

E-Learning Assistance and Application for the Auditory-Impaired Population: A Review with Recommendations

Maysoon S. AlDekhail

Department of Information Systems, College of Computer and Information Sciences,
Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia

Received: September 26, 2014

Accepted: February 11, 2015

ABSTRACT

The world has seen phenomenal growth in e-learning over the past one and half decades due to its accessibility and affordability for all segments of society. E-learning is a useful tool that has contributed in facilitating education for people all over the world. Disabled people are able to benefit from this technology by increasing their knowledge and improving their skills. Also, they can utilize the mobility feature to learn anywhere and at any time. The aim of this paper is to assist e-learning designers and those interested in special needs research to gaining an overview of existing research on e-learning systems for the Deaf; furthermore, it aims to assist Deaf people to communicate with hearing people and to derive benefits from e-learning systems. The paper investigates different types of e-learning and m-learning systems for the Deaf, and compares them based on the different criteria and features they provide. This will be followed by a study of existing research in which we make our contribution by discussing important issues that affect the success and approbation of the systems; these are: the special standards for e-learning systems, instructions to increase the accessibility of e-learning systems for the Deaf, and the guidelines given by experts that affect the availability and usability of e-learning systems.

KEYWORDS: e-learning, m-learning, disabled, deaf, Hard of Hearing, Sign Language

I. INTRODUCTON

We are now in an era of information revolution where computer-based communication and technology are developing rapidly and affect all aspects of life. One of the most important impacts of the technical revolution has been in the field of education and learning. Distance learning is very convenient for people in different demographical locations and who are not able to continue formal education [1]. As technology develops, e-learning takes the shape of a type of learning that utilizes Information and Communication Technologies (ICT) in education by using various types of multimedia (audio, video, images, and animations) and different technologies (DVD, video tape and TV). E-learning can occur inside or outside of a classroom either as synchronous or asynchronous learning. More recently, great advances in mobile technologies have led to the advent of m-learning as an extension of e-learning. M-learning is simply the use of different mobile technologies in learning [2]. The main objective of m-learning is to provide learning opportunities anywhere and at any time. It focuses on learner mobility through the utilization of mobile phones, smart phones, PDAs, Tablets and wireless communication technologies, such as GSM, GPRS, 3G, 4G, Wi-Fi and WiMax[3].

All segments of society can benefit from e-learning and m-learning facilities, including disabled people. If they do not become familiar with new technology, it can negatively affect their life [4]. In fact, e-learning and m-learning are the most appropriate options for increasing disabled persons' knowledge, and improving their skills and self-confidence. These facilities can address issues, such as travelling to traditional classrooms, or living in remote areas where there are no special educational organizations or a lack of specialist instructors. M-learning allows disabled people to continue learning anywhere and at any time they choose. Unfortunately, at present, disabled people are rarely taken into consideration in the development of e-learning system or m-learning applications [4].

Deafness is a hearing disability in which a person is incapable of receiving auditory information. Most people who are deaf are also speech-impaired and they use sign language (SL) as the main way of communication [5]. In the deaf community, the word 'deaf' has a different meaning. Capital 'D' Deaf is applied to individuals who are born or become deaf at a young age and use sign language as their first language, whereas small 'd' deaf applies to individuals who suffer some degree of hearing loss due to age and may use listening devices to help alleviate their problem. The latter individuals are not considered members of the Deaf community [6].

Sign language uses hand signs, facial expressions, lip patterns and body language instead of sound patterns. As in spoken languages, sign languages vary amongst countries and have their own vocabulary and grammar. They also vary within the same country and there is no standard sign language [7].

*Corresponding Author: Maysoon S. AlDekhail, Department of Information Systems, College of Computer and Information Sciences, Imam Muhammad Ibn Saud Islamic University, Riyadh, Saudi Arabia

According to the World Health Organization in 2006, 278 million people all over the world are Deaf or have hearing difficulties [8]. According to the World Federation of the Deaf, 80% of Deaf people are illiterate or semi-literate [9]. For this reason, greater efforts should be made to afford the Deaf equal opportunities in education and in working with others. E-learning and m-learning are excellent ways to increase the percentage of educated Deaf people by optimizing new technology. Today, many proposed systems are designed to help Deaf people access the web for learning and training.

This paper aims to assist e-learning designers and those interested in special needs research by providing an overview on the existing research on e-learning and m-learning systems for the Deaf. In addition, it will help Deaf people derive benefit from e-learning and m-learning systems by increasing their knowledge and improving their skills, and also by expanding and facilitating their communication with hearing people.

The remainder of the paper is organized as follows: Section II discusses the different existing systems in e-learning and m-learning for the Deaf, listing their features, advantages and limitations, if any. Section III compares these systems based on different criteria. Section IV explains some important issues related to the design and implementation of e-learning systems for the Deaf. Finally, a conclusion is presented.

II. LITERATURE REVIEW AND RELATED WORK

There has been some research in the area of e-learning and some proposed m-learning systems for Deaf people. In [10], four open-source learning management systems (LMSs) were evaluated to determine which was the most suitable for Deaf children in Jordan. The evaluation focused on the main factors that may affect teaching Deaf children, including language support, Rational Database Management System (RDBMS), LMS standards compatibility, HW/SW specifications, administrative tools, assessment tools, etc. The systems that were evaluated are: Moodle, Sakai, OLAT and ILIAS. The authors found that the most appropriate open-source LMS for Deaf children is Moodle LMS. Moodle has many features that facilitate e-learning for Deaf children in Jordan, such as full Arabic language support and video conferencing.

In [11], the authors studied the effects of captions on Deaf students' content comprehension and motivation in online learning. The study concluded that captions provided along with sign language videos have a positive effect on the understanding of educational content material on Deaf students. However, it found that these do not have any effect on motivation.

Another research was conducted [12] to investigate the use of three types of dictionaries while reading to learn new words by Deaf students. The three types of dictionaries are: an online bilingual multimedia English ASL (OBMEAD), a paper English ASL (PBEAD) and an online monolingual English dictionary (OMED). The study found that the online OBMEAD dictionary that uses video together with sign language had better results than either the paper-based dictionary or the monolingual online dictionary.

Another research on mobile phones for disabled people [13] presents a telecommunications device for the Deaf (TTD), which is a special teletypewriter device with a screen. The device is connected to a mobile phone for typing and displaying text in conversations during the call instead of using speech and hearing.

To complete this research we found 17 works on e-learning systems for the Deaf. However, we focus only on systems that are presented and evaluated in research papers; we do not cover commercial products. To investigate and analyze these works, we classify the research into two main parts: e-learning systems and m-learning systems. The e-learning systems can be classified into different types, such as: Learning Management system (LMS), the virtual classroom, webpage translator, and a dictionary for sign language.

