A REVIEW ON THE ICT LITERACY ACQUISITION OF MODERATE HEARING-IMPAIRED YOUTH BY ADAPTED CONSTRUCTIVISM AND LEARNATIVITY CONTENT DEVELOPMENT

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Abstract:

Hearing impairment is a prominent sensory disability that occurs due to the complete or partial loss of hearing ability in one or both ears. Based on the degree of hearing loss, hearing impairment is graded as mild, moderate, severe, or profound. The World Health Organization (2021) states that over 5% of the world's population has disabling hearing loss. The inadequate hearing negatively affects their education and makes them low-literate and unemployed in society. Based on the findings, poor hearing makes hearing-impaired learners inactive in the learning process. According to the theorists, constructivism is a learning theory that encourages active learner participation. If hearing-impaired youth are literate in information and communication technology (ICT), employment opportunities are available for them in the industry, either as graphic designers or hardware technicians. The objective of this review paper is to identify the challenges faced by hearing-impaired learners in obtaining education and ICT literacy. In addition to that, how constructivism and learnativity content development can be effectively applied in providing ICT literacy for moderately hearing impaired youth to occupy them in society gainfully.

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Keywords: ICT literacy, moderate hearing impairment, constructivism, and learnativity content development

1. Introduction

Baker *et al.* (2017) state that hearing-impaired people account for over 5% of the world's population. According to the World Health Organization (2021), nearly 466 million of the world's population have disabling hearing loss, and 34 million of them are children. It is expected that within the next 30 years, over 900 million people (one in every ten people) will have disabling hearing loss.

Moderate hearing impairment refers to an individual's inability to hear soft to moderately loud sounds and to understand speech whenever any background noise is present. The World Health Organization in 2021 specifies a moderate hearing loss range of 41–60 dB. According to the World Health Organization, a child with this level of hearing loss will have difficulty hearing regular speech, even in close proximity. According to the literature, people who suffer from moderate hearing impairment have difficulty keeping up with conversations when not using a hearing aid. Universally, youth is defined as both males and females whose age is between 15 and 24 years.

Though moderately hearing-impaired youth have good eyesight, they have difficulty reading and writing text-based content due to their inadequate hearing. The inadequate hearing negatively affects their education and makes them low-literate and unemployed. If hearing-impaired youth are literate in ICT, employment opportunities are available for them in the industry, either as graphic designers or as computer hardware technicians.

The research work carried out in the area of hearing disabilities is not so abundant. The majority of the researchers have addressed the deaf community in their research work. Consequently, hearing impairment is not specifically categorized. As a result, the hearing-impaired community also falls under the deaf category. This, in a way, is not fair to the moderately hearing-impaired community. Hence, there is a need to concentrate on moderately hearing impaired youth as a separate category who can benefit from improving their ICT literacy skills, which will make them gainfully occupied in society.

2. Literature review

2.1 Challenges faced by hearing-impaired learners in obtaining education
Luo *et al.* (2012) state that providing high-quality education for hearing-impaired students is a challenge. In their research article, Mpofu and Chimhenga (2013) highlighted the challenges faced by hearing-impaired pupils in learning institutions in Zimbabwe. Also, they suggested ways of handling challenges from the best teachers.

Mpofu and Chimhenga (2013) state that most schools that enroll students with hearing impairments do not cater to their special needs. Finding funds to equip the schools with the appropriate training requirements is a challenge faced by the schools

and the students. The impact of hearing impairment depends on the type, extent, and timing of the hearing loss. According to Mpofu and Chimhenga (2013), hearing-impaired students are isolated in the learning environment. These students have limited opportunities to have social contacts and social interactions with other students. This isolation has an impact on learning. These students frequently carry emotional baggage due to past learning failures and other put-downs, which will have a long-term effect on their confidence, self-esteem, and approach to learning. Hearing-impaired students have lower reading levels and a limited vocabulary. The vocabulary gap between students with normal hearing and students with hearing impairments widens with age. Children with hearing loss have difficulty understanding words with multiple meanings. They often cannot hear word endings with -s or -ed, which leads to misunderstanding and misuse of verb tense, plurals, non-agreement of subject and verb, and possessives. Hearing-loss children produce shorter and simpler sentences, and they also have difficulty writing and understanding complex sentences. Hearing-impaired children do not include "s," "sh," "f," "t," and "k" in their speech because they often cannot hear these speech sounds. Hearing-impaired children have difficulties in all areas of academic achievement, mostly in reading and mathematical concepts. Despite the fact that hearing-impaired children are academically and socially vulnerable when attending school, researchers say the learning process of hearing-impaired pupils is not different from that of normal pupils. Mpofu & Chimhenga (2013) have stated ways to accommodate hearing-impaired students. One such way is to use visual media, especially overhead projectors or PowerPoint, as much as possible. The teacher needs to prepare a brief course outline, a syllabus, and a list of learning objectives for the class in advance, and those could be distributed to students at the beginning of the term. All the important information should be conveyed to students in writing, as handouts, and on the chalkboard.

