Multimodal Accessibility for Deaf Students Using Interactive Video, Digital Repository and Hybrid Books

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Abstract. Modern inclusive educational approaches try to eliminate educational inequalities and barriers in the learning and teaching process. For this reason, and by using Information and Communication Technologies (ICT), it is necessary to differentiate educational material and tools in order to allow all students, including those with disabilities, to access education. The objective of this paper is to present the innovative interactive applications for the education of Deaf and Hard of Hearing (D/HH) students. The content of the educational documents is rendered in Greek Sign Language (GSL). The multimedia electronic form of the Hybrid books combines the presentation of the original printed book in GSL, the text in subtitles underneath the GSL video, videos with text navigation as well as the audio recording of the text by a native speaker. The applications are free and accessible to all via the web, offer various benefits to students, teachers, parents and others involved in the education of D/HH students.

Keywords: Interactive technology, Hybrid books, inclusive education, accessibility, Deaf education

1 Introduction

Modern educational approaches are based on the principles of inclusive education that promote equal learning and participation opportunities for all students including students with disabilities [1,2,3]. In this context educational systems design and develop policies and practices, educational environments and means accessible to all students following the principles of Universal Design for Learning (UDL) and differentiated teaching. All the above enable students to use their own learning paths, ways and strategies for the acquisition of knowledge [4,5]. This requires adaptations and variations according to the educational needs and the learning profile of each student. The dynamic relationship between UDL and ICT is a powerful tool towards differentiated teaching and inclusive education, as technology supports accessibility and differentiation of the content, material and the educational learning environments [6], [3].

The rapid development of ICT increases students participation and autonomy, triggers their interest, supports the understanding of teaching content and promotes accessibility. For D/HH students technological solutions are effective for enhancing the

learning process in all subject areas, for developing their academic and world knowledge, and for expressing their needs, opinions and beliefs [7, 8, 9,10].

For D/HH students in particular, whose basic learning channel is visual, the results from the use of interactive applications that include signed language are impressive since they can minimize the loss of incoming information. Besides, as it is supported by the international scientific community, the most effective approach of D/HH students is the bilingual educational model, with the use of signed language as a first language [11, 12,13,14]. An alternative interactive application to support the acquisition and process of information of D/HH students are visual displays with transcripts that can be read along with their translation into the national signed language [9], [3]. The D/HH realize the world through vision and operate in all areas and aspects of their lives by mainly using the sense of sight. Moreover, as they structure their thinking and language through vision they do not view their hearing particularity as problematic. The ability of D/HH people to exploit their sense of sight is their main common characteristic. This fact necessitates the strengthening of visual stimuli and the development of material that take into account their ability to see [14].

Recently and within the context of technological evolution and its use in education, various interactive tools and applications that expand the students' access to knowledge and the learning process have been designed [9]. The present work aims to present supportive interactive applications for signed language navigation and text presentation as well as proposals for their use in the learning and teaching process of D/HH students. The project, the methodology and the applications will be presented below.

2 The Project

The Institute of Educational Policy (IEP) aims to implement in the Greek educational system the decisions taken at the UN International Convention on the Rights of Persons with Disabilities [15] related to the development of inclusive policies and practices using ICT and specifically interactive applications. In this context, IEP has implemented the project "Design and development of accessible educational material and software for students with disabilities" and has developed supportive interactive open source applications adapted to the needs of D/HH students. It includes the development of video applications with interactive subtitles and the design of textbooks that provide a simultaneous use of Greek Sign Language. All applications include a comprehensive user's guide and a teacher's manual in accessible formats.

These applications were necessary in order to support the educational use of the developed material. Particularly, the applications were needed for the most efficient use of the adapted textbooks of the two first grades of primary school for D/HH students. For the implementation of this task the following questions were addressed:
1. What is the most appropriate interactive application for the most efficient support of D/HH students?
2. What are the criteria, characteristics and procedures for the development of the application?

3. How can the application be used by everyone involved in the learning or stu-dying of signed languages?

3 Methodology

This project follows the principles of a qualitative methodological approach and thematic and content analysis of texts, multimedia applications and research data. The analyzed texts were institutional, scientific, European, international and research data related to inclusive education, disability and deafness. In particular, the project focuses on the contribution and use of ICT in the learning process and modern teaching methodologies related to the pedagogical and scientific documentation of criteria and development standards of interactive applications for D/HH students [16]. At the same time, it refers and draws on emancipatory methodological approaches since Deaf native signers have been fully involved during the implementation of the project [17].