III. EXISTING SYSTEMS

The research on Deaf education using e-learning has diversified over recent years. This section analyzes different research available on e-learning and m-learning for Deaf people. The existing systems are categorized into two main parts: e-learning systems for the Deaf and m-learning systems for the Deaf.

A. *E-learning Systems for the Deaf*

This section investigates different proposed e-learning systems that help the Deaf in learning and training. Some of these were evaluated and delivered good results in terms of how they increased Deaf students' education levels.

1. An E-learning System for Deaf People

In [14], a prototype for a web-based e-learning system is presented. Based on the results of the questionnaires from Deaf people, more than 90% prefer the content of the system to be presented in sign language together with video and images. Therefore, the main idea of the proposed system is to offer Greek sign language videos that correspond to each text in the learning environment. There are many features for the different users (administrator, teacher, students). The key features of the system are: a search tool of the content of the system, glossary with main terms in the content, a tool for content extraction for further study, a tracker of student activities to help teachers track student progress, and an asynchronous test to evaluate student progress. Figure 1 shows an example of the system screen. The system also provides an option to select the video speed and to download the video

for better quality. Moreover, the system allows synchronous communication between users through a chat tool. However, the system does not provide video chat between Deaf users. Additionally, the proposed system can be applied to any sign language because the e-content can be uploaded in any language. The system was not tested to evaluate its performance and accessibility for Deaf students.



Figure1. Screen from e-learning system for Deaf people [14]

2. Accessibility System for Deaf Arab Students

Using SL can advance the reading ability of Deaf people and enhance their acceptance and understanding of the learning content. The education level of Deaf students is low due to limited accessibility in existing education systems [14]. In [9], a system has been designed to convert the web-based content to Arabic SL by using avatars. Using SL with text content supports accessibility for Deaf students. The Deaf user can enter the URL of the page that he/she wishes to translate into sign language and can choose one of two output types: a photo album displaying the format, which generates the signs, or a line- by-line display of the format, which generates the signs as a regular web page but each word is represented as a sign. Then the system scans the page and extracts the content. It uses the Arabic sign library that contains 3500 Arabic gestures corresponding to the most common Arabic words and is stored in a database that converts the requested web page to Arabic SL. Figure 2 illustrates an example to teach students the concept of a family using Arabic text and ArSL. The distinguishing feature here is the opportunity it provides to the user in output format (via photo album or line-by-line signs). The proposed system is based on the idea that using sign language with text will increase accessibility and the learning level of Deaf people; however, the system has not been tested to evaluate improvements in student understanding. The system has some limitations; it does not allow users to save the converted pages in order to return to them on demand, and translation is based on a limited DB; however, extra features can be included to allow users to add new words to the DB after they have been checked by the administrator. Also, more SL can be added to give users more options for selecting their language of choice.

3. An Enhanced e-learning Environment for the Deaf/Hard of Hearing (HOH)

The system presented in [4] proposes a synchronous virtual classroom system for Deaf students that displays and creates materials in sign language with full interactive and social tools. The objective is to provide the Deaf and the HOH with the same rights as their able-bodied colleagues in accessing and interacting with their course materials through the use of bilingual (written and sign) language. This is based on the advanced teleconference services on the Internet and other facilities for the Deaf, such as animations and videos. The system provides a set of interactive tools including hand raising and audio, direct messaging, quiz manager, breakout rooms, application sharing, whiteboard and whiteboard tools. Additionally, it provides a set of social tools, such as profile and live video. There are three users of the system, namely, administrator, instructor, and student; each has a specific role. Furthermore, the system supplies many features: video conferencing combined with text material, the translated SL video, which can be saved, and the speed of the video, which can be controlled by the user to keep track of the presented video or text. It allows communication between Deaf students and their instructor through visual chatting and video conferencing, which can be shown at same time with cooperative tools, such as the whiteboard or file sharing. The advantage of this system is that it can be applied to Deaf people in any place and with any sign language. Moreover, it can be used as a communication tool and as a knowledge and culture exchange tool between Deaf people in different regions of the world.

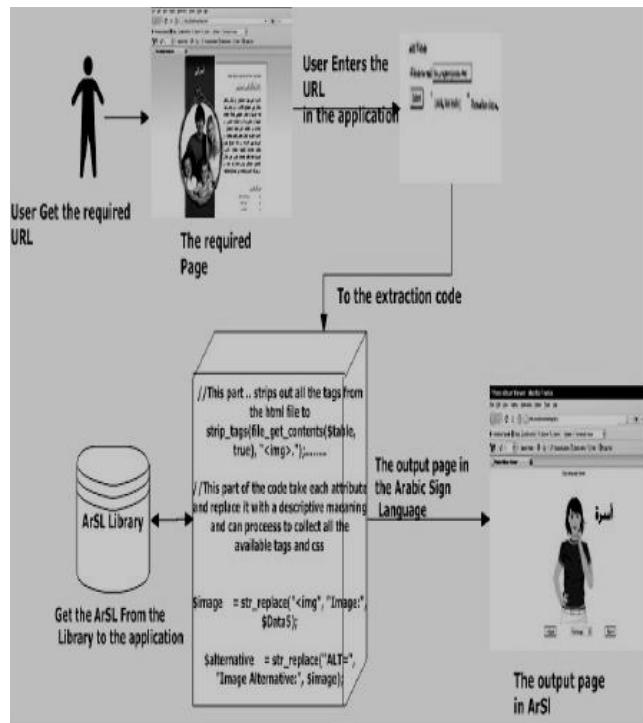


Figure 2: The process of teaching the family concept using the accessibility system for Deaf Arab students[9]

However, this proposed system was not evaluated or tested on Deaf people.

4. Swift: A Sign Writing Editor to Bridge between the Deaf World and E-learning

Sign writing is a system of writing sign language. Sign writing consists of characters, which are abstract pictures of the hands, face and body that are used to represent letters and words. Figure 3 shows a hand shape in sign writing. A common solution of transferring web content for Deaf people is by integrating a sign language video with the text content of the web page. This method has two drawbacks: it is technically demanding and it is time consuming to set up the recording for a high number of clips to transmit web content to videos. Additionally, video on the web often suffers from bandwidth limitation. Hence, a written form of sign language would address these issues. SWift presented in [8] is an editor for sign writing. The aim is to remove the barriers that obstruct Deaf people from e-learning by including the SWift editor in all e-learning modules. Sign Maker is a web-based application for writing and saving signs; it was designed previously by the same project group. Subsequently, SWift was designed as an improved version of Sign Maker. SWift interface has four components: sign display, which is a white area to display the sign, a tool box, which contains animated buttons mimicking the performed action to operate on glyphs in sign display, and a glyph menu, which contains a set of graphic elements (glyphs) to choose from and drag to the sign area to make the sign and save it in three different formats (text, image or format for the SWift database). The fourth component is the hint panel, which shows a series of glyphs that are compatible with glyphs in the sign area. To help Deaf people easily search for suitable glyphs, a puppet is presented and the main parts (head, shoulders, hands, arms) are highlighted. If the user chooses one of them, a submenu of related configurations and motions will appear. An experiment was conducted on ten Deaf users; the results were encouraging. Figure 4 shows the home screen for SWift. Although, the SWift editor is not an e-learning system, it can facilitate learning for Deaf people by associating the editor to any learning system to make it accessible and useful for the Deaf learner.

