Digital Accessibility in the Education of the Deaf in Greece

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Abstract. This article begins with an introduction to the digital accessibility as a human right followed by the presentation of the educational needs of deaf children and the challenge to fight the linguistic and cultural deprivation they are faced with. We present the project "Universal Design and Development of Accessible Digital Educational Material" and the steps and procedures for development and production of our open accessible digital educational materials for deaf students. We present the Digital Multimedia Library, the Online Dictionary, the multimedia accessible e-Books in detail within the bilingual context, the Curriculum-based Assessment instruments and the newly developed application for testing expressive sign language skills. The initial results from the implementation of these ongoing research and development project, suggest that our project is cohesive and successful pedagogical practice for accessible bilingual education and for learning of deaf children in Greece with great possibilities to be applied in any Signed Language of the world. We conclude that the use of interactive accessible digital material supports the documentation, development and use of GSL and provides deaf students a communicative tool that helps prevent linguistic and cultural deprivation.

Keywords: Open educational resources · Digital accessibility · Greek sign language · Universal Design · Multimedia bilingual e-Books

1 Introduction

Digital accessibility in the education of the Deaf in Greece, as it is in countries all over the world, has been a challenge for educators, the assistive technology sector, governments, and world organizations [1]. Accessibility is a human rights issue that the United Nations has addressed. The United Nations Convention on the Rights of Persons with Disabilities (CRPD) [2] established that accessibility is a prerequisite to enjoying the rest of the rights enshrined in the Convention.

The CRPD, the first international treaty that explicitly mentions sign language, is a human rights instrument with great importance for deaf people. Article 24 (Education) (3b), mandates that State Parties shall *"Facilitat[e] the learning of sign language and the promotion of the linguistic identity of the deaf community*."

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The 2030 agenda for the sustainable development of the United Nations [3] is a broad and universal policy with broad principles and commitments. These commitments include providing access to a quality education, fostering a sense of inclusion and equality, and creating the opportunity for lifelong learning.

The principles of the Universal Design for Learning (UDL) [4] should be accessible to all students [5]. Educational systems must provide each student with the opportunity to evolve using individually tailored methodologies, tools, and materials [6].

A recent study that systematically reviewed 31 relevant papers provided insights about accessibility and functional diversity within open educational resources [7]. The study concluded that only nine (9) countries (Ecuador, Spain, UK, Greece, Ireland, Turkey, Uruguay, Tunisia, and Italy, in order of published papers per country) were involved in the investigation of the use of Open Educational Resources (OER) and Open Educational Practices (OEP) for accessible learning.

2 Deaf Children and Educational Challenges

Over 90% of deaf children in Greece are born to hearing parents who do not know or use a natural Sign Language (SL). This phenomenon is not unique to Greece. Thus, the majority of deaf children in the world have little to no receptive experience with any language. Deaf children's lack of exposure to an accessible SL impacts language fluency and proficiency throughout their lives [8–11].

In most cases, deaf children lack exposure and access to a natural language in early childhood until they come in contact with other deaf children through sign language in school [8, 12–14] among others). It has been shown that delayed exposure to a first language in childhood affects all subsequent language acquisition in all modalities [14, 15].

International studies demonstrate that academic progress, in addition to social and emotional growth, in deaf children is directly related to the acquisition of sign language as a first language. Furthermore, empirical findings on the acquisition of sign languages by deaf children of deaf parents who learn a sign language naturally have been shown to follow the same developmental path as hearing children learning spoken languages [8, 9, 16–20].

Theoretical and practical findings alike demonstrate that early exposure to SL through proper teaching techniques improves deaf children's written literacy [8, 16, 18, 21, 22].

The work of Mirus and Napoli [23] noted the effectiveness of using Bimodal-Bilingual eBooks for both deaf children and hearing adults. Specifically, they stressed the increasing need for bimodal-bilingual eBooks for pleasure—to develop pre-literacy skills—and the need for pedagogical eBooks designed specifically for acquiring academic knowledge. Mirus and Napoli [23] concluded by acknowledging the unfortunate shortage of such eBooks.

For deaf students, technological solutions can be particularly effective for enhancing learning in many subject areas, such as language development and literacy, world knowledge, and communication [24–27]. ICT facilitates deaf students' access to communication, interaction, and information because it presents information visually. A visual approach is most effective for deaf students because they rely on sight alone to

develop language and thought. Deaf students comprehend the world through sight [9, 28]. Consequently, we take advantage of ICT by presenting information via Signed Language, which allows deaf students to visually access the data that already exists in written form. Employing this technique makes academic content fully accessible to deaf students. The next section discusses the creation of teaching and assessment materials that will deliver previously inaccessible content to deaf students.

