E-Learning Accessibility for the Deaf and Hard of Hearing - Practical Examples and Experiences

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Abstract. Development of information and communication technology has offered new horizons to the deaf and hard of hearing for their integration into working, social and economic environment. Despite the positive attitude of international guidelines, the lack of accessibility of e-learning material is still noticeable for these users. The process of adapting the e-learning materials for deaf and hard of hearing required different approach and guidelines to properly displaying sign language video. Paper presents basic e-learning accessibility guidelines for deaf and hard of hearing and basic directions for suitable design of e-learning sites accessibility. E-learning course (European Computer Driving License Course – ECDL) for deaf, automated video recording system and the transparent presentation of a sign language interpreter within the e-learning material are used as examples of good practice. Evaluations of these examples show high degree of satisfaction, ease of use and comprehension.

Keywords: E-learning, accessibility, usability, user interfaces, video streaming, human-computer interaction, deaf and hard of hearing.

1 Introduction

The development and subsequent wide availability of e-learning systems have caused significant changes in education and everyday business and also home activities for a large number of end users. The end user target group dealt with in this paper, consists of both deaf and hard of hearing people. Based on the data collected by the World Health Organization (WHO), there are 600 million people with disabilities in the world, representing roughly 10% of whole population. The World Federation of the Deaf (WFD) estimates about 70 million deaf people, approximately 80% of whom have deficient education and/or literacy problems, low speech abilities and often disordered living conditions [1]. Other studies show that the members of our target group, referred to in this paper as end users, are often confronted with a problem when acquiring the meaning of new words and notions [2].

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The increasing application of technology in educational environments, from junior schools to university, necessitates special steps to uphold the right of people with disabilities to equal participation in this technological environment.

The additional requirements of this group make it difficult to integrate them into society. The difficulties and functional barriers of people with special needs mean that they require an adapted environment for education, work and communication, which can be either of a technical or an interpersonal nature. This is often the reason for them failing to complete their education at an appropriate level. As a result, the number of people in this group obtaining any level of university degree and integrated into society and the working environment, is still low.

According to Hanson [3], for any deaf or hard of hearing individual, language experience cannot be assumed, since the individuals have diverse knowledge and skills, such as sign language, speaking clearly, lip-reading and textual reading. This knowledge has implications for designers who seek to address the needs of deaf and hard of hearing users.

Some of the key problems of using videos of sign language interpreters on web pages are already recognized. The existing solutions on the Web, for example AILB [4], which also gives support for forum contributions, SMILE [5], ShowSounds [6], Signing Web [7], SignOn [8], History of the Deaf [9] and Signing Savvy for American Sign Language [10] demand additionally placed space for the video of the sign language interpreter, which unfortunately reduces the area available for regular positioning of the website's content with text and images.

Further, it has been noted that, to date, natural video is more widely welcomed and accepted than signing avatars and synthetic gestures [11]. Due to this fact, a higher value has been set on the quality of the video of a natural sign language interpreter, integrated into e-learning materials.

2 Overview of Policies and Guidelines

Deaf and hard of hearing users have limited options for additional education; such as learning a foreign language, and for the use of online tools at all levels of education. This aspect shows the high demand for enabling appropriate access to information, professional development and contextual integration of information and telecommunication technologies into educational and social process for deaf and hard of hearing persons.

The most important worldwide document, improving the status of this area, is the Convention on the Rights of Persons with Disabilities, adopted on December 13th, 2006 [12]. This is the first legally binding document by the United Nations in the area of disability and ensures the promotion of human rights and the principle of equal opportunities and equal treatment, as well as prevention of discrimination as experienced by disabled people in various walks of life. In 50 articles of the Convention, accessibility, education, health, training, rehabilitation and other similar issues are discussed.

The European Union follows the trends of the United Nations. With their "Disability Action Plan", they want to establish equal treatment for people with disabilities, in working, social and private life. In the European context, European guidelines are

defined, such as the Resolution to foster the integration of information and communication technologies (ICTs) in educational systems in Europe, adopted on May 11th, 2004 and the action plan by the European Commission for the support of equal rights for persons with disabilities, adopted on October 30th, 2003 and the European initiative "eEurope: An Information Society For All" adopted on 19th June, 2000. The European Commission wants to broaden the usage of World Wide Web and to grant access to Internet and distance education in every education institution, household and office.