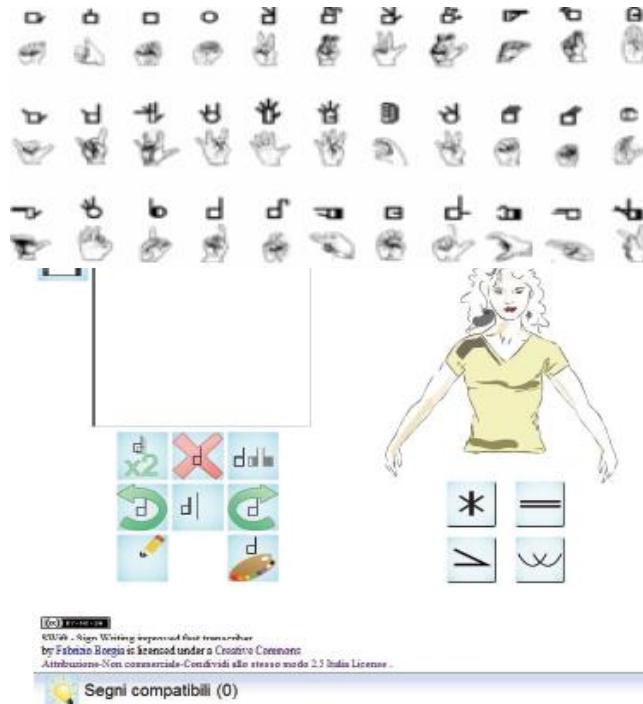


Figure 4: Home screen for SWfit [8]

5. An E-learning Environment for Deaf Adults

The AILB project [32] aims to develop a bilingual web-based learning system for Deaf adults. This project is based on the theory that using sign language alongside text content will improve the reading skills of Deaf people and enhance their understanding and acceptance of the learning content; for example, the student can retrieve the German SL video for each text block. The video is not shown immediately, as the learner is encouraged to read the written text first. The system provides chat and video conferencing to enable Deaf students to communicate directly with each other while they are working on the course. The system also uses templates for pages, exercises and tests to make the learning content easier for the instructor to create. The interface of the learning system is divided into four sections as shown in Figure 5; these are: interaction control includes general functions that are needed, learning and working space that contain the course content, navigation control, and the display area for sign language video. The experiment was conducted in 2004 on twenty Deaf people; however, the results of the project are not presented in this paper. Actually, this proposed learning system is not limited to German SL; it can be applied to any sign language.

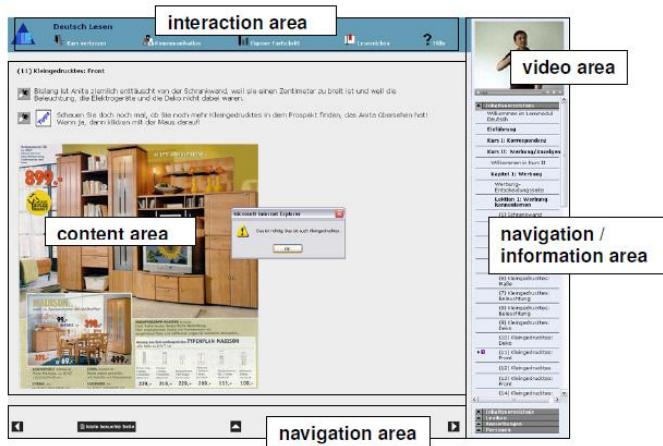


Figure 5: Components of learner's interface [32]

6. An Adaptive WWW-based System to teach British Sign Language

Kids Sign Online (KSO), presented in [15], is an adaptive web-based system designed to be bilingual (teaching British Sign Language as well as English) for Deaf children; it is an adaptive system that allows for the personalization of user

interaction and content. The system architecture consists of: user interface server (web browser), database server, hypermedia server and hyperpages designer. The hypermedia server consists of a collection of hyperpages whose topology enables navigation between them. In addition, the hyperpages designer generates a hyperpage that contains a sequence of chunks, which is an information unit containing text, figures, video clips, etc. The system commences when the user passes the test and then, based on the score of the test, the personalized hyperpages are presented to the user together with an action list that contains the actions to be executed over the content. The system has been tested on over 70 students in the UK; the feedback received was positive and useful for future development. Figure 6 shows an example of the KSO screen. The method proposed in KSO is the adaptive technique that allows the displayed content to be adapted according to the students' level and is adjusted to meet changes in their level.

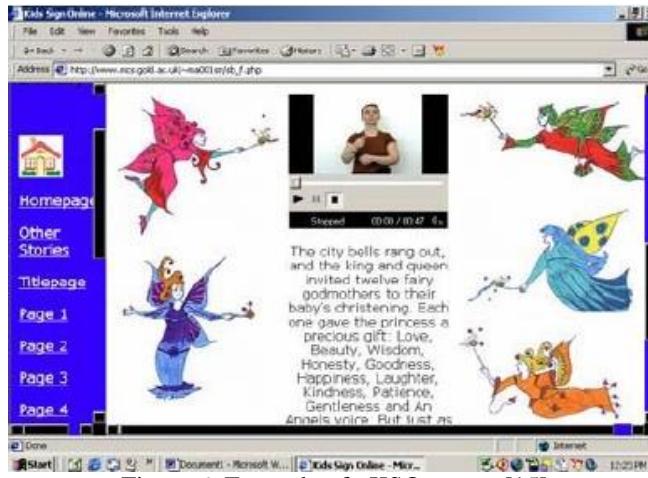


Figure 6: Example of t KSO screen [15]

7. The Italian Sign Language Sign Bank: Using WordNet for Sign Language corpus creation

In [7] an Italian sign language sign bank is described. It is a large scale Italian sign language dictionary linked to WordNet. The system consists of WordNet DB, which contains all the lexemes of Italian WordNet and a multimedia DB that provides all the videos of signs. The search screen allows users to search by text in an easy GUI; the system generates all possible meanings with multiple senses (noun, verb, etc) using WordNet along with the signs of the word. The main idea in this work is the connection with WordNet to create sign language corpus.

