khetarpal presented in his study some applications that can be helpful for visually impaired people [13]. The MOCR software is a visual character recognition application that allows blind users to take a picture of a text and then the application can read the text aloud to them. BrailleLearn offers games that encourage the learning of Braille to blind children. Another application that was presented in the study was LocalEyes, which uses Google maps and GPS to help visually impaired people when they do not know what is around them. Just with the use of a phone, the blind user knows which shops are on his left or how far he is from a restaurant [13]. Assistive technologies, such as audio texts, can be used in visually impaired students to support their reading skills. Also useful are the tools to change the page, course material printed in Braille, magnifiers, and screen reader software [14]. Also, the Optical Braille Recognition (OBR) software allows visually impaired users to scan a Braille document which is then parsed, translated into text, and displayed on a computer screen [15].

Fujiyoshi *et al.* presented in 2010 an evaluation system with a digital audio player for the recently blind users who have difficulty with Braille [16]. Through this system, they have the opportunity to take part in the national exams for admission to University. Additionally, Choi and Walker developed the Digitizer Audory Graph, which is a software tool that allows visually impaired users to take a picture of a graph through an optical input device, such as a webcam, and then listen to an audio graph of the digitized image [16].

Learning a foreign language is an essential part of all levels of the education system in modern society. However, a common foreign language course may not be appropriate for a visually impaired person. Malinovská and Ludíková researched to see if new technologies can help visually impaired people learn a foreign language [17]. The study involved four visually impaired people aged 35 to 55 years old. For writing and reading all participants used a desktop computer with specialized software (ZoomText, Jaws, etc.), and an mp3 player or mobile phones for listening to books. According to the research results, teaching foreign languages to visually impaired adults is a very important issue that needs to be addressed. Whereas in the past blind people needed a Picht or Braille machine, today both are being replaced by computers, mobile phones, special compensating devices, and related software. On the one hand, these technological changes provide a larger and more stable platform for the integration of visually impaired people. On the other hand, language teachers often lack adequate methodology as well as knowledge of the capabilities of these individuals [17].

Visually impaired people have many limitations, including the freedom to shop independently. They find it difficult to read ingredients or nutritional information that is usually found in small print on products. This information is considered important for the final decision to purchase the product. Shopping Assistant is a mobile application developed to make life easier for visually impaired people. This application is designed to help identify products without the need for the individual to read the information on the packaging while shopping [18]. The camera of the phone scans the barcode of the product and the product description is displayed based on the barcode ID retrieved from the database server. This application provides, also, proposals for similar products.

Blowmick and Hazarika mention in their study several assistive technologies that assist the visually impaired [19]. For example, they mention augmented reality glasses and artificial intelligence lenses. Also, they present the assistive device BrainPortV100, which aids the visually impaired to see with their tongue. Additionally, Eye Music is a device that converts visual information into audio. Another Kinect software is NAVI which helps people to move. Lastly, Blowmick and Hazarika mention Braille e-book readers and a 3D smartphone that detects the barriers [19].

Nicolau *et al.* developed an assistive application that helps users interact with technological environments such as cooking devices [20]. Another similar application is called INHOME, which allows remote control of home appliances and provides messages regarding their condition. For example, when the washing machine is finished, a message appears on the screen accompanied by a sound [20]. At the same time, Sanchez and Torres developed a mobile phone-based system that uses a combination of incoming and outgoing audio and GPS technology to make it easier for visually impaired people to move around in familiar and unfamiliar environments [19]. The ABBI (Audio Bracelet for Blind Interaction) technology aims to improve spatial skills, mobility, and social interaction of visually impaired children and adults. Specifically, the ABBI bracelet provides spatial information about body movements, orientation, posture, and movement orientation mechanisms [4]. Interactive video games can be more pleasant, more interesting and, therefore, more effective than traditional interventions to enhance motor skills.