3 The Universal Design Project

In the context of the project "Universal Design and Development of Accessible Digital Educational Material," bearing the acronym "Prosvasimo," we will present the instructional materials (e.g., creating, adopting, and adapting teaching materials) that we developed for the last five years in Greece. The final products of Prosvasimo are, first, Open Educational Resources and, second, resources for students with various disabilities that attend mainstream schools. All material is publicly available on project's site: http://prosvasimo.iep.edu.gr/el/.

The development and production of our open digital, educational materials for deaf students follow the basic accessibility technological requirements proposed by Kouroupetroglou [29]. Since that study, Zhang et al. [7] also have recommended four accessibility attributes that researchers should focus on when providing Open Educational Resources (OER):

Perceivable Content: Information should be presented to users in modalities they can perceive—in Greek Sign Language, in written Greek, or in a natural voice (for deaf children that can perceive information acoustically with the sound amplification devices). We use professional narrators who are native Greek speakers, instead of the recommended Automated Reading Devices (ARD) or Text-to-Speech systems [29], which are too expensive and time consuming to meet the receptive needs of hard of hearing students.

Operable Platform and Software: The interface components, navigation, browsing and searching require simple interaction that deaf children can easily perform.
Understandable Content: Content should be fully understandable and tested with curriculum-based assessments. The levels of content must be differentiated to meet the needs of all language users.

Robust Content: The material should be complete from Kindergarten through Fifth Grade, along with five additional levels of content teaching GSL as a first language. All interfaces should be interrelated, open, and accessible to a wide variety of users, including parents and teachers.

In the present article, due to size limitations, we will focus on only materials designed for bilingual education of deaf children with the use of sign language. Specifically, we will present 1) the interactive Digital Multimedia Library, 2) the Open Online Sign Language Dictionary, 3) the fully Accessible, Multimodal e-Books for bilingual instruction, and 4) the Curriculum-Based Sign Language Assessment instruments.

4 Methodology

The methodology for the development and production of our open, accessible digital educational materials for deaf students is presented in accordance with the four steps and procedures proposed by Ruemer, Kouroupetroglou, Murillo-Morales, and Miesenberger [30]: the source, the conversion, the presentation, and the workflow, in addition to the evaluation of the end result by teachers.

4.1 The Source

The source of our academic content (Modern Greek, Greek literature, History, Math, Social-Environmental studies and Religion affairs) is the official printed textbooks used in general education developed by the Department of Education from K - 12. The source consists of 43 books with a total of 4601 pages making it the largest accessible digital educational materials ever produced in Greece for the education of deaf students.

The source of Greek Sign Language as a first language is developed by the first author and Marianna Hatzopoulou (4th Grade). It covers, so far, five levels (grades K-4th).

4.2 The Conversion

All printed source materials are available in PDF or enriched HTML format at the official website of the Publishing House of the Department of Education "ITYE Diofantos" http://ebooks.edu.gr/new/allmaterial.php. All content of the text books is divided into meaningful units from a word level (single vocabulary items or terms) to a sentence level for voicing, presenting in GSL, and for integrating interactive subtitles.

The materials for teaching GSL as a first language are transcribed using simple GLOSSING and written Greek. Glossing is a transcription system of signs in a written form that uses capital letters (and other indicators of pointing signs, classifiers etc.) for writing the meaning of each sign in order of appearance following GSL syntax [31]. We follow the same methodology for the fairytales, oral stories, and picture stories.

4.3 The Presentation

The procedure of the presentation of the sources in GSL is the most innovative, expensive, time-consuming, and demanding part of the production. We used only native signers when developing our digital material [8] of all GSL data, interactive signed stories, signed lexical items, and signed assessment tools. Native signers come in two forms. First, they can be Deaf adults that have Deaf parents and learned GSL as a first language. Second, they can also be Deaf adults that learned GSL as a first language at a residential school for the Deaf, are active members of the Deaf Community, and/or teach GSL as a first or second language. In all production processes native signers collaborated with professional GSL interpreters and active members of the Deaf Community.

4.4 The Workflow

The efficient production of accessible educational materials involves management of human, financial, and technical resources to deliver robust and understandable content that will be used in an operable platform and/or software. This was a significant challenge.

4.5 The Evaluation

Two groups of teachers of the Deaf (fifty-one in total) evaluated the effectiveness of the applications we developed. The first group was comprised of twenty-three (23) teachers of the Deaf in five (5) day schools of the Deaf (K - 12). These teachers completed the assessments after school. The second group was comprised of twenty-eight (28) teachers in twenty one (21) inclusive educational setting serving deaf children. This group completed a seven-section online quantitative and qualitative evaluation.