8. Exploring Usability of an E-Learning System for Improving Computer Literacy

Reference [16] is an adapted e-learning environment for the Deaf and hard of hearing. The aim is to increase computer literacy among unemployed Deaf people using ICDL e-learning materials with adapted streaming video with subtitles. Moodle is used for e-content management and for controlling student activities and evaluating progress. Moodle tools and functions give full support for e-learning, such as multimedia content support, forums, chat, e-mail and questionnaires. Furthermore, it supports simple navigation between system levels and activities. To make the system learnable, the content topics are divided into two levels: basic and advanced; some accessibility standards (ISO technical, ISO 9241-14, W3C) are considered in the user interface. Figure 7 shows a screen of the system. Results of the tests taken before and after the courses show that Deaf people can successfully use the system and learn from the materials.

Figure 7: Screen of e-learning system for improving computer literacy [16]

9. E-learning Modules of Tutorial Lessons for Deaf Students: Development and Evaluation

In [17], an e-learning module of tutorial lessons for Deaf students are developed and evaluated. The motivation behind this module is the difficulty in finding teachers for special needs. Also, the time needed for building online courses for Deaf students is longer, as teachers need to translate all the material into sign language. E-learning technologies provide many features for Deaf people, such as individualization; therefore, the authors developed eLMs for Deaf students to help them access course materials through tutorial e-lessons. The system is offered to two users: teachers and Deaf students. The system provides an empty template for teachers to enter the course material; then, the system reconstructs the entered material to e-learning modules of tutorial lessons. After that, the system translates the material from text to sign language and finger spelling coinciding with text words. The authors conclude that developing e-lessons for Deaf students should be based on a systematic model. In addition, e-lessons were developed to provide engaging interaction between Deaf learners and computers. Figure 8 shows a screen of the system. Experts evaluated the system and offered some comments. Firstly, they suggested adding real voice to the video clip of sign language, as this would support partially Deaf students in understanding more effectively. Also, they advised the redesign of the colors of forms, backgrounds, text fonts and pictures.

This system has advantages for both teachers and students. For teachers, they can build an e-lesson for Deaf students without any experience in sign language. For Deaf students, as the system is easy to use, they can use it with basic computer skills. They can also take control of the learning process, which is strongly recommended in any learning environment.



Figure 8: Screen of e-learning module of tutorial lessons for Deaf students [17]

10. Effects of Special E-Learning Program on Hearing-Impaired Learners' Achievement and Perceptions of Basic Geometry in Lower Primary Mathematics

In [18], a special e-learning program was designed to teach the basics of geometry to hearing-impaired students in primary schools in Kenya. The problem was the low achievement in mathematics by hearing-impaired students. The reasons behind this were the lack of textbooks and resources, and ineffective techniques used in teaching Deaf students. The system was developed by using the recommended syllabus for primary schools; the information was presented using a combination of sign language, text, graphics, animation and sound. The system was tested and the results showed that the learning had become easier by presenting information in a way that was more accessible to Deaf students. The study also demonstrated that a well designed e-learning program can be used effectively to improve hearing-impaired achievement in basic geometry.

11. Multimedia Course Generator for Deaf Children

In [19], a web-based tool was developed to specialize in creating multimedia courses for Deaf students. The course consists of a group of lessons; a lesson being a group of web pages. The system can be used either by Deaf people to learn sign language or by hearing people to be able to communicate with Deaf people. The tool offers two interfaces, namely, teacher interface and student interface. The teacher interface provides tools to create, modify and delete lessons. The student interface is a very simple interface that gives Deaf students the possibility to choose the mode of interpretation of the lesson: sign language or finger spelling. The tool provides an avatar that plays the sign that has been already translated by the WebSign tool. The user can use the system online, and can also download the lesson to use it in an offline mode. Figure 9 shows the course interface.



Figure 9: Course interface of multimedia course generator tool [19]

B. M-learning systems for the Deaf

Mobile devices have become extremely popular due to their attractive functionality. Many people use them in learning and for improving their skills and knowledge. Even if the Deaf wish to benefit from mobile technology in learning, to date, very little research and mobile learning applications for the Deaf are available. This section discusses a number of proposed m-learning systems that may help Deaf people utilize mobile technology.

1. A Proposed Pedagogical Mobile Application for Learning Sign Language

In [26], a mobile Deaf tutorial system is proposed to facilitate learning Arabic sign language. The system is designed to enable Deaf users to communicate and learn via handheld devices. The proposed system has an SL database that contains large numbers of words, images and videos in SL. Users can view the word lists, numbers, nouns and verb representations, and pictures and video games related to the SL for practice. Figure 10 illustrates some system screens. The proposed system was tested and the results provided evidence of learnability and memorability. During the test phase, the participants gave their comments on the system. The repetition of the video for each letter increased the memorability but there was confusion between some letters, which could be addressed by displaying different pictures from different angles for each letter.

The system is extremely simple; it also has extra features, such as teaching different sign languages to enable Deaf students to learn about and communicate with people from different countries and with those who use different sign languages. Tests or exercises can be added so the users can evaluate their own level in learning specific sign language.



Figure 10: Screens from mobile applications for learning Arabic sign language [26]

2. Mobile Arabic Sign Language

In [20], a mobile application is presented to teach Arabic sign language and to communicate through it. It provides many features, such as translation from Arabic text to sign language as video clips, and translation from sign language to Arabic text using a keyboard that represents the alphabet of Arabic sign language in order to communicate with hearing people, as shown in Figure 11. Furthermore, the system proposes an index for sign language words, sending and receiving SMS in sign language, translation to text or vice versa, video chatting using sign language, recording, and saving students' own sentences using video. The system was evaluated regarding its performance by measuring the system's response time and the time required to produce the result. The cost of using the application was also evaluated, as the application required an Internet connection. Moreover, the system was evaluated against other similar systems in terms of performance and cost.

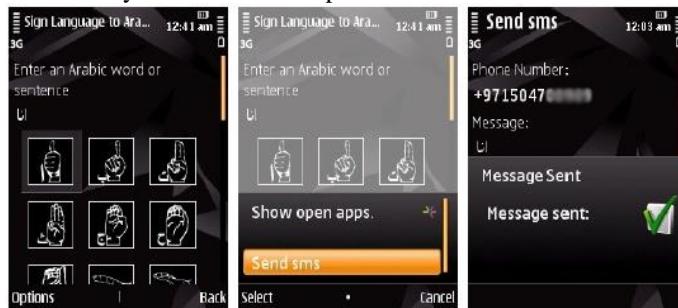


Figure 11: Using ArSL keyboard and sending SMS [20]

The system has good interdependent functions, which makes it an excellent communication application for enabling Deaf people to communicate with both Deaf or hearing people either by text messages or by video chatting. Moreover, the system facilitates the Deaf in learning Arabic sign language. It is a good idea to encourage users to participate in improving the system by allowing them to record a new sentence and save it on the system's DB. More sign language can be added to help the Deaf communicate with each other through using other SL.