Abuzinadah *et al.* (2017) state that, as a world concern, all students should be provided with equal educational opportunities, whether they are hearing impaired or not. According to the researchers, deaf and hearing-impaired students have issues only with their hearing capacity but not with their visionary ability. Hence, they can always find a way to best understand a programming language. However, according to research studies, deaf and hearing-impaired students find it difficult to learn applied disciplines like medicine, engineering, and computer programming. Hence, Abuzinadah *et al.* (2017) designed a study to investigate the readiness of deaf students to pursue higher education in applied sciences, especially computer science, to challenge the general perception that deaf students cannot learn complex subjects. According to worldwide statistics, a considerable number of deaf students enroll in higher studies, but they do not complete them due to their hearing difficulties, which range from partially to wholly. This is due to the lack of special facilities required for them to overcome the personal and social barriers that they encounter. With the rapid advances in educational technology, hearing disabilities should not be considered barriers to academic achievement. The King Saud University of Saudi Arabia has implemented adequate learning and hearing facilities for deaf students to allow them to complete their courses without much difficulty.

Researchers have developed software tools and applications to improve the lifestyles of deaf and hearing-impaired people. Avatar creation is an example of that. Based on the findings, videos and avatars are functionally different in respect to teaching for deaf learners.

According to researchers, e-learning, content visualization, virtual reality, and mixed reality are promising technologies that can be used to facilitate accessible higher education courses for deaf and hearing-impaired students. Studies that considered personality-type measures and social interaction approaches found that deaf students have a more field-dependent cognitive style than their hearing peers. Thus, it has been suggested that deaf college students prefer certain learning styles more than others. Their preferences were related to the level of students' academic achievement, to their motivation, and to the manner in which they used course resources. According to the findings, family relationships play a unique and significant role in academic success.

In Jordan, in 2007, a centralized e-learning system was implemented to teach mathematics to deaf children, with the aim of evaluating whether existing ICT technologies are suitable for introducing interactivity within the classrooms for the deaf. Successful application of this system paved the way for a complete support system for the education of deaf pupils in Jordan. The signing avatar system is an explicit invention geared towards improving learning for deaf and hard-of-hearing students, specifically in Saudi Arabia.

Baglama *et al.* (2018) pointed out that hearing-impaired individuals face many problems in school and in social life. They state that children born with hearing loss do not acquire linguistic and speech skills due to various reasons, which include not hearing enough voices, not perceiving verbal stimuli, and being deprived of the use of the mother language every day. Many students with hearing impairments have lower reading levels and a limited vocabulary. Baglama *et al.* (2018) examined the use of technologies in the training of hearing-impaired children in Turkey. According to Baglama *et al.* (2018), providing proper and appropriate education for hearing-impaired individuals is very important. Hearing-impaired children may feel embarrassed and hesitant when they fail in the classroom. Hence, planning for individual differences in education is the main feature required by hearing-impaired learners in education. Only the use of traditional teaching methods is insufficient to provide education for hearing-impaired individuals because they fall into the category of individuals who need special education. The authors say that the use of modern technologies is more useful in training hearing-impaired individuals. Many studies have shown that computer training programs have a positive influence on the development of academic skills, language, mathematics, literacy, and competence in children with disabilities. With computer programs and adapted tools, students with hearing impairments can read materials created on the computer. The quality of education received by hearing-impaired children is greatly affected by the environment. Teaching knowledge and skills with visual means is very effective for hearing-impaired children. Based on the findings, the application of information technology has removed the distraction problem because students with hearing

impairments have increased their interest in the lessons, and it has become more fun to learn. Hence, the use of information technologies provides a contribution for hearing-impaired students. When information and communication technologies are correctly used, they have the potential to provide vital opportunities for hearing-impaired people. Hearing-impaired individuals can use computer-aided materials on their own. This initiative provides the opportunity to repeat the individual learning environment, which creates the individual's self-confidence and influences learning positively. Visually rich, game-based learning materials are effective for hearing-impaired individuals. Based on the findings, computer-aided teaching material positively affected the students' written expression skills, such as writing sentences and using correct past, present, and future tenses. According to Kot, Sonmez, Yikmis, and Ince, the touch-math technique is effective in teaching addition skills to hearing-impaired individuals.