Another problem faced by visually impaired people is their mobility and autonomy in public transport. The RAMPE system is designed to assist these people when traveling by bus or tram. With this system, they can receive real-time information on public transport [21]. In addition, SmartVision is a navigation system created to enhance the mobility of the blind. SmartVision essentially complements the cane as it detects the obstacles that the cane hasn't touched yet [22]. As mentioned above, visually impaired people need help to feel safe while walking outdoors. Nada, Fakhr & Seddik report that a special stick has been made with low weight and cost, easy to use, and consumes little energy [23]. It includes sensors that recognize obstacles within two meters and audible message alerts. The alerts vary depending on the distance of the person from the obstacle and are accompanied by different volume sounds. The advantage of this 'smart' device is that it can recognize obstacles at low heights, such as stairs or objects on the floor. Thus, it is highlighted that technology helps the daily life of these people and allows them to live equally in society.

In addition to research related to exploring outdoors and avoiding obstacles for visually impaired people, technologies have been designed to help with the identification of objects. An application was designed that is supported by a portable device, is placed on the chest, and helps the visually impaired person to navigate indoors, avoid obstacles and identify objects around them using a camera and laser sensors [24].

II Hearing Impairment and Deafness

Deaf and hard of hearing people communicate using sign language so they face many communication difficulties around the world. As the vast majority of people do not know sign language, the need for a sign language translator has increased significantly. Drigas *et al.* presented in 2005 a Learning System designed for the deaf and hard of hearing [25]. This original system offers videos in Greek sign language corresponding to all texts in the learning environment. Students for the first time had the opportunity to learn in their language, the Greek sign language. Also, in 2008 Drigas *et al.* presented the program "Daedalus" which teaches English as a second language to the deaf [25].

Also, for the deaf and hard of hearing students, accessible digital educational tools were developed in Greece that include all the books of the first two grades of Elementary School in written and oral Greek Sign Language, as well as special educational materials for the readiness to use sign language as a first language in kindergarten and the first two grades of primary school. Specifically, the creation of electronic and printed educational materials included the basic vocabulary of Greek semantics and basic phrases for its teaching in kindergarten [26].

The platform tuniSigner offers ICT-based applications and promotes the learning of sign language [27]. ICTs, according to research, have the potential to improve phonological awareness skills in children with hearing problems. Specifically, the ARTUR program helps children with hearing problems to practice their pronunciation. Its main advantage is the provision of feedback through clear instructions to improve the articulation. Also, Nasiri *et al.* developed a game in which children learn the words they are expected to know by the age of 7 [28]. The game includes an avatar controlled by the child's voice commands. During the game, an object appears on the screen. The avatar collides with this object, the sound of the object is heard and this sound is repeated by the child. SmartSignPlay is an interactive mobile application. The application supports the learning and practice of American Sign Language by using an animated avatar [29].

Any software tool that helps people practice reading finger gestures must be natural enough to represent the fluidity of that gesture, while at the same time being flexible enough to write any word in the target language in any order. To address these needs, a new mobile app called "Fingerspelling Tutor" was presented. Toro *et al.* introduced the Fingerspelling Tutor application, which uses a 3D character that displays spelling [29]. The application includes quizzes and tutorials that allow the user to type words that the 3D character can spell. At the same time, it connects to social media and creates a virtual community with people with hearing problems. Hearing-impaired people experience intense stress when they try to communicate and interact with another person as they try to maintain conversation and eye contact. Mobile phone applications have been designed to meet the needs of hearing-impaired people and reduce the levels of anxiety, isolation, and frustration [30]. Such applications are: "Say it with Sign", 'Glide', "Visual hear" and "Let Me Hear", which are easy to use, accessible and provide real-time communication. With the use of these applications, the stress levels of the hearing impaired are reduced but at the same time, their data are protected [30].

Based on the above, Muljono *et al.* designed the web application 'BacaBicara', which is based on non-verbal communication, in videos and images that teach lip-reading, trying to combine educational materials with entertainment [31]. The target of the application was that the user learns to recognize and understand syllables, words, and grammatical phenomena when at the same time his communication skills are developed. The final goal was the reduction of the stress for interaction with the social environment. Leap Motion technology can be used to improve communication between deaf and hearing people in Saudi Arabia. Al-Nafjan *et al.* explored the possibility of using a Leap Motion system to provide continuous recognition of ArSL (Arabic sign language) for two-way communication, to improve communication between deaf and hearing, in terms of speed and independence [32]. The system translates ArSL into spoken words for hearing people and translates spoken Arabic into text for deaf people [32].