In the Riga declaration, adopted on 11th June, 2006 [14], the European Union, among others, also defines accessibility of all public websites until 2010. However, the review from 2008 ("Measuring progress of eAccessibility in Europe" (MeAC) study) [13] reveals slow progress towards achieving this goal that should have been fostered.

Thus, on 31st March, 2009, the European Council adopted conclusions with the support of the European Communication "Towards an accessible information society" COM (2008) 804. Moreover, WCAG 2.0 [15] was included in the development of standard 376, which will offer new aspects for accessibility of web sites to public ICT intermediaries [16].

3 E-Learning Web Design Guidelines

This paper will focus on a limited number of guidelines and instructions for the design of e-learning sites, suitable for our special target end user group: the deaf and hard of hearing. Further, three examples of good practice developed by University of Maribor, Faculty of Electrical Engineering and Computer Science (UM FERI), Slovenia, will be presented.

These users are characterized by their particular need for visually supported information, as opposed to that of blind and visually impaired people. These students can listen to a certain extent with the help of technical equipment; such as hearing aids, induction coil or FM systems with wireless microphones for hearing aids and cochlear implants for the deaf [17]. This requires them to ensure maximum use of all channels in order to receive the information (auditory, visual, tactile and other channels), and as far as possible, to reduce verbalization and abstraction. To enable this, sounds must be visualized for the students: subtitles, translation of text into sign language (especially for the deaf) and the classrooms equipped with wireless devices to listen to the professor or assistant.

According to WebAIM (Web Accessibility in Mind) [18], the following current basic additional recommendations for web design are especially suitable for this user group:

- Enable subtitles or transcripts for other media. Videos must be subtitled or the transcript (written copy of speech) must be enclosed.
- Verify that the text is clear and easily readable. Text on the web should be written in a clear, simple form with titles and appropriate lists.

- Use standard forms. Accessible websites in HTML language are more robust and offer an easier implementation of search mechanisms. Cascading Style Sheets (CSS) allow distribution of content from the presentation of information, thereby offering greater flexibility and accessibility of online content.

The list does not contain all the aspects of accessibility for deaf and hard of hearing persons, however, by using these basic guidelines, we can achieve significantly higher accessibility of our websites. Further guidelines can be found in WCAG - Web Content Accessibility Guidelines [15].

4 E-Learning Examples for Deaf and Hard of Hearing

4.1 ECDL Educational Site for Deaf

European Computer Driving License (ECDL) is a European certification in end-user computer skills. In the European Union, ECDL is the standard for certifying/*determining* individual computer skills and verifying knowledge of use of specific software using practical examples.

An ECDL e-learning site has been constructed to fulfil the needs of teaching the skills required to obtain ECDL certificate to the target group. Here, the learning material has been prepared in advance with an added sign language interpreter video [19].

For the management of the material, the course management system Moodle, which is a free, open-source system for managing e-materials, was selected. Although there are many different open source systems for the management of teaching materials, we decided to use Moodle since it is user friendly, it supports installation on various platforms, and particularly because it includes the most important pedagogical principles.

The e-learning materials were made according to the plan for the ECDL 4.0 and were adjusted and updated for the target group. In the Moodle system, the content was organized into four modules or thematic sections, namely: Introduction to Information Technologies, Computer use and file management, Word processing, and Information and communication. In addition to media content, each of the modules included the following basic activities: forum, dictionary and the initial and final examinations to monitor progress of participants. Figure 1 shows an example of the material with an interpreter within the module.

From experience in working with the users less experienced in ICT in other projects and following usability guidelines [21], we have highlighted some additional guidelines and have taken them into account in adjusting ECDL materials:

- User interface should be simple and clear, without too many additional options.
- User interface should be simple in design.
- Navigation should be placed in the same (clearly visible) position throughout the site.
- No new windows should be opened automatically, as this may confuse the beginner user.
- Language and interpretations should be relatively simple; use of simple technical computer terms is recommended.