Most participants (44) were female, and most participants (40) were hearing. Thirty-two (32) evaluators were below forty years old and nineteen (19) were above forty years old. The majority of the participants work on the mainland (46); only five work on the islands.

The methodology and the tools used to develop the applications are presented in each separately due to the unique character of each tools used.

5 Open Accessible Applications

In this section we will present the Digital Multimedia Library, the Online Dictionary, the Curriculum-based Assessment instruments, the newly-developed application for testing expressive sign language skills, and, finally, the e-books that cover the educational needs of deaf children in Greece. We have been developing and refining these projects since 2010. All of the digital material is designed to meet the needs of learners who use Sign Language as a first language (L1) or as a second language (L2).

5.1 The Digital Multimedia Library (DML)

The Digital Multimedia Library (DML) for bilingual education (SL and Print) is a platform for teaching signed language as a school subject and also general content teaching, such as Written Greek Literature (Fig. 1). (http://multimedia-library.prosvasimo.gr/DZ/player/E). The DML is based on the pan.do/ra platform (http://pan.do/ra) and the javascript OxJS library (https://oxjs.org/#doc) and is implemented, using the PostgreSQL database. The Digital Multimedia Library is installed in Ubuntu OS 14.04 LTS 64 bit, runs on nginx web server and is able to accept various video formats (.mp4, .webm, .mpeg) all of which are easily converted into .webm format during the uploading. The signed stories can be viewed in many different ways to meet the pedagogical and communicative needs of the users.

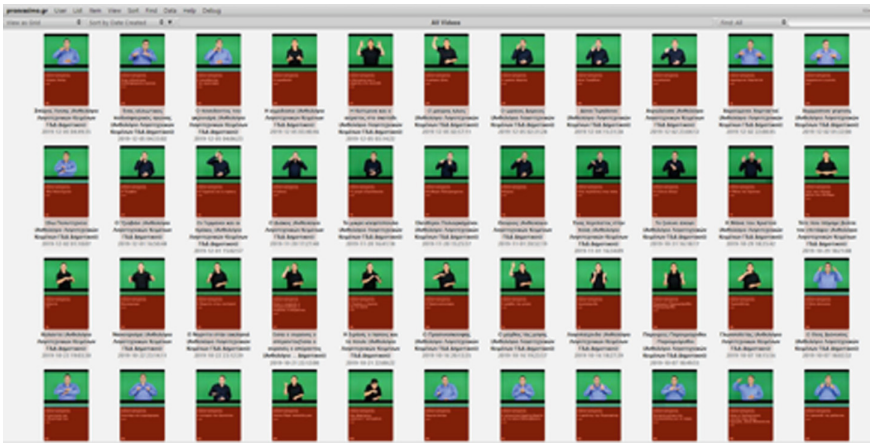

Fig. 1. Partial display of Written Greek Literature content in the DML

The Digital Multimedia Library (DML) for bilingual education (SL and Print) (Fig. 1) is an independent platform that contains signed stories from the digital e-Books. It is continuously updated with newly-developed content (http://multimedia-library.prosvasimo.gr/DZ/player/E).

The DML does not allow the user to upload videos of their own. The administrator of the project can upload such videos if she chooses. Video downloading is available to anyone through the platform's web graphical interface. The interactive video subtitles are generated automatically using the graphical interface or by uploading subtitle files (. srt files) using the platform's video upload interface.

The Digital Library includes signed stories ranging from 38 s to 35 min in length. A GSL corpus of more than forty-thousand signed videos has been constructed and is open to all, making it the largest trove for GSL available. Part of the open data has been used for a PhD thesis at the University of Western Macedonia, Kozani, Greece, and for developing sign language applications in a European funded research project "aRTIFICIAL iNTELLIGENCE for the Deaf" (https://aideaf.eu/) at the University of Technology, Limassol, Cyprus.

This multisensory (visual: SL & print, plus audio: spoken translation) approach may be used in a bilingual environment to motivate students. An increase in motivation will result in an increase in their participation in classrooms; as information becomes more accessible, students will better comprehend the material. These applications support teaching and learning GSL (L1) and written Greek (L2) [8, 19, 22, 31].

The signed stories can be viewed in many different ways to meet the pedagogical needs of the users. Users are able to sort the video clips by title, program name, subtitle number, duration, resolution, video size, etc. An example will be illustrative. Students can choose to view video clips like they would view a story, or they can view it as a grid that displays the video as a cover page (like a book cover) along with screenshots of individual frames (Fig. 1), with a visual time line presenting the duration of the video under the video window (Fig. 2, D). All these display modes are depicted in the drop-down menu.

The videos can also be viewed in various resolutions, from a low resolution of 240p to a high resolution of 1080p (high definition), to meet the hardware needs or preferences of the user.

