(REVIEW ARTICLE)

ICTs in education for Deaf and Hard-Of-Hearing learners

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Abstract

This study is a literature review which focuses on the educational needs for the deaf and DHH and the various environments that are available for them, based on ICTs. Most of the reviewed articles are quantitative researches (Survey Research, Experimental Research Design), focused on the effectiveness and the design of the applications and programs that contribute to the communication, as well as the education of deaf and DHH students. Other articles that were studied are literature reviews addressing the educational needs, ICT based tools, as well as suggesting necessary future improvements for this educational approach.

Keywords: Disabled; Deaf; Hearing Disabilities; Digital Technologies; Inclusion

1. Introduction

Deaf and Hard-of-Hearing (DHH) kids are frequently enrolled in oral programs in mainstream schools, which do not adequately address their educational, social, or emotional requirements. Instead deny them the right to participate in supportive learning environments, such as those that allow for visual access to education (Constantinou et al., 2018). Moreover, classes rely on spoken information and communication, so sign language is typically not an option in mainstream classrooms. This demonstrates that is difficult for instructors and other peers to understand as well as communicate with Deaf and Hard-of-Hearing students (DeWitt et al., 2015).

Even when a sign language expert is present in the regular classroom, he/she is frequently not a teacher and might not be able to accurately translate the instructor's lectures for the student, leading to yet another instance of poor communication (Hyde et al., 2009). Because verbal contact between students and their instructor is the most crucial component of typical classroom, many Deaf and Hard-of-Hear students miss out the chance to learn. For students with hearing loss, there is a need for educational institutions that effectively utilize visual learning equipment, adaptive devices such FM systems, and speech-to-text transcription (Constantinou et al., 2018).

In addition, more of these kids are attending mainstream schools thanks to advancements in universal screening and sensory assistance technologies (such cochlear implants) (Kelman & Branco, 2009). It is crucial to concentrate on the abilities needed by the teachers and staff, such as adaptability, technology changes, and ongoing professional development, to meet the children's educational and emotional needs while also providing an environment that meets their psycho-social requirements. It will be difficult to provide services that are tailored to each child's requirements and take into consideration their skills, aspirations, and attitudes (De Raeve, 2010). However, it is also important to consider the unique demands of deaf students and offer flexibility in satisfying those needs (Constantinou et al., 2018).

An additional study of Drigas et al. (2009), which looked at the reasons why deaf individuals use the internet, was carried out by creating and distributing an online questionnaire to the members of two deaf organizations in Athens. The focus of this project is understanding the needs and preferences of the deaf community with regard to the

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informational and communicational capabilities of new technologies, as well as whether these capabilities support the active social and economic participation of those who have hearing loss.

The goal of the aforementioned study (Drigas et al., 2009), is to clarify that the usage of the internet has substantially enhanced deaf people's ability to inform themselves and communicate. Greater social engagement results from improved communication since it is easier to influence social change while communicating with others. Better knowledge, on the other hand, refers to a greater understanding of the environment, concepts, values, and societal orientation. The internet's extensions and applications, which provide an open framework for communication, enable deaf people to make clear contact with all potential listeners, whether they are deaf or not. This effectively ends the social isolation and exclusion of deaf people from social life and activities.

2. The inclusion of ICTs in the educational approaches for the deaf and hard-of-hearing

In the past years, the social inclusion of individuals with disabilities has been a popular topic, and an increasing database of studies suggests ICTs offer the deaf new opportunities (Glaser and Tucker, 2004).Deaf and hard of hearing people's inclusion and engagement in society can be improved by using ICTs, according to a variety of researchers (Drigas et al., 2004; Drigas et al., 2005; Drigas et al., 2006; Barak& Sadovsky, 2008;Power& Power, 2009 Drigas et al., 2010).

According to Zaharudin et al. (2011) their research findings demonstrated that Deaf students have no difficulty interconnecting with computer-based learning materials. Deaf Students don't think twice to participate when there is a misunderstanding. Most educators accept that ICT courses supplied to deaf students are extremely adaptable to them.

The use of video technologies can greatly improve communication between Deaf individuals whose primary language is sign language. The selection of the technically complex video in the e-learning system is crucial. It is necessary to have a way for evaluating a system's utility when choosing or creating sign language communication systems. For deaf individuals, enhanced connectivity via video offers many advantages.

Learning games should be designed in a way to convert auditory inputs in a deaf-friendly visual modality, to make learning games accessible for DHH users. The incorporation of written text and sign language translation into the game design are two potential options that may be helpful to overcome language and communication obstacles (Westin et al., 2022).