Moreover, special experts have developed the needed standards and criteria for the project while they sought for corresponding on-line software. Some of the mandatory criteria were the following: the application had to be licensed as open source software, it had to offer quick and easy navigation and also to be editable and adaptable to the needs of the D/HH. Specifically, it had to provide all available teaching material with Greek Sign Language (GSL), and so a corpus of more than twenty-two thousand sign videos was built, using interactive subtitles and natural voice recordings, presenting as such all information multimodally. Multimodality allows D/HH children to have a better understanding of the text [18]. Other standards followed was full screen video, all known functions of playing video (i.e. custom regulated speed and text navigation) and screen captures for individual sign printing, a useful tool in the hands of D/HH teachers.

The most appropriate application for the interactive digital library that was chosen from the search results and met the necessary criteria was pan.do/ra (http://pan.do/ra#about). Pandora is a free, open-source platform of digital files that allows the management of large video collections, the collaborative creation of metadata and time based annotations. Finally, it offers the option to view files as a network application on any computer.

The platform is based on a java digital library (OxJS) (https://oxjs.org/#about). Initially this application was translated into Greek and then adapted to the needs of the D/HH students and GSL. It was updated with the use of GSL in films of educational context, natural voice (in Greek), and finally transcripts were added on the entire content of the material which was further divided into subject areas. This is a procedure that many renowned researchers and developers have followed [19], [16], [21], [18].

4 Interactive Digital Library

The development of this application for the education of D/HH students was created to cover the need for designing and developing differentiated and accessible educational resources and materials drawing from the principles of Universal Design for Learning (UDL) [22,23]. The application is free and accessible to everyone interested or involved

in the teaching and learning process of D/HH and hearing students. Access to the platform is available in the project website www.prosvasimo.gr. The application allows users to browse the filmed content through the use of time defined transcripts, set next to the video in the form of selectable menus that link to the respective time point in the video. The educational content is rendered both in natural voice, in GSL and includes video transcripts that can be read by the users. This multisensory approach and use of a bilingual educational environment motivates students, increases their participation, allows access to information and enhances understanding of the teaching material. In addition, this specific application supports GSL teaching and learning of GSL [16], [24,25]. This interactive application involves a) the use of interactive smart subtitles and b) the creation and enrichment of a digital library-repository.

The filmed educational material for D/HH students that is uploaded on the platform, such as tales, stories, textbooks and presentations, is presented with interactive subtitles. The user can browse the video by selecting subtitles (Fig. 1.A) and also search for words and phrases included in the subtitles (Fig. 1.B) with a simultaneous playback of the video in the specific-selected point. The total number of search results can also be displayed and users can navigate among them. It is also possible for users to search subtitle content among all videos (Fig 1.C) of the platform. The application supports the introduction of new subtitles and their processing, the presentation of the video in time series (time - line) in four different forms (Anti-Alias, Slit-Scan, Keyframes, Waveform), and gives users the option to select and play back certain segments of the filmed material. Furthermore, the users can add new material or combine information that has already been collected in the platform. During video playback there is an option to repeat the current scene of the video, the possibility to upload videos in mpeg and mp4 formats and to optimize the playback quality (playback videos in high definition (1080p). All users can download in a WebM format the presented videos using direct download or torrent software. Another feature is the possibility to save the URL address of the video as it is being played, at a specific time, and then use this address for the video playback, starting from the time when the URL address was saved. The video is stored and played from a local server, without the use of a central video service like YouTube. The entire application with its material can be installed either in schools or locations which do not have internet access but have computing units (with good processing power and storage options), or in schools whose computers are interconnected in a local area network.

Fig. 1. Playback of educational material with interactive video subtitles (A. Browse video using subtitles, B. Search for subtitles in the video being played, C. Search for subtitles in all the videos of the platform.)

Except for the possibility to use interactive video subtitles, this platform is actually a digital database, a repository that apart from audiovisual material can also accept documents (PDF, Word) which can be then either combined with or linked to specific videos. In this way an integrated content base is created.