Nowadays, augmented reality is being expanded and used widely. It has many possibilities as an educational aid in complementing and improving communication, as deaf people do not have the physical ability to share their thoughts aloud. So, there is a desperate need for cost-effective devices that could turn the languages of the hearing into gestures using 3D animated hand movements to create independent learning and communication capabilities for the deaf. The study by Suman Deb and Bhattacharya aimed at creating an AR (Augmented Reality) application that will be used on mobile phones and have 3D gestures [33]. When the camera focuses on a media card, the letter highlighted on the card will be detected by the application and a moving 3D hand will replace the letter with a gesture. The motion for the corresponding letter will be displayed in real-time. The experimental results of the study showed a significant improvement in the sign language learning of deaf students. The initial hypothesis of augmented learning is essentially achieved in this project and can be further extended to cover a wider variety of teaching-learning scenarios [33].

In 2015, Noor Tubaiz *et al.* proposed a glove recognition system of Arabic sign language, using a technique for sequential data classification [34]. They compiled a data set based on a 40-sentence sensor using an 80-word dictionary. Data marking is performed using a camera to synchronize hand movements with their corresponding meaning in sign language. In 2014, Tushar Chouhan, AnkitPanse, Anvesh Kumar Voona and S. M. Sameer designed and implemented a low-cost wired interactive glove with a high degree of accuracy for gesture recognition [35]. The glove maps the orientation of the hand and fingers with the help of sensors and an accelerometer. The data is then transmitted to a computer using automatic repetition as an error checking scheme. They managed to achieve a high degree of accuracy (96%) for recognizing hand gestures by using smart gloves.

N. Sriram and M. Nithiyanandham designed a smart glove and a software application based on ASL (American Sign Language) [36]. The gesture recognition was done with the help of a glove consisted of 5 accelerometer sensors, a microcontroller, and a Bluetooth chip that were placed on the fingers and not all over the hand. Regarding the software, they developed an android application called Talking gestures, which was more direct and easier to use for speech synthesis. Nikhita Praveen *et al.* proposed in their study another approach using a smart glove [37]. The technology created detected the gesture on each finger and connected the analog voltage to the microcontroller. The microcontroller converted these analog voltages into digital samples and the information was transmitted wirelessly.

ICTs in Physical Disabilities

Students with motor skills problems may need a larger keyboard. For users with severe motor impairment, keyboard simulation, including scanning and entering Morse code, can be used with special switches controlled by at least one muscle the person controls, such as the head, finger, knee, or mouth [15]. Chin *et al.* introduced in 2008, a control system through electromyography and eye monitoring for people with mobility disabilities [16]. This system was designed for users who cannot use their hands due to spinal dysfunction or other ailments [16].

According to Borgestig *et al.*, gaze-based AT technology has the potential to provide children with severe mobility difficulties, with the opportunity to communicate as some of these children are deprived of speech [38]. These children have no control over their body movements and are dependent on others for all activities, including communication, eating, and playing. Eye movements may be the only ones they can control voluntarily. For this reason, assistive technology (AT) based on a computer-controlled by the eyes may be the only option for people with severe mobility problems to use a computer. Thus, using only their eyes, children can control the computer and access various activities such as games and music [38].

Gaze-based computers can play an important role in communication and participation in everyday life and society. Introducing this technology at home and school can enable the child to communicate, express their wishes, receive school support, and participate more in social activities [39]. Writing skills require specific cognitive skills as well as certain physical skills. Various supporting technologies are: i) portable talking dictionaries, ii) portable word processors, iii) computers with accessibility features, iv) computers with word processing software, v) alternative keyboards, vi) word prediction computers and vii) computers with word processing voice recognition software [14]. 'EyeDraw' software allows people with mobility problems to paint with their eyes [16].