Despite some difficulties, Augmented reality (AR) games offer positive changes in the educational field, with various sign languages for DHH children. Studies regarding AR-based educational games for DHH and particularly deaf children, seem to be lacking in current research or are less investigated, compared to studies about AR games for learning and for DHH individuals in general (Westin et al., 2022).

3. E-learning and teleeducation

E-learning tools can be used to create a distance and life-long training environment for deaf persons in the e-commerce and new technologies industry. Thereby, e-learning tools can encourage Deaf people's equal rights to access and participation in professional training. They can also provide them with a pathway into the new professional domains through their training in specific knowledge and skill sets related to the usage of the rapidly evolving e-learning and e-commerce industries (Drigas et al.,2004). E-learning also enables the "anytime-anyplace" learning environment for deaf students as they can access tutorials, notes, slides, and other materials at their own pace (Zaharudin et al., 2011)

The term "Education 2.0" refers to the changes that technology has made to the educational landscape, using Web 2.0 tools (Alexander,2006). The use of Web 2.0 tools promotes the growth of new competencies among students as well as more collaborative and creative learning and scaffolding. Online mind maps, which can also be used in synchronous collaboration, are one example of an ICT application that implements learning theories and didactical models for e-learning. As new e-learning trends have evolved in the era of e-learning 2.0, courses are primarily delivered through learning management systems, including the usage of social networks, wikis, and blogs (Carr et al., 2008).

Another online course for teaching foreign languages to deaf people whose first language is sign language was created and developed by Drigas et al. (2010). The course is focused on online readings, video broadcasts, and web 2.0 applications including social networking and blogs. The course, which was created specifically for deaf people, explores the opportunities that e-learning, vodcasting, and web 2.0 tools can provide to improve the learning process and produce more useful learning outcomes.

Weblogs are being used in teaching and learning by an increasing number of educationalists. The usage of blogs improves learning since it enables it to begin when the students begin actively participating and collaborating for a common goal. Blogs have proven to be a flexible and valuable medium that improves social and academic skills development (Seely Brown and Adler 2008).

Teachers regularly use also social networks in the classroom as they encourage students to express their own ideas, facilitates better communication and teamwork, improves the learning experiences of students, and creates an online learning community. Thus, with the rise of social networking as a significant trend in education, the phrase "educational networking" was established (Anderson,2007; Dalsgaard, 2008)

4. Technology-related programs and activities

Because information is largely presented visually and less audibly in this situation, the Internet and its services significantly lessen the gap between hearing individuals and hard of hearing people (Swain and French, 2004). A hard of hearing individual may access the same depth and variety of information as a hearing person. The most extensive and well-known internet service is the World Wide Web. It is a multimedia service that acts as a built-in foundation for other internet services. (Sanger, 2006).

Drigas et al. (2005) found helpful information about creating accessible HTML sites for the Deaf and hard of hearing on the World Wide Web Consortium (W3C) website. These include:

Synchronized equivalent alternatives with presentations for any time-based multimedia presentation.

Any type of multimedia, whether a movie, animation, or slide show, can be used in a time-based presentation.

Captions, which provide users access to audio tracks, and audio descriptions, which give users access to visual tracks, are equivalent substitutes for these presentations.

It has already been stated that any audio or video track must have a text transcript, as well as a text description of the video track. It is generally acknowledged that on-screen captioning enables Deaf and hard-of-hearing people to enjoy a movie or multimedia production more fully. It must be acknowledged, nevertheless, that a text transcript by itself is not the best way to give people with disabilities an inclusive experience. An after-the-fact separate written transcript does not offer the same kind of experience (Chuck and Geoff, 2000).

4.1. Neural sign reenactor

In order to transfer the body motions, head attitude, and facial expressions of a source actor in a driving video to a target subject in a reference video, Tze et al. (2022) introduced Neural Sign Reenactor, a revolutionary neural rendering pipeline. They have utilized it in the complex situation of sign language videos. Their approach consistently transfers manual and non-manual signals from a source signer to a target signer and is effective among signers of different genders and body types, according to thorough qualitative and quantitative tests. It also generates more realistic and natural appearing outcomes in comparison to prior methods of human motion retargeting that drastically alter the appearance of the target subject. Their work opens the door for the creation of unique sign language production systems that go beyond avatars and create photo-realistic continuous sign language films, enhancing user attractiveness and engagement.