All materials along with the subtitled text are quickly and easily available through the use of advanced search options where the user can search for specific words and phrases among the subtitles. Search results can be limited to either a video or contain elements from all the material of the platform. Search can display the videos or clips which include the word or phrase that has been searched, classify them by using various filters (e.g. duration, title, resolution etc.) and also play each clip or video separately. In every search the detected words or phrases are highlighted in yellow.
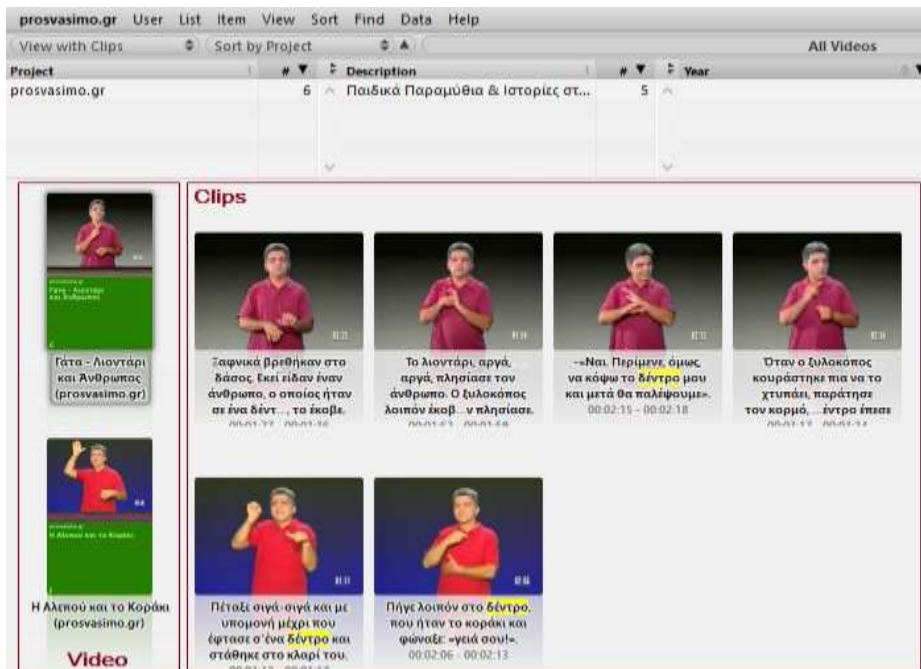
Fig. 2. Search Example. Displays the videos on the left and the corresponding clips containing the word "tree" on the right.

The material of the interactive application is characterized by ergonomy and vi-sually appealing graphics. The interactive application operating as a digital library offers the alternative to archive and search through the uploaded material (Fig. 2) within the framework of several criteria: thematic, calendrical and geographical. U-sers can also view the history of the uploaded files. These features support both educational and administrative work. The application can be used to archive student data as well as to evaluate them [26]. In addition, all the material (documents and visual components) can be printed and are automatically distributed du-ring upload into separate folders.

5   Hybrid Books

A recent study [24] of dyslexic children in Denmark suggests that hybrid audio books are in many ways an obvious candidate for a standard format for accessible schoolbooks for people with reading difficulties. Still, questions regarding the appropriate formats for different end users or contexts, the use of speech synthesis, the typography and structure remain unanswered.

A similar technology used by the Masaryk University known as "Hybrid Book" [27] was used as a model for the creation of study materials aimed at users with different disabilities such as visual, hearing, motor, mental and others.

Our initial focus group consists of D/HH students attending the first two grades of primary school. The format that has been developed in order to cover the educational needs of this age group and to avoid further differentiation, is following the original text format of the national curriculum books.

The multimedia electronic form of the Hybrid books (either in the form of a single copy or a web application) combines the presentation of the original printed book in GSL, the text in subtitles underneath the videotaped presentation of the GSL video, videos with text navigation (see Interactive digital library) as well as the voicing of the text by a native speaker. The data in multimedia PDF, video and audio files is available in independent files for multiple uses.

Fig. 3. Screen from a Hybrid book whose accessible interface presents the text with the use of Greek Sign Language for the Deaf and Hard of Hearing students.

The end products include a) all the textbooks of the first two grades of elementary school, developed by using written and spoken Greek and Greek Sign Language (see sample screen shot in Fig. 3) b) the development of special education material for language readiness (Kindergarten) and the learning of Greek Sign Language (GSL) as a first language in the first two elementary grades.