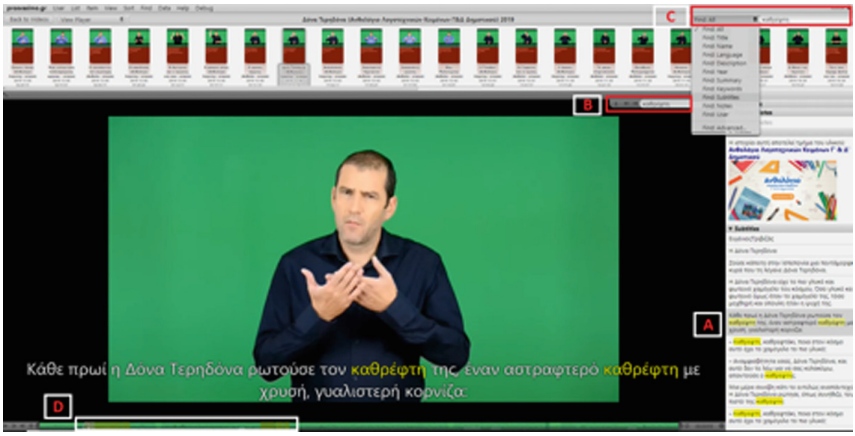

Fig. 2. Playback of educational material with interactive video subtitles. *Note.* Sections: A. Browse video using subtitles, B. Search in subtitles of the video being played, C. Search in subtitles in all of the videos of the platform, D. Visual presentation of the timeline of the video

The interactive subtitles are a useful tool that allows the user to browse the video by searching for various words (see Fig. 2, Section A). The user is able to search for words and phrases included in the subtitles. When a phrase is selected, a signed playback of the segment identified will occur in the large window on the left of the screen (Fig. 2, Section B).

The total number of search results are tabulated and may also be displayed (Fig. 2, Section B). It is also possible for users to search subtitle content within and across all videos (Fig. 2, Section C) of the platform. In the timeline (Fig. 2, Section D), it shows at what times the signed word appears in the video. Clicking the highlighted areas of the timeline moves the video to the corresponding scene.

The platform features an advanced search engine, which allows the user to search for words (transcribed signs) or phrases across the entire platform, so the user can view and compare all the available video clips matching the searched word or phrase. This is a useful tool for students, teachers, and parents with varying sign language skills. Users can download the presented videos in a WebM format, which is not space demanding, using direct download or torrent software.

Another feature is the ability to identify and save the URL address of the video as it is being played in a specific time range. For example, if someone is interested in a specific portion of a video, they can copy the URL of that specific segment. The URL address of the video (with or without subtitles), in its entirety (or merely a segment) can be saved and later used for homework assignments, for self-evaluation, or for formal assessment or research.

The videos are stored and played on a local server and do not depend on a central video service like YouTube. The entire application can be installed in traditional schools, in locations which do not have internet access but have computing units (with good processing power and storage options), or in schools whose computers are connected to a local area network.

The innovative search engine used for the development of the DML enables the user to search for a signed segment in the digital sign language database, something that until recently was impossible in the language training of deaf students [31]. The DML is also linked to the Open Online Dictionary, which we turn to now.

5.2 The Open Online Dictionary

The Open Online Dictionary is the largest fully-accessible, interactive online dictionary for Greek Sign Language. It contains more than 3,500 signed lexical entries (lemmas), sorted into 38 categories. It also includes 1,815 phrases and sentences categorized according to the 5 types of sentences: questions, statements, negation, simple, and conjoined. It is enriched with content from educational material that is currently being developed by project "Prosvasimo", which makes textbooks accessible with the use of Greek Sin Language.

There are presently two existing online dictionaries for sign language (http://lexiko.sign1st.eu/ and http://prosvasimo.iep.edu.gr/el/onlne-lexiko-ennoiwn). After completion of the debugging process the two dictionaries will merged into one Uniform Resource Locator (URL) under the auspices of the Institute of Educational Policy: http://prosvasimo.iep.edu.gr/dblexiko/.

The new database will include signs from native signers or from other available signed sources. The signs will be presented in different styles to account for regional variations (Fig. 3). The user is able to search for Greek words or phrases in the database (GSL Lexicon) using several filters and selections from display menus (see Fig. 3, left).