4.2. "DELFE" PROJECT

The learning system (LS) presented in Drigas et al. research (2005) provides Greek Sign Language films that correlate to each text in the learning environment. The system is specifically created for deaf adults in order to support their ongoing vocational and academic training. The LS meets the unique learning demands of Deaf students, including bilingual material (in text and sign language), high levels of visualization, interactive and exploratory learning, and the possibility of peer learning via video conferencing. Greek signers are able to study in their own language—the sign language—for the first time in this setting. In order to meet the aforementioned situation, the LS is customized to the unique learning challenges of the target audience, which consists of deaf teenagers and young adults.

The information offered is bilingual. The use of sign language in the classroom has been demonstrated to dramatically increase reading proficiency in bilingual (spoken and signed language) studies in deaf and hearing-impaired schools.The primary goal of this e-learning environment is to facilitate Deaf people's equal rights to access and actual participation in vocational and educational training.

4.3. "DEDALOS" PROJECT

The primary goal of this project of Drigas et al. (2006) is to encourage Deaf people to learn English as a second language. They have developed a pedagogic technique for remote linguistic training as well as cutting-edge instructional materials that are suitably fitted to the specific team. The entire procedure has been planned and consists of audits and evaluations of the e-student's linguistic abilities. The educational materials have been divided into levels based on the student's prior knowledge. Using an intelligent taxonomy system, the system is intended to evaluate the student and arrange the instructional content at the appropriate level.Quality and creativity of the self-paced learning educational materials, which make extensive use of modern technologies such as animation and digital video into the Sign Language of each partner, have been given special consideration in the design.

4.4. "THETOS" PROJECT

In Poland, THETOS is utilized in medical settings where staff members enter questions. The system then analyzes the questions and determines what animation should be made to convey the same information in Polish Sign Language. A word doesn't necessarily have a "matching sign"; instead, it contains qualities that, when combined, produce a sign. (Suszczanska, 2002).

4.5. "SIGNGUIDE" PROJECT

The main objective of this project (Kosmopoulos et al., 2022) is to create a prototype interactive museum guide system using mobile devices for deaf visitors that will be able to answer questions about the exhibits in the visitors' native language (sign language) and provide additional content in sign language using an avatar or video using methods from the fields of computer vision and machine learning. This study aims to implement and experiment with real users. There are several difficulties to overcome, the most prominent ones being the modeling, translation, and rendering of the continuous SL into an avatar in real-time.

4.6. AR-GAMES

In the twenty-first century, games and game-based learning have developed quickly and widely. Digital games are enticing a sizable portion of the public thanks to the combination of the two categories of intense games and casual games (Juul, 2012). Nevertheless, accessibility for deaf and hard-of-hearing (DHH) individuals remains one of the major obstacles to full inclusion in modern society (Costello et al., 2019). Game designers should try to communicate the content of auditory data in a deaf-friendly visual modality in order to make learning games accessible for DHH users. The incorporation of written text and sign language translation into the game design are two potential options that may be helpful to overcome language and communication obstacles. They can both be experienced through an intact sensory modality, namely sight, and do not reliant on the audio modality, making them both accessible to DHH patients (Westin et al., 2022).

In educational settings with various sign languages for DHH children, augmented reality (AR) games offer chances for developing happy learning. Particularly, the technology known as augmented reality (AR) overlays virtual items on real-world things (Akçayır, 2017). Real-time connection, 3D registration, and the blending of the physical and digital world are its three key characteristics (Azuma, 1997). The application of augmented reality in education might increase student engagement and learning effectiveness (Lee, 2008). The term augmented reality (AR) games describe digital games which can be played in a real-world setting while also adding a virtual overlay to it (Squire and Jan, 2007). It is feasible for gamers to engage with both digital things and real-life people, preventing social isolation (Offermans and Hu, 2013).

Recent research has investigated augmented reality for DHH sufferers for a variety of reasons. Quintero et al. (2019) proposed a way for co-creating AR material utilizing principles for universal design learning. They also did a systematic review of AR for inclusive education, containing several papers regarding DHH. This essay especially addresses AR studies for DHH individuals. Parton et al. (2010) conducted a pioneering study on mobile AR for DHH individuals combining 2D barcodes and teacher-produced YouTube videos to build an accessible and workable AR-based learning environment on early cellphones. Earlier study was done by Zainuddin et al. (2010) who created an alternate language AR book for education. The book's content, which was written in Bahasa Malaysia and English, was supplemented by AR videos of sign language and 3D models for illustration.