3. Embedding Sign Representation in Mobile Phones to Assist the Disabled

Sign writing is a pictorial representation that is confirmed to be closer to real signs made by SLIn[5], a mobile sign writing application used in mobile phones to convert text messages to sign messages and vice-versa either in sending or receiving messages. Figure 12 gives an example of a preview message in sign representation.

4. Applying User Interface Design Process Modes for Mobile Community Project for the Deaf

In [21], a prototype of a mobile social network for the Deaf in Malaysia (DHeaT) was designed to bridge the communication gap between the Deaf and hearing people while they move around. The authors believe that it is highly attractive for the Deaf to have a localized social network on mobile devices for exchanging information as well as for sharing knowledge, experience, interests, hobbies, difficulties and special needs. The systems provide many features, such as blogs, message box, Deaf news, bulletin board, horoscopes, games and fun box. Each of these features is presented in simple graphical icons. Other functions are designed using hierarchical menus. In their evaluation of the system, Deaf users were generally appreciative of the concept of the DHeaT and they enjoyed using the avatar. They expressed that using sign language and video chatting enhanced the communication and learning process. According to the hearing users, the DHeaT is viewed as a novel idea in Malaysia; they believe that sign language texting is a good way to learn sign language.



Figure 12: Example of using mobile sign representation[5]

5. Mobile Sign Language Learning Outside the Classroom

In [22], a mobile sign language learning tool called SMARTSigns was constructed. The goal was to enable hearing parents to learn sign language on their mobile phones to facilitate communication with their Deaf children. The application has three components for learning: search, quiz and practice. Search functions can be used when parents search for ASL videos either by typing the English word or by speaking using speech recognition. Quizzes are used when parents want to study new vocabulary, and a video with ASL is shown. Subsequently, different choices of vocabulary words are displayed and the user has to select one of them. Finally, parents can use the practice components to record themselves performing signs and then compare them to the example videos.

Providing hearing-impaired students with learning care after classes through smart phones and the GPRS network

In [23], authors developed a learning support system to provide after-class learning care by using smart phones and GPRS network. The issue was that teachers of Deaf students face a significant challenge in providing after-class learning care or instruction to support student motivation. The system allows teachers to report student levels in class by using an online in-class interaction system that produces a report for students and sends it to the after-class learning support system. The system applies six strategies to support student learning motivation and improve learning activities; these are: reminding students of homework, assistance strategy if students have difficulty in doing homework, reward strategy to increase student interest in learning, praise strategy to sustain positive learning activity in classrooms and at home, and finally, peer awareness strategy to provide students with peer activity status when students participate poorly in the after-class system. The synchronous interaction between teachers and students is conducted through text messages. The results of the effectiveness test show good results in Deaf student levels.

IV. COMPARISON BETWEEN EXISTING SYSTEMS

After analyzing the existing systems, we compare them to gain a deeper understanding and to exploit the findings of previous works. The comparison is based on different criteria, such as the category of the system, the technique used to present the content, the type of presented data, and technology used to represent sign language. The comparison also includes the features that each system provides.

A. E-learning systems for the Deaf

Table 1 shows the comparison between e-learning systems for the Deaf based on different criteria as follows:

- Type of system: LMS, virtual classroom, webpage translator, dictionary for sign language, etc.
- Technique used to present the content: sign language, sign writing or finger spelling
- Type of presented data: video, animation, images or text
- Language used: either in text or in sign language
- Technology used to represent sign language: video or avatar (animation in virtual world)
- Available features:
 - Select video speed: very important for learners, particularly for beginners
 - Save video: gives the user the option to download and save learning videos to access them offline
 - Glossary with main terms in the content
 - Search in the content
 - Content extraction for further study
 - User file: a file for each user that contains their personal information and test results
 - User tracking: an important facility that helps the teacher track student improvement.
 - Automatic test and automatic grading: either in adaptive systems to evaluate a student's level before starting or as an assessment tool after the lesson.
 - Chatting: either text chat or video chat between Deaf users using SL. This is an important tool that helps Deaf people make contact with other Deaf or hearing people.
 - File sharing: for sharing files between users.
 - Whiteboard and whiteboard tools: considered a shared space between instructor and students with tools that are useful in making asynchronous connections between them and for assisting the instructor to explain lessons more clearly.
 - Template: for the course content, templates help instructors easily build the lessons and the tests.

B. M-learning systems for the Deaf

For mobile learning applications, existing systems are compared according to the following:

- Type of the system
- Techniques used in presented data
- Type of data presented

- Language used
- Technology used to represent sign language
- Available features:
 - Select video speed
 - Save video
 - Search tool
 - Glossary
 - Chatting
 - Use of special sign language keyboard: this will help Deaf people write to and contact other Deaf people easily.
 - Convert SMS text to sign language: facilitate communication between Deaf people and hearing people.
 - Education games: using games as an interesting technique to test and increase Deaf users' level in understanding sign language.

Table 2 illustrates the comparison between the existing systems of m-learning for the Deaf.

The comparison in Table 1 shows that most existing e-learning systems for the Deaf are LMSs. All these systems used sign language as a technique to present data; two systems also used finger spelling as well as sign language. The sign language is presented using video in almost all systems except two systems, which used avatar technology. The data in these systems are presented using text and video, while some add images.

Furthermore, the comparisons in Table 1 and Table 2 demonstrate the different levels of functionality and flexibility in different systems; while some systems have many useful features, others have limited features.

V. OPEN RESEARCH ISSUES AND CHALLENGES

In order to meet the present day needs of the Deaf to keep pace with technology and to maximize the utilization of e-learning and m-learning, certain design requirements should be considered and more research issues should be investigated, as only a few research papers have discussed the special requirements for e-learning systems for Deaf to date. These issues have a strong impact on the accessibility and usability of the systems; therefore, they should be addressed when designing e-learning systems for Deaf users. In this section, we discuss three important elements that affect acceptance and success of e-learning or m-learning systems: the standards in e-learning, how to increase the accessibility of e-learning systems for Deaf users, guidelines for designing and implementing e-learning systems for the Deaf.

Standards in E-learning

E-learning standards are documented agreements containing common rules and guidelines that are used throughout the design and the implementation of any learning course [24].

Standardization is essential in system design and implementation to ensure reusability, portability, flexibility and interoperability. Furthermore, management of learning content becomes easier when standards are applied. Moreover, this will reduce the time and effort the learner needs to learn new courses [25, 26].

Many organizations and institutions have developed standards for e-learning. The most well-known are [24, 26]:

- Aviation Industry Computer Based Training Committee (AICC)
- IEEE Learning Technology Standards Committee (LTSC)
- Instructional Management Systems Project (IMS)
- International Standardization Organization (ISO)

Most e-learning standards can be organized into different classes, such as metadata, glossary and vocabulary, learner information, accessibility, user interface, assessment and collaboration. In [24], the authors illustrate the need for specific standards for m-learning and devices used by m-learning. They indicate the importance of some classes of m-learning standards, such as educational modeling languages, learner information, accessibility and interfaces.