Major attention was given to the relationship between the spoken and the sign language text, so that end-products will be used effectively in bilingual educational practices. The signed text is in accordance with the Greek text at a word, phrase or period level. The quality of the text in GSL is the most important aspect of accessibility and has also played a key role in the evaluation of the end-product. The translation of a text in GSL is either very close to the original context or it is more flexible and closer to an adaptation. Using the same textbooks, the authors sometimes either seek for content comprehension or place emphasis on learning vocabulary, Modern Greek grammar or the acquisition of phonological awareness. If the objective is to understand the text, then the signers - interpreters have followed an approach that tolerates distance from

the text and focuses on the gist. If the objective is grammatical, syntactic or phonological awareness, then interpretation mostly follows the original source.

It is made evident from all the previous productions that signing Greek texts is an extremely demanding and difficult task [9]. The signing of the texts is done, on the one hand, in cooperation with experienced native signers, deaf tutors or consultants (all fluent in Greek) and on the other, with professional interpreters of GSL. These two categories of professionals have worked collaboratively forming a team of bilingual translators. Their subject knowledge, the knowledge of the target group and their experience in educational interpreting are also important factors that have been taken into account.

It is emphasized that, during the conversion of textbooks to accessible educational materials, much significance has been given to signed text because the efficient use of GSL constitutes the core of the project.

Finally, all material developed aim to fulfil the requirements of Design-for- All and are compatible with international practices such as the DAISY Web Player [28].

6   Results

The deliverables of the Project have been evaluated by a group of experts, teachers and pre-service teachers of Deaf children.

Table 1. Evaluation of both the sample and the final material

Subjects	GSL (2 subjects)	Hybrid books (4 subjects)	Interactive digital library
Sample	109	109,4	107
Final	110	109,5	107

The evaluation of the sample and the final material was based on the evaluation criteria developed by the expert committee and resulted in the above mean values results. The evaluation scale was developed to either decline the deliverables if they were rated below 80, accept them if they were rated from 80 to 100 and strongly accept them when the deliverables where rated from 100 to 110. All the accepted samples were ra-ted from 107 (Interactive digital library) to 109,4 (Hybrid books for D/HH) and all the final material was rated between 107 (Interactive digital library) and 110 (Teaching Greek Sign Language as a first language), (Table 1.). This high rating of the final material is very encouraging for any further developments and applications while it is consistent with the overall evaluation.

Evaluation of the pilot implementation is currently underway and will be completed by the end of the school year 2015-2016. The accessible educational material was presented in four regions of Greece (Ioannina, Alexandroupoli, Volos and Rhodes) with impressive quantitative and qualitative initial results. More than 200 in-service and pre-service teachers of the Deaf are currently evaluating the material.

A formative assessment of the overall project was carried out to ensure its quality and effectiveness when put into broader practice. The project and its deliverables were evaluated by the European Union (European Social Fund – ESF 2007-2013). As a result of this evaluation the project was rated as one of the 11 best of the Ministry of Education and one of the 30 best in Greece. These results are very encouraging, particularly for continuing the development of accessible educational material for students with disabilities and special educational needs.

7   Conclusions

The benefits of the application are multiple and affect students, teachers, parents and everyone involved in the educational process. D/HH students can thus acquire access to knowledge and information, the national curriculum and the learning of GSL. Hence, their involvement in the learning process is increased and their capability to understand and handle the incoming information is enhanced [21], [29], [10], [6], [5]. Moreover, teachers can use the application in the design and implementation of educational programs, in the evaluation process and in many other aspects of their work. Parents can use it not only to support their children, but also to learn GSL by themselves. Finally, any other professional interested in expanding their skills and understanding the problems of special education may optionally use this application.

The development of this application promotes accessibility to education and thus minimizes barriers to learning, particularly among D/HH students, at the same time, it also creates the right environment for the implementation of inclusive practices. This application apart from supporting the education and learning process of D/HH students and their learning of GSL, can be also used by all students. Such broader usage and practice can make it more viable, further developed and adapted to various environment. The innovative use and development of interactive subtitles makes it the appropriate tool, accessible to all, freeware, and adapted to the needs of D/HH students. It is an application that could be also used as a repository for the collection and processing of new material like videos and documents.

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