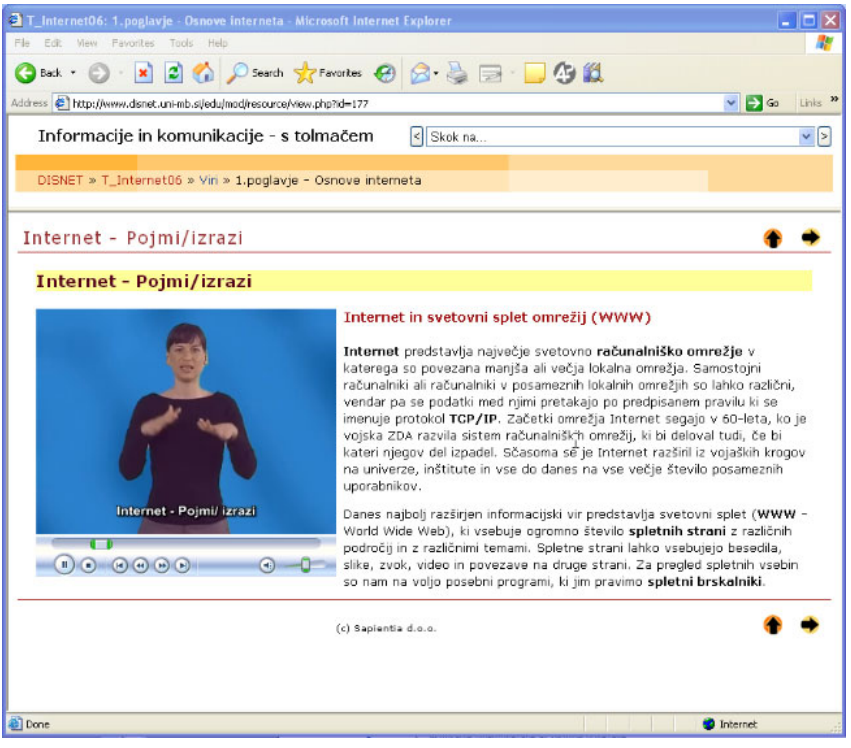

Fig. 1. ECDL material with a sign language interpreter in Moodle

After considering various video installations with an interpreter and based on the recommendations, we decided to permanently position the box with an interpreter in the relevant modules on the left side in the browser window.

Video and subtitles should be especially underlined in the above guidelines, since other solutions, such as the project AILB [4] or SignOn [8], do not include subtitles into the sign language video. Specifically, the sign language video for a translation of the spoken text into sign language must be of appropriate quality, without any additional information and continually present without interrupting.

Evaluation study. Usability evaluation, using Software Usability Measurement Inventory (SUMI) method [22], with unemployed deaf and hard of hearing adults with a knowledge of Slovene sign language who had taken part in the education process, shows global usability acceptance [23]. SUMI "global" usability sub-scale was 54, which is slightly above the positive limit of 50.

On the other hand, the usability sub-scale "efficiency" and "learnability" shows greater disagreement among users on this matter. After investigation of the problem, we found that it was based in the Moodle functionality and not in the ECDL e-learning content. After removing the left and right part of the typical Moodle design and after interviewing three deaf people, the acceptance of the new design was higher.

4.2 Hypermedia Based Virtual Lecture Room

For the purpose of web based streaming lecturing, the online video lecture was created for the deaf and hard of hearing in live streaming or on demand.

Our Video Supported Web Lecture incorporates a portable interactive system with video and audio equipment, interactive streaming video technology (video streaming) and virtual hypermedia environment into a new learning environment. The development of such an interactive system along with the appropriate furniture and audio equipment in lecture halls also requires the purchase of adequate hardware and software. When this equipment is provided in the lecture room, the student is able not only to listen to lectures live, but also has the opportunity to listen to the lectures later. The difference is that the subtitles are added to the video and other media if needed, such as audio subtitles for the blind and sign language interpreter video for the deaf.