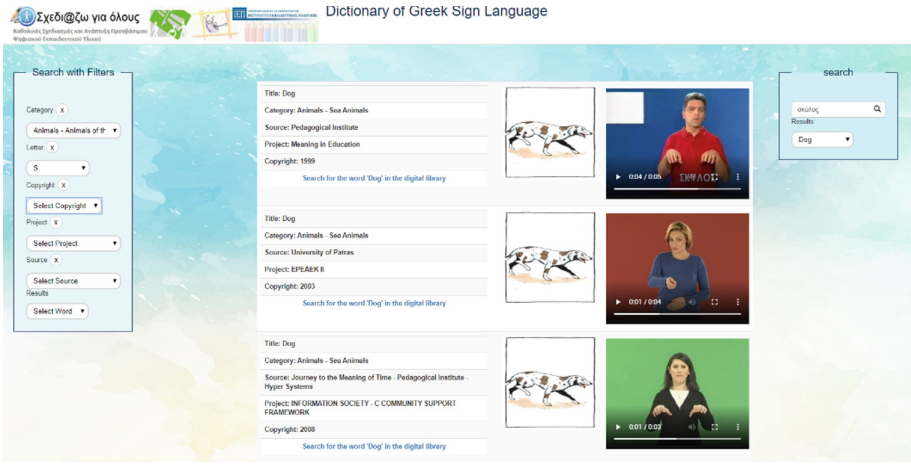

Fig. 3. A search for the word – sign "DOG" in the dictionary.

Lexical items can be identified by alphabetic search, by the source of the GSL data, or by a scroll down list. To search using Signed Language properties, one will search by handshape or by location of the signs, a feature currently under development.

Because students can not learn a language from a dictionary, which presents words out of context, our main goal has been to connect the dictionary to the Digital Multimedia Library (DML). Connecting the dictionaries database to the DML permits students to access signs in meaningful contexts. All GSL content in the DML and the GSL Lexicon is drawn from native signers, providing access to more meaningful and useful content. This visual presentation of information is now accessible for the many deaf children who have limited access to native signed languages.

An example will be useful: A search in the dictionary for the word/sign "DOG" is presented in Fig. 3. The results show that there are three variations of the sign for "DOG." The signs are signed by different signers, which allows deaf students to view variations of signs used by the Deaf community of Greece. In addition, if someone wants more context, she can also search the DML. The DML search will locate signed stories that contain the sign for "DOG." The dictionary and DML were tested in three schools for the Deaf in Greece. Professionals who participated in the beta testing reported that the DL search functionality was found to be a valuable teaching tool.

The GSL Lexicon contains 1,815 phrases, which are categorized by their type (e.g., question, negation, or statement), their content, (e.g., Wh-YES/NO questions) and their structure (Simple or Conjoined). When the user selects a type of phrase from the menu available (Fig. 4), the remaining filters are, by default, available. The search results are shown at the bottom of the search column.

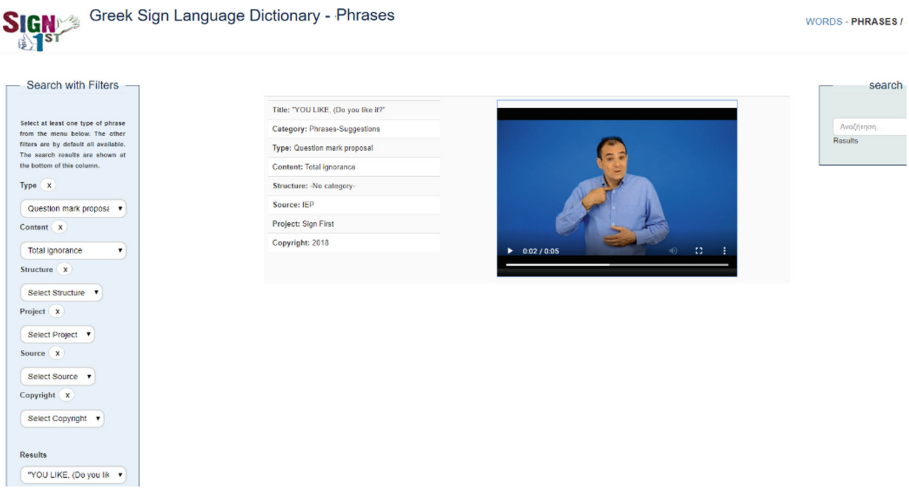

Fig. 4. Results for Yes/No question phrase type search.

Figure 4 depicts three components: 1) the Search with Filters window (on the left), 2) the resulting information and the corresponding video clips (in the center), and 3) the Text Search window (on the right).

In addition to searching by category, users can search the database by typing a single word in the Text Search window (on the right).

5.3 The Multimodal Accessible e-Books

The multimedia form of the accessible e-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 in the GSL video, and the voice translation of the text.

Recent technology used by the Masaryk University known as “Hybrid Book” [32] was used for the creation of study materials aimed at users with different disabilities. We also followed the proposed system for delivery of accessible e-Books by Pino, Kouroupetroglou and Riga [33] to create e-Books for deaf students. The format we created was developed following the text of the national curriculum textbooks. The electronic form of the e-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 in the GSL video, and the voice translation of the text. The components of this app are presented in Fig. 5. The multimedia data are shown in PDF, video, and audio files, and are now available as independent files for other uses.