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Robots can be a helpful tool for children with physical disabilities. For example, LEGO Mindstorms facilitates play and learning activities while the PlayRob system successfully helps children with physical disabilities play with LEGO. Also, the IROMEC robot had positive effects on the achievement of individual therapy but also the fulfillment of educational goals. However, all the robots mentioned above have only been used in studies and are not available for purchase [40]. In contrast, the ZORA robot is commercially available and includes many features suitable to support recovery, play, and training goals. ZORA is a humanoid robot that was originally developed as a NAO robot. His height is 58 cm and he has seven senses for physical interaction: movement, sensation, hearing, speech, sight, connection, and thought. Programmed scenarios can be used to enable the robot to dance or interact with the user [40].

The Multimodal Tongue Drive System (mTDS) is a wireless support technology in the form of a handset that uses three communication skills of people with severe mobility impairments to access computers. The first is the movement of the tongue as a switch (clicks), the second is the monitoring of the head (mouse pointer movements) and the third is the recognition of speech for typing [41]. Sahadat *et al.* presented in their research an mTDS in the form of a headset and multiple sensors, capable of capturing the movements of the tongue, head, and speech and providing the user with multiple inputs at the same time [41]. The main contribution of this research is to provide exclusive, simultaneous, and accessible inputs to people with severe mobility disabilities to control their daily devices such as the computer, the mobile phones, and the wheelchair.

López Sánchez *et al.* report that there are electronic systems that help people with speech problems communicate with people around them [42]. These are: i) The 'Verbo' software that adapts to special keyboards or screens and the user uses pictograms to visualize his message to others, ii) The 'IRISBOND' system, used by people suffering from paraplegia or injury spinal cord and other similar diseases, with the help of which they can structure sentences with a virtual keyboard., iii) The 'AraBoard' which offers the creation, processing and use of communication tables for different electronic devices where the user selects pictograms to write his message, iv) The 'Eyescan' project which introduces a 'mouse' computer that is visually controlled so that users suffering from quadriplegia can communicate [42].

Lastly, it is worth mentioning a case study of a Scottish girl with cerebral palsy [8]. Kim was using a wheelchair, could not draw, turn the pages of the books and she also suffered from dysarthria. Her oral speech was not understood by people who did not know her. For the above reasons, the use of ICTs was necessary so that Kim can access the educational process and receive the necessary knowledge. Kim's case is one of many that exist worldwide [8]. As a result, we conclude that without the use of ICTs equal opportunities in education would not be provided to people with disabilities.

Discussion and Conclusion

The study discusses that with the impressive advances in Information and Communication Technologies (ICTs), the learning technologies are transforming and modifying the educational systems. Moreover, when these technologies are available, accessible, usable, and affordable, they represent real opportunities with access to inclusive education and help to overcome the barriers that exist in traditional education systems. Disability is not incapability. A disability is a real disability only when it prevents one from doing what he wants. It is necessary not to think of students with disabilities as passive recipients of diagnoses and services, but instead recognize their potential and support them to achieve their goals. It is necessary to adopt similar policies by European countries that will enhance the use of ICTs and will face the obstacles that arise. However, financial support is needed for the acquisition of appropriate knowledge and training for families and teachers and the updating of the school unit.

In conclusion, without the use of ICTs, people with sensory and physical disabilities would not participate equally in society nor have the same opportunities as people without disabilities. ICTs provide a model that allows people with disabilities to be included socially and economically in their communities through access to information, knowledge, and educational processes. It is important to note that appropriate ICTs should be used according to the personal needs of each individual. Therefore, assistive technology serves to bridge the gap, helping to educate children in the same class, including children with sensory and physical disabilities, helping them to learn the material in a way that they understand, and eliminating the obstacles they had. It is important, though, that assistive technologies are suitable for their users and their environment, low cost, and easy to buy and use so that they can easily be included in the educational process. The conclusion is consistent with the finding that ICTs improve the quality of life of people with disabilities, reduce social exclusion, and strengthen their participation in the social ensemble. Lastly, ICTs help to achieve the final goal which is equal access in society and higher levels of intelligence and consciousness. Thus, there is a great need for the inclusion of ICTs in the educational process.

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