Accessibility of e-learning for the Deaf

Accessibility means the system is usable and accessible to both disabled and non-disabled people. The term is also used to describe the degree to which a system is useable by as many people as possible without modification [25]. It is essential that e-learning systems are easily accessible in order to provide equal access and opportunity to people with disabilities. Deaf people are not the same as other types of disabled people; they do not need specific technology to improve their access to the web. However, they need to be considered by designers and developers when designing e-learning systems [27]. There are several guidelines given by experts in [28] to increase the accessibility of e-learning systems for the disabled. The following are the ones that relate to Deaf learners:

- Materials should be designed for easier conversion into alternative formats. For example, documents created in Microsoft Word or HTML can be read by most screen reader software, and therefore, can be easily converted to sign language when compared to documents in PDF format.

- When information is presented in two ways, visually and with sign language, it is essential that sufficient time is made available for Deaf users to absorb the two modes of information, as the Deaf cannot multi-task; they are unable work on the two modes at the same time.
- Video or films should be captioned to provide access to learners who are Deaf. Captioning is the translation of information presented in audio to a text format. Closed captioning is text that is visible at the discretion of the viewer, whereas open captioning is captioning that remains visible for viewers at all times. Captioning is not the same as subtitling in that captioning includes information about who is speaking as well as background sounds, including sound effects and music. Captioning is essential for learners who are Deaf.
- Communication between instructors and Deaf learners can be undertaken using a teletypewriter and a relay service operator. Video relay service allows a Deaf person to make a call from their video phone to someone who uses a regular phone. This occurs via a video relay call center, which has staff that are professional sign language interpreters. The interpreter and the Deaf person can communicate via video conferencing. At the same time, the interpreter is connected to the hearing caller through a phone and interprets in real time. This allows both parties to communicate in their own language without the need for specialized equipment.
- Video relay service can be used to help Deaf learners participate in video or audio conferences.
- Visual cues or signal feedback should be provided to Deaf learners to inform them about their progress on the course.

Using a text-to-sign browser will increase the accessibility. However, it is not easy or convenient, as it does not translate text word for word into sign language and it requires a huge library of video clips; therefore, it is difficult to translate a site directly. Using plain language on the web will help improve the performance of a text-to-sign browser. Furthermore, making the content suitable for different levels of understanding and using a glossary for specialized vocabulary will increase accessibility [27].

Guidelines for Designing and Implementing E-learning Systems for the Deaf

To increase the availability and usability of e-learning systems for the Deaf, the designer and implementers should consider certain guidelines related to the interface, the features they provide, information presentation methods, etc. The following are guidelines given in [16, 29-31]:

- Choose the most appropriate type of e-learning module according to the system objectives, user's background and user's age. The different e-learning modules that can be selected are: tutorial, exercises, e-exams, simulation and learning using computer games. Tutorials and exercises are suitable for all levels, e-exams are suitable for post primary levels, simulation for high-level Deaf students and computer games are suitable for pre-primary and primary Deaf students.
- Structure material in an understandable and logical manner; and information should be broken down into easily readable chunks.
- Reduce difficult vocabulary and offer a dictionary and glossary of terms.
- Present information in bilingual (written and sign) language).
- Include visual presentation of all audio information.
- Speed of sign language video clips should be suitable for Deaf users so they can track and understand them easily.
- Allow users to repeat play video clips of sign language if needed.
- Use captions with simple language and short sentences that are synchronized with the audio being played.
- Assure quick and understandable navigation inside the learning material.
- Ensure simple user interface.
- Use clear font, large size and color in contrast to the background.
- Remove visual noise from all images, pictures, diagrams, charts etc.
- Ensure that each screen includes output of one unit of learning material or exercise and includes minimal text.
- Let the learning process be controlled by the Deaf user.
- Provide help and guidance in sign language.
- Offer a chatting room between Deaf users, and between Deaf and hearing users. The chatting room should provide a tool to facilitate the communication between Deaf users and between Deaf and hearing users, such as an online translation tool from text to sign language.

VI.CONCLUSION

It is a fact that e-learning has been widely used in all its aspects in recent years. E-learning is an educational process that consists of the use of multimedia and information technology to facilitate access to study materials and support the learning process. The level of computer usage depends on current technological possibilities as well as access to the technology for intended users. This paper has focused on e-learning for the Deaf. The paper gives an overview of research on e-learning systems for Deaf and provides an analysis of the different systems that are proposed to help Deaf people benefit from e-learning technology to increase their education levels and to improve their skills and knowledge. An additional bonus is that it helps expand their relations with hearing people. Some of this research also affords an opportunity for hearing users to connect with

Deaf users easily by learning sign language. Subsequently, we compared the systems according to specific criteria and the special features that they contain. We finalized our survey by discussing important issues that affect the success and approbation of the systems; these are: the special standards for e-learning systems for the Deaf, the instructions to increase the accessibility of systems for Deaf users and the guidelines given by experts that affect the availability and usability of the systems.

Table 1: Comparison between existing e-learning systems for the Deaf

| | Type | Technique used to present data | Data type presented | Language used | Technology used to represent SL | Available features | | | | | | | | | | | | |
|--|--------------------------------------|--------------------------------|--|---------------|---------------------------------|--------------------|------------|-------------|--------------------|----------|--------------|---------------|--------------------------------------|-----------|------------|--------------|---------------------------------|---------------------------|
| | | | | | | Select video speed | Save video | Search tool | Content extraction | Glossary | User profile | User tracking | Automatic test and automatic grading | Text chat | Video chat | File sharing | Whiteboard And whiteboard tools | Template (test , content) |
| An e-Learning System for Deaf People | LMS | sign language | video + text | Greek | video | * | * | * | * | * | | * | * | * | | | | |
| Accessibility System for Deaf Arab Students | Web page converter | sign language | animation + text as line by line SL | Arabic | Avatar | | | | | | | | | | | | | |
| An Enhanced e-learning Environment for Deaf/HOH | virtual classroom | sign language | video + text | ----- | video | * | * | | | | * | | * | | * | * | * | |
| Swift: A SignWriting Editor | Sign writing editor | sign writing | Input: glyph + puppet Output: image | --- | | | | | | | | | | | | | | |
| An e-learning Environment for Deaf Adults | LMS | sign language | video + text | German | video | | | | | | | | | * | * | | | * |
| An Adaptive WWW-based System to teach British SL | adaptive web based e-learning system | sign language | video + text | English+ | video | | | | | | | | * | | | | | |