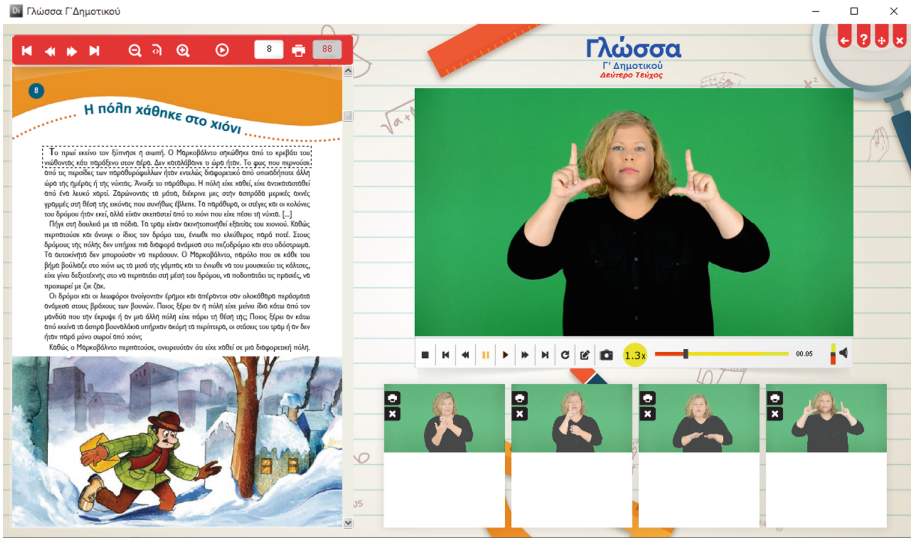

Fig. 5. Screen from a Multimodal Accessible e-Book book (Modern Greek, 3rd grade) whose accessible interface presents the text with the use of Greek Sign Language. There are three separate sections: A. The video window (Upper right corner), B. The boxes of individual frame captures of video clips (Lower right corner), and C. The story as it appears in the printed text book (Left part of the screen).

Our application allows students to view the GSL translation either continuously or in parts.

The user is able to view the story at different speeds, in full screen mode or in reduced screen size, and with or without subtitles (Fig. 5, Section A). But most importantly (educationally), the user is able to take snapshots (still frames) of the signed videos. The user can use the snapshots alone or can connect the still frame to text, (Fig. 5, Section B). The user can then print them and/or develop tests, homework, or presentation with them.

The end result of this application entails creating textbooks to be used in the first four grades of elementary school. The textbooks will feature written, spoken, and signed Greek. Emphasis was placed on the relationship between the printed and signed concept. Accessibility critically depends on the quality of the text in GSL. The translation of a printed text in GSL can closely parallel the original content or may be more flexible to reflect an adaptation. Using the National curriculum textbooks, the native signers either focus on content comprehension or on learning vocabulary, Modern Greek grammar, or the acquisition of phonological awareness.

If the objective is to understand the meaning of the text, then the Deaf native signers will not follow the text word for word, as that would severely inhibit comprehension. If the objective is to foster grammatical skill or phonological awareness, then interpretation mostly follows the original source. It is clear that signing Greek texts is an extremely demanding and difficult task [26]. The signing of the texts is done by experienced native signers or Deaf tutors/consultants (all fluent in Greek). An additional translation component of the text is done with professional interpreters of GSL. These two categories of professionals work collaboratively to form a team of bilingual translators.

While converting textbooks to accessible educational materials for deaf students, we have placed additional emphasis on the signed text because the efficient, clear use of GSL constitutes the core of the project. Finally, all material developed aim to fulfil the requirements of Design-for-All.

5.4 The Curriculum Based Signed Language Assessments

The Curriculum Based Signed Language assessments (CBSLA) is a collection of online applications aimed understanding and evaluating of Signed Language story comprehension skills (Examples are in GSL), question formation in GSL, phonological and syntactic structures, and vocabulary knowledge. All these applications have been developed using Javascript and especially the JQuery library, PHP, CSS and HTML. They are accessible to all at: http://www.sign1st.eu/en/assesment-tools/.

The Signed Language Story comprehension component contains two parts. One part is a video of a complete story and the second part consists of individual video clips of the story selected from the full video. Two rows of up to eight (8) individual clips of a story are contained in this application (Fig. 6). In the first row, the video clips of a signed language story are presented in a random order. The second row contains empty boxes. Two approaches may be implemented. First, the user can start by viewing the

full story (by clicking the box on the upper left corner) and then work to arrange the story sequence clips in the correct order. Second, the user can begin with the story sequence clips and put them in the order they think is correct.