The research conducted by Dogan and Akdemir (2015) has observed that computer-assisted instruction makes hearing-impaired learners fast learners. It is seen that hearing-impaired learners learn words faster in computer-assisted instruction than in classical methods. The use of visuals in computer-assisted instruction to explain unknown words encountered during the reading-writing process shortens the length of the teaching period for hearing-impaired learners. The use of ICT helps moderately hearing-impaired learners develop their vocabulary. The rich visual medium provided by ICT allows hearing-impaired learners to improve their general knowledge and linguistic abilities. Teachers also stated that information and communication technologies facilitated the presentation of lessons and increased the motivation of the learners. It was determined that computer-assisted teaching positively affects students' geometric academic achievement. The environments in which hearing-impaired individuals are trained should be enriched using appropriate visuals for a more remarkable level of development in order to overcome auditory deficits.

2.2 ICT literacy

Rockman (2005) defined ICT literacy as the ability of students to use digital technology, communication tools, and/or networks appropriately to solve information problems and function in an information society. JISC (2014) describes ICT literacy as a learner's ability to adopt, adapt, and use digital devices, applications, and services. It refers to a learner's ability to navigate the technical requirements of being an online learner. Hence, ICT-literate, hearing-impaired youth are employed as graphic designers or hardware technicians in the industry. ICT literacy acquisition is very important for them to be fully occupied in society.

2.3 Challenges and barriers faced by hearing-impaired learners in obtaining ICT literacy

The research conducted by Nordini *et al.* (2015) aims to identify the problems and challenges faced by hearing-impaired individuals in learning various ICT educational courses. Then, the researcher found that various ICT courses specially designed for

hearing-impaired individuals were scarce. In the research, a need analysis was done in all schools in Malaysia that execute the hearing impaired education program for the secondary level to identify the problems, issues, and challenges amongst them in learning these ICT courses, like computer graphics, multimedia, 3D animation, ICT literacy, etc. Exposure to ICT education has increasingly become popular in higher education because it is essential for hearing-impaired individuals to prepare them for the world of employment (Gibson *et al.*, 2002). However, many hearing-impaired individuals are not exposed to the latest ICT tools and technologies today (Nordini *et al.*, 2015).

According to Nordini *et al.* (2015), the schools that offer ICT courses for hearing-impaired students do not have the latest ICT tools and technology, which consist of attractive graphic images, though vision is a dependent sense for them. Although the teachers saw great talent and knowledge among their hearing-impaired students, computer classes were not offered for them due to the inadequate computer equipment and the packed timetable. Most teachers argued that the students were really interested in computing but were not given a chance to experience the latest ICT technologies. Computer classes and courses were not offered in most schools. According to the findings of the research, around 90% of the teachers agreed that hearing-impaired students should learn ICT courses online. In the observation conducted in the schools offering computer graphics, the hearing-impaired students showed great potential in drawing graphic images, and they showed interest in learning computer graphics. Most teachers and students optimistically agreed that they would like to have this course available online, with tutorials, etc.

Nordini *et al.* (2015) found that students were interested and determined to learn computer graphics courses virtually in the schools that offer basic computer literacy and computer graphics courses online. This was positively supported by their teachers too, who claimed that computer courses that include visual media aids like graphics, charts, and tables are important for hearing-impaired individuals. Based on their comments, almost 96% of the sample teachers agreed on the fact that hearing-impaired individuals learn computer graphics online, and almost 70% of the student participants agreed on learning computer graphics online. According to the findings of the research, the computer graphics course was chosen by the majority of the hearing-impaired individuals rather than 3D animation, web design, and multimedia. When considering various ICT courses, the majority of the participant students were 'Strongly Agree and Agree' on the following courses: 3D Animation, Multimedia, Web Design, and Computer Graphics, in contrast to other non-graphic courses like Database Organization, Programming, and Networking. Courses that contain attractive graphics, multimedia-supported content, and attractive animation designs caught the attention of hearing-impaired individuals' vision, compared to the plain black-and-white graphic-less courses. The researcher also found that web accessibility is crucial for hearing-impaired students. The lack of web portals developed for hearing-impaired individuals is an additional identified problem. Most of the teachers stated that there is still no satisfactory web portal for hearing-impaired students. In terms of the development of the e-learning