A mobile AR software developed by Al-Megren and Almutairi (2018) that maps written words to associated signs for learning ArSL has been demonstrated to be more successful than conventional teaching methods that use ArSL, visuals, and fingerspelling. Using a cheap pair of AR glasses, Ridha and Shehieb (2021) developed a system with real-time transcription, voice emotion detection, sound indication features, and classroom assistance capabilities. For usage in

schools, Luo et al. (2022) developed Avatar Interpreter, a real-time sign language interpretation visualization application for head-mounted AR.

Augmented reality (AR) is more intriguing and engaging than traditional learning, particularly when it comes to games. The learning mechanics of augmented reality games include group problem-solving activities, competitiveness, and sharing of experiences, not only between students but also between students and teachers (Li et.al., 2017).

The educational program CopyCat enables deaf children to interact with the computer using ASL and motivates them to practice signing in a fun manner. The child is instructed to wear colored gloves with wrist-mounted accelerometers and place themselves in front of the computer that has a video camera for computer vision recognition system" (Lee et al., 2005). In initial testing, kids quickly figured out when to press the "attention button" to make the computer begin to observe them sign, and the wireless accelerometers didn't bother them.

5. Applications

Enhancing deaf people's access to communication can raise their educational attainment and professional performance while also boosting their independence and self-assurance in carrying out daily duties. A small number of studies have looked at deaf people's communication problems and offered advice to those creating mobile apps. Deaf persons can use smartphones to communicate with those around them(Alnfiai et. al., 2018). Some modern communication applications are presented below:

5.1. ROGERVOICE

The world's first mobile app, RogerVoice, translates mobile voice calls into a significantly more accessible form of text in order to provide subtitles for phone conversations. Olivier Jeannel, a deaf engineer, created it. The program converts voice to text using speech recognition technology so that hearing impaired persons may read what the other person is saying. The program was developed as a result of a successful Kickstarter campaign; a beta version of the program is presently accessible and is possible downloaded via the RogerVoice website (Koshtura et.al., 2021).

5.2. LIVE TRANSCRIBE

The program reads spoken words and converts them into text. The program accomplishes this using a smartphone microphone and Google's language API, which supports more than 70 different languages. Making sure the recording is as error-free as possible is the responsibility of machine learning technology. However, Live Transcribe can not only decode the voice, but it can also alert the user that someone is trying to speak to him. It also enables you to take part in the conversation immediately by responding with the built-in keyboard. The Android phone's microphone picks up the spoken text, which is then sent to the device's screen through Wi-Fi or another network connection. When attending conferences or seminars, for instance, this may be helpful for those who cannot hear. The individual who possesses the applications' phones will display spoken words (Koshtura et. al., 2021).

5.3. MYEAR

Gerald Isobe, a deaf golfer, and his son Brandon created the MyEar app. Gerald learned to read lips as a young child but was frustrated that he could only comprehend 30% of what he said. This tool, which he and others use to interact with their hearing coworkers, friends, and family, was developed in response to these problems. The MyEar app records and interprets anything someone says. It is also suitable to be used in emergency situations (Koshtura et. al., 2021).

5.4. AVA

One of the key motivations behind the creation of AVA was the fact that lip reading might be more challenging among a group of individuals. If a deaf or hearing-impaired person is with a group of friends, he or she can persuade those people to sign up for the service so that the deaf or hearing-impaired person can watch the live broadcast of the group chat.The phone's microphone picks up the language, and before someone starts speaking, their name is shown on the screen. Employers, educators, event planners, and other accessibility specialists who want to fully involve with deaf and hard-of-hearing people can partner with AVA. With Ava, deaf and DHH people have a completely new degree of autonomy in many areas of everyday life.

5.5. VOXSCI

A voicemail-to-text tool called Voxsci turns voicemails into texts and emails that you can keep, search for, and share. Voicemails may be extremely difficult for listening to. By turning voicemail into text, VoxSciences offers a paradigm

improvement. With all the advantages that come with it, including texture search, audio communications now have a significant advantage over email, SMS, and instant messaging.

Voice transmissions are converted into text messages using the VERBS engine (virtual engine for basic language recognition), which then sends the text messages through email, SMS, or API. Voicemail to Text (SMS) solutions are perfect for home or business use. Call centers, comment or contest lines, and business voicemail systems are the major users of audio messages that are transcribed and sent through email.

A market research method called "The Client's Voice" offers a complete list of desires and client needs. It involves feedback analysis from a range of sources, including email surveys, the Internet, and IVR. VoxSciences offers an important service that makes it easier to analyze audio feedback for research by offering virtually real-time transcription of transcripts for the business class (Koshtura et. al., 2021).