| | Type | Technique used to present data | Data type presented | Language represented | Technology used to represent SL | Select video speed | Save video | Search tool | Content extraction | Glossary | User profile | User tracking | Automatic test and automatic grading | Text chat | Video chat | File sharing | Whiteboard and whiteboard tools | Template (test , content) |
|---|------------------|--------------------------------|---------------------------------|----------------------|---------------------------------|--------------------|------------|-------------|--------------------|----------|--------------|---------------|--------------------------------------|-----------|------------|--------------|---------------------------------|---------------------------|
| The Italian Sign Language Bank Using WordNet | large dictionary | sign language | video + text | Italian | video | | | * | | * | | | | | | | | |
| Exploring Usability of an E-Learning System for Improving Computer Literacy | LMS (Moodle) | sign language | video + text | ----- | video | | | | | | | * | * | * | * | * | * | |
| Module of Tutorial for Deaf Students | LMS | sign language+ finger spelling | video+ image+ text | English | video | | | | | | | | * | | | | | |
| Effect of special e-learning program on perception of Gemetry | LMS | sign language | video + animation+ images+ text | English | video | | | | | | | | * | | | | | |
| Multimedia course generator for Deaf Children | LMS | sign language+ finger spelling | animation | Different languages | avatar | * | * | | * | | | | | | | | | |

Table 2: Comparison between existing m-learning systems for Deaf users

| | | Type | Technique used to present data | Data type presented | Language used | Technology used to represent SL | Available features | | | | | | | | |
|--|--|---|--------------------------------|----------------------|---------------|---------------------------------|--------------------|------------|-------------|----------|-----------------|---------------------------------------|-----------|------------|-------------|
| | | | | | | | Select video speed | Save video | Search tool | Glossary | Education Games | Convert SMS text to SL and vice versa | Text chat | Video chat | SL keyboard |
| | Proposed Pedagogical Mobile Application for Learning SL | Mobile application to teach sign language | sign language | video + images+ text | Arabic | video | | | * | * | * | | | | |
| | Mobile Arabic SL | Education and communication mobile application for the Deaf | sign language | video | Arabic | video | | | | | | * | * | * | * |
| | Embedding Sign Representation in Mobile Phones to Assist Disabled | Mobile application | sign writing | picture | | | | | | | | * To SW | | | |
| | Applying mobile social network in Makyzia | Mobile social network | sign language | animation | Malay | avatar | | | | | | | * | | |
| | Mobile SL learning outside the class | Mobile SL learning tool | sign language | video | English | video | | * | * | * | * | | | * | |
| | Providing Deaf students with care after class | Learning support system | sign language | video | English | video | | | | | * | | * | * | |

REFERENCES

- [1] A. T. KORUCU AND A. ALKAN, "DIFFERENCES BETWEEN M-LEARNING (MOBILE LEARNING) AND E-LEARNING, BASIC TERMINOLOGY AND USAGE OF M-LEARNING IN EDUCATION," *PROCEDIA - SOCIAL AND BEHAVIORAL SCIENCES*, VOL. 15, PP. 1925-1930, // 2011.
- [2] D. T. A. SALEEM, "MOBILE LEARNING TECHNOLOGY: A NEW STEP IN E-LEARNING," *JOURNAL OF THEORETICAL AND APPLIED INFORMATION TECHNOLOGY*, VOL. 34, 31ST DECEMBER 2011 2011.
- [3] M. S. A. N. EL-SEoud, ANN; TAJ-EDDIN, ISLAM; EL-SOFANY, HOSAM; RUMMAN, NADINE ABU, "A PROPOSED PEDAGOGICAL MOBILE APPLICATION FOR LEARNING SIGN LANGUAGE," *INTERNATIONAL JOURNAL OF INTERACTIVE MOBILE TECHNOLOGIES*, VOL. 7 P. 46, 2013.
- [4] M. M. NASR, "AN ENHANCED E-LEARNING ENVIRONMENT FOR DEAF/HOH PUPILS," IN *COMPUTER TECHNOLOGY AND DEVELOPMENT (ICCTD)*, 2010 2ND INTERNATIONAL CONFERENCE ON, 2010, PP. 724-727.
- [5] A. M. R. C. VENKATASUBRAMANIAM, K. DURAISAMY, D. SUBRAMANIAM, AND M. CHELLADURAI, "EMBEDDING SIGN REPRESENTATION IN MOBILE PHONES TO ASSIST DISABLED," *COMPUTER TECHNOLOGY & APPLICATION*, VOL. 2, PP. 42-47, 01// 2011.
- [6] C. NEWELL AND M. DEBENHAM, "DISABILITY, CHRONIC ILLNESS AND DISTANCE EDUCATION," IN *ONLINE AND DISTANCE LEARNING: CONCEPTS, METHODOLOGIES, TOOLS, AND APPLICATIONS*, ED: IGI GLOBAL, 2008, PP. 3214-3223.
- [7] P. PRINETTO, U. SHOAIB, AND G. TIOTTO, "THE ITALIAN SIGN LANGUAGE SIGN BANK: USING WORDNET FOR SIGN LANGUAGE CORPUS CREATION," IN *COMMUNICATIONS AND INFORMATION TECHNOLOGY (ICCIT)*, 2011 INTERNATIONAL CONFERENCE ON, 2011, PP. 134-137.
- [8] C. S. BIANCHINI, F. BORGIA, AND M. DE MARSICO, "SWIFT - A SIGNWRITING EDITOR TO BRIDGE BETWEEN DEAF WORLD AND E-LEARNING," IN *ADVANCED LEARNING TECHNOLOGIES (ICALT)*, 2012 IEEE 12TH INTERNATIONAL CONFERENCE ON, 2012, PP. 526-530.
- [9] S. M. SHOIEB, A. E. HASSAN, M. A. ELSOUD, AND M. S. KANDIL, "ACCESSIBILITY SYSTEM FOR DEAF ARAB STUDENTS," IN *COMMUNICATIONS AND INFORMATION TECHNOLOGY (ICICT)*, 2009 ITI 7TH INTERNATIONAL CONFERENCE ON, 2009, PP. 57-60.
- [10]S. KHWALDEH AND M. SHAH, "THE ADAPTABILITY OF AN OPEN SOURCE LEARNING MANAGEMENT SYSTEM FOR DEAF CHILDREN IN JORDAN," IN INFORMATION MANAGEMENT AND ENGINEERING (ICIME), 2010 THE 2ND IEEE INTERNATIONAL CONFERENCE ON, 2010, PP. 34-39.
- [11]Y. JOONG-O AND K. I. M. MINJEONG, "THE EFFECTS OF CAPTIONS ON DEAF STUDENTS' CONTENT COMPREHENSION, COGNITIVE LOAD, AND MOTIVATION IN ONLINE LEARNING," *AMERICAN ANNALS OF THE DEAF*, VOL. 156, PP. 283-289, SUMMER2011 2011.
- [12]H. HAMILTON, "THE EFFICACY OF DICTIONARY USE WHILE READING FOR LEARNING NEW WORDS," *AMERICAN ANNALS OF THE DEAF*, VOL. 157, PP. 358-372, 2012.
- [13]H. AL-KHALIFA AND A. AL-SALMAN, "MOBILE PHONES FOR PEOPLE WITH DISABILITIES," IN *ENCYCLOPEDIA OF MOBILE COMPUTING AND COMMERCE*, ED: IGI GLOBAL, 2007, PP. 569-575.
- [14]A. S. DRIGAS, D. KOUREMENOS, S. KOUREMENOS AND J. VRETTAROS, "AN E-LEARNING SYSTEM FOR THE DEAF PEOPLE," IN INFORMATION TECHNOLOGY BASED HIGHER EDUCATION AND TRAINING, 2005. ITNET 2005. 6TH INTERNATIONAL CONFERENCE ON, 2005, PP. T2C/17-T2C/21.
- [15]J. OHENE-DJAN AND S. NAQVI, "AN ADAPTIVE WWW-BASED SYSTEM TO TEACH BRITISH SIGN LANGUAGE," IN *ADVANCED LEARNING TECHNOLOGIES*, 2005. ICALT 2005. FIFTH IEEE INTERNATIONAL CONFERENCE ON, 2005, PP. 127-129.
- [16]M. DEBEVC, P. POVALEJ, M. VERLIC AND Z. STJEPANOVIC, "EXPLORING USABILITY AND ACCESSIBILITY OF AN E-LEARNING SYSTEM FOR IMPROVING COMPUTER LITERACY," *NEW TRENDS IN ICT & ACCESSIBILITY*, PP. 119-124, 2007.
- [17]K. HUSSEIN AND A. AL-NISOUR, "E-LEARNING MODULES OF TUTORIAL LESSONS FOR THE DEAF STUDENTS: DEVELOPMENT AND EVALUATION " *IJCSNS INTERNATIONAL JOURNAL OF COMPUTER SCIENCE AND NETWORK SECURITY*, VOL. 9, SEPTEMBER 2009 2009.
- [18]J. K. KIBOSS, "EFFECTS OF SPECIAL E-LEARNING PROGRAM ON HEARING-IMPAIRED LEARNERS' ACHIEVEMENT AND PERCEPTIONS OF BASIC GEOMETRY IN LOWER PRIMARY MATHEMATICS," *JOURNAL OF EDUCATIONAL COMPUTING RESEARCH*, VOL. 46, PP. 31-59, 2012.
- [19]O. EL GHOUЛ AND M. JEMNI, "MULTIMEDIA COURSES GENERATOR FOR DEAF CHILDREN," *INTERNATIONAL ARAB JOURNAL OF INFORMATION TECHNOLOGY (IAJIT)*, VOL. 6, PP. 458-463, 2009.