web portal, it is important to develop a constructive portal with respect to a few criteria, such as its ease of use, the built-in features, its customizability, and the testing of flexibility and extensibility (Debevc *et al.*, 2007). User-friendly multimedia-based telecommunication and Internet information services can be used as a standard electronic platform to support the main procedures of distance, lifelong, and continuing training for hearing-impaired individuals (Nordini *et al.*, 2015). The hearing-impaired individuals deserve the same rights as the normal-hearing individuals to learn ICT in their educational lives, and they also cannot be neglected or left behind in learning computer courses (Drigas *et al.*, 2005). In their research conclusion, Nordini *et al.* (2015) stated that an e-learning portal is needed to educate hearing-impaired individuals on ICT education.

2.4 Constructivism

Reigeluth (2009) states that different learners have different learning rates and different learning needs. Also, he states that the current paradigm of training and education was never designed for learning but for sorting.

According to Kelly (2012), learning theories help us better understand how learning occurs. The principles of the learning theories are used as guidelines in selecting instructional tools, techniques, and strategies that promote learning. Constructivism believes learning is based on how the individual interprets and creates the meaning of his or her experiences. Thus, knowledge is constructed by the learner. However, learning is unique and different for each person since everyone has a different set of experiences and perceptions. According to Kelly, constructivism is the process of adjusting mental models to accommodate new experiences. The constructivism theory focuses on preparing people for problem-solving. To be successful, the learner needs a significant base of knowledge to interpret and create ideas. With constructivism, outcomes are not predictable. Constructivism does not work well when the results always need to be consistent.

Becker (2015) defines learning theory as ideas about how people learn. Though there are many learning theories developed by teachers and learners that exist today, no learning theory has been specifically developed for hearing-impaired learners. Therefore, teachers, when teaching for hearing-impaired learners, have to adapt the existing learning theories to meet the requirements of the hearing-impaired learners. Becker (2015) defines instructional (design) theory as ideas about how people should teach. Smith *et al.* (1996) argued that though Gagne's theory is considered a learning theory on most occasions, it is most appropriate to consider it an instructional theory.

A learning theory is a principle that explains how a student can best acquire, retain, and recall information. Though teachers and learning designers are aware of learning theories and related jargon, all of them approach training in a way that is governed by one of the learning theories (Vancouver, 2017). Vancouver (2017) states that "*learning theories offer frameworks that help understand how information is used, how knowledge is created, and how learning takes place. Learning designers can apply these frameworks according to different learning and learner needs and make more informed decisions about choosing the right*

instructional practices." Also, Vancouver (2017) states that "*different theories are best suited to different learning outcomes and different audience profiles.*".

Though there are hundreds of learning theories available, three schemas remain dominant. Hence, all the learning theories fall under the schemas of behaviorism, cognitivism, and constructivism. According to constructivism, knowledge is constructed by adapting new information that is based on previous experience.

2.5 Application of adapted constructivism for moderately hearing-impaired youth

To meet the learning requirements of moderately hearing-impaired youth, the constructivism learning theory needs adaptation. The adapted constructivism can be presented as "*Moderate hearing impaired learners construct new meanings and understandings by integrating new information with prior knowledge mainly gained by way of visual information.*".

2.6 E-learning opportunities for moderately hearing-impaired youth

Abuzinadah *et al.* (2017) state that e-learning, content visualization, virtual reality, and mixed reality are promising technologies that might facilitate the provision of accessible higher education courses for deaf and hearing-impaired students.

Hashim *et al.* (2013) state that the usage of e-learning environments in education involves a wide range of types of students, and this includes hearing-impaired students. Some adjustments or enhancements need to be implemented within the e-learning environment based on the needs or adaptability of hearing-impaired students.

Hearing-impaired individuals, particularly hearing-impaired students, usually acquire the same level of mental capability as normal hearing students in terms of studying. The term 'deaf and dumb' is not practically to be used since the hearing-impaired students are only lacking in their hearing capability but not their intelligence level (Schwartz, 2002). Therefore, hearing-impaired students will be undertaking the same subjects or courses in any educational department or institution that are taught to normal hearing students of the same age. However, a problem could occur for hearing-impaired students if the technique used by the teachers or instructors in teaching them is the same as that used for normal hearing students. Thus, the usage of technology is vital in preparing hearing-impaired students with the appropriate learning environment since, by using technology, and the hearing-impaired students can access sound in their own suitable way (Berndsen and Luckner, 2010). However, most of the e-learning environments available today lack adaptability. They often encounter problems accessing information. Therefore, to assist hearing-impaired students in accessing information adequately, the e-learning environment needs to be developed and designed according to the needs of the hearing-impaired students by adding or enhancing some features within the e-learning environment (Hashim *et al.*, 2013).