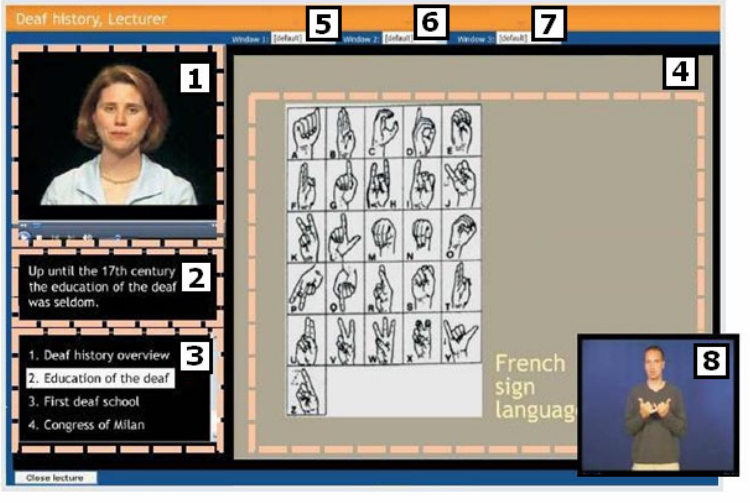

Fig. 2. A typical web based video lecture for deaf and hard of hearing people

The result of this process is the e-lecture, designed for our target group, demonstrated in Figure 2. It consists of the following media elements: video (1), audio (1), visual subtitles (2), a table of contents (3) (for content navigation) and presentation slides (4), as well as three media switches (5, 6, 7). The media switches are drop-down lists. In this way, the user can control the screen layout by selecting their own custom viewing preferences. The third switch (7) triggers a pop up window (8) with alternative streams (for instance, a sign language interpreter). This can be placed on any part of the screen over the e-lecture.

Evaluation study. There were 11 deaf and 2 severe hard of hearing participants in the experiment, whereby 23% were female and 77% were male. Participants ranged from 34 to 72 years of age, with a mean age of 52. 61% of the participants had no previous Internet browsing experience, while 8% had browsed only a couple of times and 31% had excellent skills.

As the main purpose of the Web portal is to deliver Web lectures, we tested basic tasks in online participation for both groups. Users were asked to complete six tasks that were read out to them one at a time: log in to the user account, find profile settings, find a specific lecture, change the video in Window 1, quit the lecture and log out of the system. A gestural think-aloud protocol was used in the evaluation to gather rich information [24]. The main focus with the subjects was the Web lecture experience; therefore there were 30 seconds available for each mode shown in Table 1. During each mode, the evaluator observed the participant's reactions. The communication among evaluator participants was established with a sign language interpreter, where he asked questions about e-lecture interface.

Table 1. Web lecture GUI modes for deaf

	Window 1	Window 2	Window 3 (pop-up)
Mode 1	Lecturer	PPT slides	Nothing
Mode 2	Lecturer	SL interpreter	Nothing
Mode 3	SL interpreter	PPT slides	Nothing
Mode 4	Lecturer	PPT slides	SL interpreter

The results from the experiment revealed that 69% needed help when performing tasks, basically due to their lack of browsing experience. They received additional instructions from the evaluator (assistance in completing the task was given). 77% of our test subjects confirmed that the most appropriate configuration for the e-lecture was provided by mode 3, where the sign language video is in top-left corner (Window 1), presentation slides are on the right (Window 2), and the third window was hidden. With this, we conclude that deaf persons do not prefer two different videos, streaming simultaneously (one video of a lecturer and one of a sign language interpreter) [25].

4.3 Sign Language Interpreter Video

Transparent video for deaf and hard of hearing users has been developed within the framework of the DEAFVOC 2 [20] project, enabling interactive lectures with sign language interpreter videos embedded on the websites. We named the system the Sign Language Module (SLIM). A practical example of the transparent sign language is visible at http://www.slimodule.com/.

When designing the system, we took into account linguistic specifics and bilingualism, both characteristics of substantial proportion of our target population. In the system, we wanted to focus first on sign language and emphasize the importance of adopting knowledge and delivery of information in this language. A system which offers the display of transparent (translucent) video, on the users' request, anywhere on the existing Web page has been developed. This offers users, whose primary language is sign language, a previously prepared translation of certain words, text, pictures, photos, animation or any other video clip.

The innovation of the system is reflected in the fact that the display on the site combines video, audio, subtitles and navigation links over the existing site as a transparent video and at the user's request. (Figure 3). When the short video clip is finished or manually terminated, a standard web site is displayed.

Research done by Debevc and Peljhan [9] has shown that deaf students perform better when they have an online system with a sign language interpreter video available than with traditional forms of teaching. Having materials in sign language also increases their daily exposure to sign language and enables students to use the material for independent study at home and for repetition of the material.

With an increasing number of similar materials in Slovenian sign language, we expect the users to become much more literate in their Slovenian mother tongue. It will then be easier for them to integrate into the larger social group, while maintaining their own identity, improving their self-esteem and developing their culture and language.