6. Teachers' perspective

Having already mentioned in detail the necessity of access and implementation of ICT in curriculum of children with hearing disability, we should also highlight the imperative need for training teachers in use of assistive technologies in teaching deaf students. Many nations around the world have endorsed the use of Information and Communication Technologies (ICT) in the instruction of deaf students in the classroom. ICT and the mastery of key skills and concepts are understood and values in the educational "reality" as being equally important to reading, writing, and math proficiency (Keirungi, 2021). According to Ouma, Awuor and Kyambo (2013), many deaf students must be familiar with and proficient in ICT in order to participate in and benefit from educational programs.

Regarding a study carried out in Kabale, the capital of Ugannda, various information is provided regarding the investigation of teachers' perceptions of the use of ICTs in teaching deaf students (Keirungi, 2021). The main purpose is to find out teachers' views about the use of ICT in deaf education, as well as the role of ICT in teaching deaf students along with the challenges teachers face when their educating programs are based on using technology methods. This led to the emergence of two entirely different viewpoints, according to which some teachers believe that ICT is a useful tool for instructing and communicating with students who have hearing impairments, while others believe that it is challenging to use and requires a lot of application time. However, deaf students are more likely to succeed in their educational program if they have access to the right ICT method (Keirungi, 2021).

Hameed (2009) reported that excellent learning opportunities are created for deaf students when they use visual forms which are less dependent on written language. ICT speeds up learning in many different ways. To prevent the child from falling behing other children in language development or acquisition, this interaction must be made sure of at a young age. Adequate computer labs and ICT equipment are important components in the use of ICT at schools for deaf. This will guarantee that teachers always have simple access to technology tools (Hennesy, Ruthven and Brindley, 2005). Turel and Johnson (2012) state that technical problems become a significant obstacle for teachers.

According to a survey conducted in all schools in Malaysia, including Sabah and Sarawak, where digital tools are used for teaching hearing –impaired children, it was found out that almost 90% of teachers concur that deaf students should take ICT lessons, compared to around 10% who disagree with this state (Nordin et al., 2015). Teachers recognized that their deaf students have great talent and knowledge, but due to a lack of computer equipment and busy schedule, they were not provided with ICT techniques. Since most schools don't computer classes or courses, the majority of teachers claimed that although students are very interested in computers, they haven't had the chance to use the most recent ICT technologies. It was enthusiastically supported by the teachers, who participated in this study that computer courses including visual media aids such as graphics, graphs and tables are crucial for individuals with hearing impairments. This is primarily due to teachers' beliefs that ICT courses supported by multimedia, attractive animations, and drawings, are more suitable for deaf students because they grab their attention visually more than plain, black and white lessons without visual media (Nordin et al., 2015).

Keirungi (2021) conducted a study to investigate teachers' perceptions of the use of ICT in teaching and learning process in the classroom of deaf students in Uganda in two Special Schools for Deaf in Kampala city. He tried to raise teachers' awareness of the value of ICT in teaching deaf students, serve as a source for other researchers looking to understand how ICT is used in classroom instruction, and inform implementers to compel teachers to use technology to improve learning process in deaf students (Keirungi, 2021). As a result, effective integration of ICTs depends on the perspectives of teachers and the leadership of the school. Older teachers in Kampala, who are accustomed to using traditional teaching techniques, do not want to switch to modern techniques. They are forced to using teaching-centered

approaches and face-to-face instructions, which give them a sense of authority in front of the students (Tedla, 2012; Makgato, 2012).

The main challenge is that teachers may not be able to use ICT effectively at the initial stage of lesson planning, neither to design interesting and attractive teaching strategies to guide deaf students to computer classes, which prevents them from actively participating in, discovering and learning about ICT (Keirungi, 2021).Positively, there is interest in flipped classroom models, which involve using computers and internet-based technologies in place of the traditional classroom (Amal, 2019). To improve learning opportunities and involve deaf students in the classroom, educators continually investigate new teaching strategies and styles (Zainuddin and Halili, 2016; Mehring and Leis, 2017).

Technology and communication strategies are clearly needed, and 21st century teachers need a set of specialized knowledge and abilities to use ICT in the classroom. According to several studies Mazlan, 2011; Mich, Pianta, & Mana, 2013 ICT should be taken into account to support hearing-impaired students learning. But teachers still don't use ICT (Chong and Shaffe, 2015). The teachers' knowledge and digital proficiency are crucial for maximizing the benefits of any technology initiatives. There was no predetermined framework for integrating technology into the curriculum previously, leaving educators uncertain about ICT and the pedagogy with which to incorporate it. To this end, a theoretical framework for integrating technology, pedagogy and content knowledge known as "TPACK" was created to instruct teachers in the development of ICT in schools (Amal, 2019).