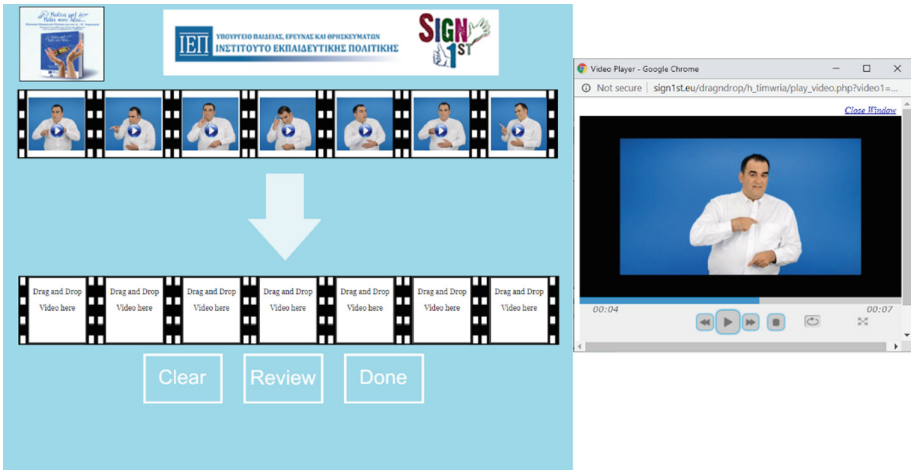

Fig. 6. Interactive application of sign language story comprehension "The Punishment" ("I Tomoria")

The video clips are presented in a sequence that may not make sense or flow correctly. The user watches the individual video clips in the first row. When the user decides on the flow of the story, they drag and drop the videos into the empty boxes in the second row. The user then examines the clips to decide if the sequence is appropriate. The expectation is that the student will rearrange the individual clips into the correct sequence of the story by dragging them into the boxes in the second row. At any point they can click "Review" and watch the videos in the sequence they have chosen. If the user is not satisfied, they can drag and drop the videos again and place them in another position. When satisfied, they click "Done." When the "Done" box is clicked, the application evaluates the user's choices. If all the choices are correct, then the user sees a positive message. If the sequence is not correct, then the user is referred back to the initial page. The user is then prompted to rearrange the videos in the correct order. If the correct sequence is created this time, a positive message occurs; if another incorrect sequence is submitted, the student will repeat the exercise until they find the correct sequence of videos.

After implementing these applications in two schools for the Deaf, we concluded that this design helps students by positively reinforcing their correct choices, minimizing their frustration, enhancing their memory, and, most importantly, supporting their story sequence skills. The application presented here is for Greek Sign Language Stories. However, it can easily be adapted to other signed languages as well. The application is able to connect and retrieve stories from a database using any Signed Language story as a template.

Fig. 7. Sign language video evaluation test matching questions – answers "The Five Giants".

Two columns of videos and a story window are depicted in Fig. 7. The column on the left contains questions from the story. After watching a signed video of the story, the user matches the videos with the questions in the left column by selecting the correct answer box in the right column. The example shown in Fig. 7 is for the Greek sign language story *"The Five Giants"* "Oi Pente Gigantes". This application can easily be adapted to other Signed Languages as well.

This playful test is an informal, child-centered activity that can help teachers collect evidence of story comprehension. This information can then, in turn, be used to structure teaching strategies, develop individualized educational plans, and produce reports. We found that students greatly enjoyed interacting with this application. All of the above assessment instruments are receptive. Expressive assessment instruments in web-based or stand-alone applications are challenging to develop. We will next present our first Expressive Sign Language Test application in detail.

5.5 The Expressive Sign Language Test Application

Despite the need for sign language fluency tests, there are presently no standard measures of SL competency readily available. Most instruments are available via only the authors [34, 35]. Recognizing this need, we have developed the Expressive Sign Language Test application. This application was designed by the second author for data collection for her PhD thesis. The third author developed the application. All authors collaborated in all stages of development.

This online, interactive application has been developed using PHP, CSS and Javascript. It is a test where the students are asked to find the question of an answer and express it using sign language. The student is able to record the answer using her computer camera and the recorded video starts to play automatically when the recording ends. This allows the student to quickly check her response and correct it, if needed. The recorded video is available for download in HTML5 (webm) format. No special setup is needed, the application starts to record as soon as the record button is pressed. The recording application has been developed using the WebRTC Javascript library. It is an open source library which has been developed and supported by Google, Mozilla and Opera and provides browsers and mobile applications with Real-Time Communications (RTC) capabilities via simple Application Programming Interfaces. In order to correctly operate it requires a web server with PHP version 7 enabled.