- [20]F. AL AMEIRI, M. J. ZEMERLY, AND M. AL MARZOUQI, "MOBILE ARABIC SIGN LANGUAGE," IN INTERNET TECHNOLOGY AND SECURED TRANSACTIONS (ICITST), 2011 INTERNATIONAL CONFERENCE FOR, 2011, PP. 363-367.
- [21]W. CHUI YIN, K. CHEE WENG, AND H. THWAITES, "APPLYING USER INTERFACE DESIGN PROCESS MODEL FOR A MOBILE COMMUNITY PROJECT FOR THE DEAF," INTERNATIONAL JOURNAL OF INTERACTIVE MOBILE TECHNOLOGIES, VOL. 2, PP. 30-37, 2008.
- [22]K. A. WEAVER AND T. STARNER, "MOBILE SIGN LANGUAGE LEARNING OUTSIDE THE CLASSROOM," ONLINE SUBMISSION2012.
- [23]L. CHEN-CHUNG AND H. YI-CHING, "PROVIDING HEARING-IMPAIRED STUDENTS WITH LEARNING CARE AFTERCLASSES THROUGH SMART PHONES AND THE GPRS NETWORK," BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, VOL. 38, PP. 727-741, 2007.
- [24]F. MIKIC AND L. ANIDO, "TOWARDS A STANDARD FOR MOBILE E-LEARNING," IN NETWORKING, INTERNATIONAL CONFERENCE ON SYSTEMS AND INTERNATIONAL CONFERENCE ON MOBILE COMMUNICATIONS AND LEARNING TECHNOLOGIES, 2006. ICN/ICONS/MCL 2006. INTERNATIONAL CONFERENCE ON, 2006, PP. 217-217.
- [25]F. MIKIC, L. ANIDO, E. VALERO AND J. PICOS, "ACCESSIBILITY AND MOBILE LEARNING STANDARDIZATION," IN SYSTEMS, 2007. ICONS '07. SECOND INTERNATIONAL CONFERENCE ON, 2007, PP. 32-32.
- [26]I. ADINA, "E-LEARNING STANDARDS," INFORMATICA ECONOMICA, VOL. 1, 2007.
- [27]C. BOLDYREFF, E. BURD, J. DONKIN, AND S. MARSHALL, "THE CASE FOR THE USE OF PLAIN ENGLISH TO INCREASE WEB ACCESSIBILITY," IN WEB SITE EVOLUTION, 2001. PROCEEDINGS. 3RD INTERNATIONAL WORKSHOP ON, 2001, PP. 42-48.
- [28]F. BROKOP AND S. MCINTOSH, "ACCESSIBILITY TO E-LEARNING FOR PERSONS WITH DISABILITIES:STRATEGIES, GUIDELINES, AND STANDARDS," NORQUEST COLLEGE2008.
- [29]K. STRAETZ, A. KAIBEL, V. RAITHEL, M. SPECHT, K. GROTE AND F. KRAMER, "AN E-LEARNING ENVIRONMENT FOR DEAF ADULTS," PRESENTED AT THE CONFERENCE PROCEEDINGS 8TH ERCIM WORKSHOP ON USER INTERFACES FOR ALL, 2004.
- [30]M. AL-BAYATI AND K. HUSSEIN, "EVALUATING THE EFFICIENCY OF THE INSTRUCTIONAL WEBSITES "WHICH ARE ORIENTED TO THE DEAF STUDENTS " ACCORDING TO THE TECHNICAL CRITERIA", JCIT, PP. 138-145, 2010.
- [31]A. DELLAPORTA, "WEB ACCESSIBILITY AND THE NEEDS OF USERS WITH DISABILITIES," IN ADVANCES IN UNIVERSAL WEB DESIGN AND EVALUATION: RESEARCH, TRENDS AND OPPORTUNITIES, ED: IGI GLOBAL, 2007, PP. 1-24.