7. Challenges and barriers

Learning ICT is vital to the development of deaf students, while ICT education (e-learning) enables them to diversify their learning preferences (Nordin et al., 2013). It is crucial that all people, especially deaf students, have access to these virtual learning environments and other educational technologies used in e-learning techniques.

According to Nordin et al. (2015) research, the challenges and obstacles faced by deaf students and teachers in the use of ICT in the education programs, are presented. They referred that communication between people with severe hearing problems and people with normal hearing can be very difficult. Most of the time, interpreters are rarely available outside of the classroom. Since the video for an online instruction on cooperation, communication and dissemination of information, the subtitles and video image of spoken text translation into sign language must be of suitable quality. Additionally, ICT (Information Communication Technology), which acts as a tool to modernize education system for deaf students, has the chance to enable new teaching and learning practices.

In the analysis of the research, only 7 schools in Malaysia provide ICT courses for hearing-impaired students (Nordin et al., 2015). The 17 other schools that do not offer ICT classes to students with hearing problems, have expressed their resentment and frustration over the fact that their students are not receiving an education in this field even though their students are really interested in it (Nordin et al., 2015).

In addition, visual display is crucial for deaf students, as only visual methods can help deaf students understand a particular task (Nordin et al., 2013).However, some of the barriers revealed, were: insufficient electronic devices, fear of using ICTs, lack of interest in learning ICT skills. A challenge in schools was also poor service delivery, inadequate budgeting for ICT maintenance and improper maintenance while also limited internet connectivity (Bingimlas, 2009). Internet access and inadequate ICT resources are the most major issues that schools for deaf students must deal with. But as already stated in the survey of Keirungi (2021), deaf schools in Uganda and whole Africa are not provided with many computers and ICT tools in classrooms to held deaf students to learn. At the same time, neither teachers nor students were given assistance to learn how to use and apply ICTs in learning process of deaf students.

Another obstacle that arises in the teaching of deaf students at King Saud University in Saudi Arabia, as Amal (2019) refers in his research, is that deaf students' interpreter occasionally translates incorrectly because they don't understand the scientific terms that were introduced in the lecture. So, Amal's research aims to address these barriers by implementing "flipped" classroom teaching method based on the integration of ICT in the teaching process, while also trying to enhance student learning quality.

Therefore, it is realized that deaf students face significant difficulties in the learning process through the integration of ICT in the educational program while misunderstandings are often created between teachers and sign language interpreters. At the same time, the limited supply of digital tools and computers in the classrooms leads students and teachers to avoid using ICT in their teaching. However, all students with hearing problems are entitled to equal rights in education for the purpose of future professional training and for this it is necessary to provide mandatory training to teachers in the use of ICT in the teaching program and to provide the necessary technological equipment.

8. Discussion

Finally, it's critical to emphasize the beneficial and influential role that digital technologies play in the field of education. Mobile devices (70-74), a range of ICT apps (75-87), AI & STEM ROBOTICS (88-102), and games (103-105) are examples of the technologies that facilitate and improve educational processes including evaluation, intervention, and learning. Additionally, the use of ICTs in combination with theories and models of metacognition, mindfulness, meditation, and the development of emotional intelligence [106-140], as well as with environmental factors and nutrition [66-69], speeds up and improves educational practices and results, especially for deaf students.

9. Conclusions

Taking into account the challenges and difficulties faced by deaf and hard of hearing people, it is important to emphasize that the use of ICT is essential for the educational, social and professional life of all people with or without disabilities. Thus, as summarized by the aforementioned research, a wealth of digital tools and applications have been created, which analyzed in detail in this research, aiming to help deaf and hard of hearing students overcome educational barriers, actively participate in society, develop their skills and most importantly have equal rights and opportunities with other people. However, as evidenced in many countries mainly in Africa, deaf students and citizens are not offered digital tools and computer lessons. Teachers do not have the knowledge and the education to integrate into the curriculum of deaf and hard of hearing students ICTs subjects and other technological tools. As a result, against the will and interest of deaf students to use ICTs in their learning process, lack of teachers training and limited technological equipment in their schools, makes use of ICTs impractical or sometimes ineffective.

Compliance with ethical standards

Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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