Tosho *et al.* (2016) say instructional-based courseware faces serious usability problems due to ineffective design interfaces. The development of instructional interface design principles to cater for the needs of low-vision and hearing-impaired learners in

their learning activities was the main objective of the researcher's study. The specific objectives of the study were to determine appropriate instructional interface elements and design principles for courseware designed for low-vision and hearing-impaired learners. The preliminary analysis was used to determine the limitations of existing learning materials and identify the instructional elements that are applicable to low-vision and hearing-impaired students before determining a suitable model of instructional interface design principles for courseware. The principles of multimedia design were appreciated in the instructional interface design. The identified instructional design principles for the hearing-impaired user group were as follows: A speech-to-text system, closed captions, providing a text equivalent, conforming to current interface design standards, and providing transcripts for all audio content. Provide captions and descriptions of the multimedia used. Use text to label images, turn off graphics, turn off sounds, and provide enough contrast between text and background color. Use descriptive links rather than "click here." Use the largest font size. Provide feedback. Avoid blinking, flickering, or moving elements. Do not design something differently from user expectations just to be different. Eliminate unnecessary complexity.

2.7 Lernativity content development for moderately hearing-impaired youth

Khali and Elkhider (2016) say the faculty members involved in instructional design activities in higher education lack formal training in learning theories and the science of instruction. The foundation for the selection of instructional strategies is provided by learning theories, which allow for reliable predictions of their effectiveness.

The learnativity content model describes the way content should be organized for e-learning and knowledge management applications (Yatigammana & Wijayarathne, 2020). According to Yatigammana and Wijayarathne (2020), content assets are the most important part of the content development environment. Content assets include raw media like photographs, illustrations, diagrams, audio, video, or animations. An information object can be a concept, a fact, a process, a principle, a command reference, an exercise, or a procedure. Individual information objects are combined to form a learning object. Learning objects are a collection of reusable information objects to achieve a common job task or a learning objective. Learning objects are sequenced to build a lesson or course called a learning component. A learning environment is created by bundling the learning components with additional functionalities called communication tools or peer-to-peer computing. In their research, Yatigammana and Wijayarathne (2020) considered MP3 files to be learning objects. An MP3 file is a collection of content assets composed of photographs, illustrations, diagrams, audio, video, and animations. The authors have adopted the learnativity model to develop a tool to bundle multiple images, an audio file, and a text file together to form a single learning object, introduced a mechanism to extract them from the learning object, and showed them to the students. According to the model, information objects contain raw media elements. Learning objects contain information objects. Aggregate assemblies contain learning objects and other aggregate assemblies. The Microsoft Model (Elliot) and the Academic Co-Lab

Model (Brown, 2002) are variants of the learnativity content model. The learnativity content model describes the way of organising the content for e-learning. The investigation led to the development of a tool for teachers that can be used to build a lesson as an MP3 file. A single MP3 file contained embedded audio, text, and images. According to the literature, the combined use of audio, text, and images is much more effective in providing education, including ICT literacy, for moderately hearing-impaired learners. When delivering a lesson using learning content development, the lesson can be broken down into several small sections. Since hearing-impaired learners have short-lived memories, breaking down a lesson into small sections allows for better understanding and makes it easier to remember.

3. Conclusion

This review was done to identify the barriers and challenges faced by hearing-impaired learners in obtaining education, including ICT literacy. Based on the findings of the review, constructivism has been identified as a suitable learning theory to provide ICT literacy for moderately hearing-impaired youth because it addresses students' knowledge gaps and their adaptation to modern learning environments. To be effectively used in providing ICT literacy for moderately hearing-impaired youth, adaptive constructivism has been applied in the e-learning environment. The use of learnativity content development in the e-learning environment is a remedial solution to overcome the problem of short-lived memory in acquiring ICT literacy skills by moderately hearing-impaired youth. Appropriate use of text and graphic content assets in the e-learning material encourages the visual learning of moderately hearing-impaired youth. Also, the appropriate use of audio in the e-learning material provides an opportunity for moderately hearing-impaired youth to listen to sounds in their own suitable way.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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