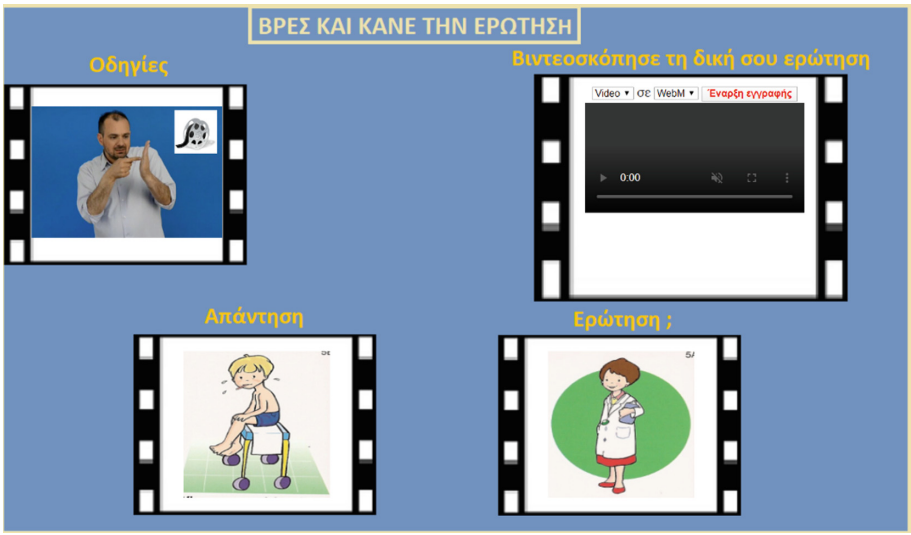

Fig. 8. The Expressive Sign Language Test application. Illustrations used with permission of Super Duper Publications, www.superduperinc.com.

The four visible interactive response features (Fig. 8) of the application are:

1. (Upper left corner) A signed video containing the test instructions
2. (Lower left corner) The statement part of the Phrase ("When I am sick," in a picture and in a video recorded in sign language)
3. (Lower right corner) The answer part of the phrase ("the Doctor" in a picture and in a video recorded in sign language)
4. (Upper right corner) The window for video recording the participant's responses. (Expected answer: Where do you go when you are sick?)

The current test has 25 items, but there is no limit to how many items the test can have. The application can be and will be developed for all types of expressive sign language data collection. The video recording can offer the user the possibility to view her answer, and, if need be, she can change it and record another one. The administrator can have immediate access to the results without any additional recording devices. This allows the application to be self-administered. Alternatively, the application can be used with a test-administrator. Participant responses can either be saved on a designated folder on a computer or on a secure server to be evaluated.

6 Results

The initial results from the implementation of this project suggest that it is a cohesive and successful pedagogical method for teaching the grammatical structures of GSL as an L1. We believe this holistic approach to be effective in the bilingual, bicultural education of deaf children [9]. Learning about the grammar and increasing vocabulary knowledge in GSL will support learning written Greek as an L2 [10].

Access to curricula and materials for teaching GSL as an L1, as reported by teachers themselves, has helped teachers who are not proficient in SL in four critical ways: 1) by providing teachers with all of the fully accessible visual materials—especially pre-recorded video narratives by native signers, 2) by providing interactive and accessible curriculum-based assessment material in both GSL and printed Greek, 3) by providing teachers with access to video narratives by native signers to improve their learning of GSL in a supportive way, and 4) by providing them with curriculum-based assessment essential for their teaching practices.

The deliverables of the project presented are perceivable and meet the receptive and expressive linguistic and educational needs of deaf and hard of hearing students, are stored in an operable platform and software for deaf children, have a fully understandable content and include a robust content that meets the educational needs of deaf children up to 4th grade.

The main request of most teachers was the need for continues training and support ether by in school training or online distant learning.

7 Conclusions

The benefits of the presented applications are numerous; they apply to students, teachers, and parents alike. If these projects are implemented, deaf students will have the opportunity to acquire knowledge and information at a much earlier age. The use of interactive, digital material supports the documentation, development, and use of GSL. Finally, and most importantly, these resources provide deaf students with a communicative tool that helps prevent linguistic and cultural deprivation.

The development of accessible interfaces in digital resources for bilingual education of deaf students using information technology offers solutions to support deaf students' learning to the maximum. We argue that using digital, open and accessible resources will enhance inclusive, effective and accessible learning in a bilingual

education of deaf environment. Training of educators of the deaf remains a challenge. We are in the proses of developing and we will soon present Massive Open Online Courses (MOOCs) (www.iepX.gr) based on the Open Edx platform of Harvard and MIT (www.edx.org) to tackle this challenge.

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