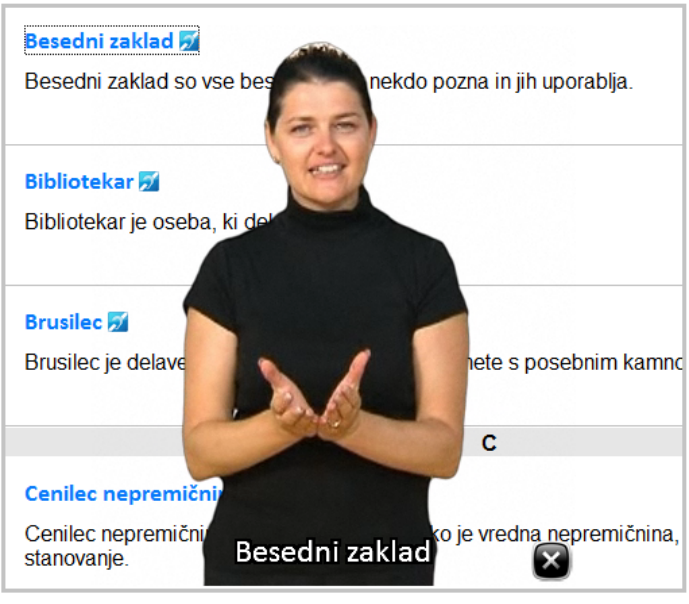

Fig. 3. Transparent sign language interpreter video for deaf and hard of hearing persons

This system also offers a contribution to the Slovenian Act on the use of Slovenian sign language. This Act gives deaf people the opportunity to use the Slovenian sign language as a language of communication with each other and as a natural means of communication, as well as the right to receive information in adopted techniques.

Evaluation study. There were two evaluation studies conducted with deaf and hard of hearing users. The first evaluation included 14 participants who use sign language as their first language, and were aged from 18 to 72. In the second evaluation 31 deaf and hard of hearing participants were involved, and were aged from 15-21. The aim of the first evaluation was to gather first impressions about the first prototype. We applied the gestural thinking method [24]. The communication between the evaluator and the participant was carried out with the help of a sign language interpreter. At the end of the evaluation, the user had to fill out the questionnaire with three basic questions about user experience.

The second evaluation combined several methodologies: pre-test questionnaire for the participant's demographic profile, post-test questionnaire for evaluating usability (5-point Likert scale), and an open debate to determine positive/negative or missing functionalities of the prototype.

Results from the first evaluation showed a high degree of users' satisfaction; 92% of the participants thought that the system was useful, while 8% were undecided. Based on results gathered throughout the evaluation studies in [26], we have provided further suggestions for the development of the transparent video for the next prototypes: providing a clearer and more easily recognizable icon for the sign language video, providing an additional button for closing the video, displaying the video appearance and disappearance in a slow rather than a sudden action, providing video playback controls (play, pause and stop) for longer videos.

The second evaluation, done by Kosec, Debevc and Holzinger [27] of the prototype confirmed a high degree of evaluated usability metrics, such as satisfaction (80%), ease of use (77%), comprehension (83%). The most interesting information that we received was revealed by a group debate, which confirmed some missing functionalities in the prototype. Some of the participants found that the video of the sign language interpreter was too fast; therefore they would needed a functionality for slowing down the video playback. Moreover, a few participants wanted to move the video around the screen. These features were taken into consideration for the implementation of the next prototype.

5 Conclusion

The use of Information and Communication Technology is, with appropriate adaptation to enable accessibility, even more suitable for deaf and hard of hearing people, as it offers better options for equal integration into a working, social and educational environment.

International documents and action plans, such as the United Nations' Convention on the Rights of Persons with Disabilities, the European Action plan, the Riga Declaration and the Slovenian Action Plan for Persons with Disabilities are all legal documents, which explicitly specify that web sites must be accessible to everybody, irrespective of the degree of their handicap. It is therefore necessary to invest more effort in raising awareness of appropriate technological options and the requirements and needs of deaf and hard of hearing people.

In examples of good practice, such as ECDL e-materials, we have examined, among other things, the appearance on the screen for the visually impaired, as well as for the deaf and hard of hearing. The text must be short, concise, with clear navigation links in the top right hand corner of the screen, with images having text in the background and sign language interpreters in a video window, located on the left side.

For the needs of monitoring and storage of lectures, a system for the automatic recording of lectures has been arranged, allowing simultaneous capturing of speaker, slides, subtitles, sign language interpreter and text typing. Immediately after the lecture, which may also be broadcasted live, all elements are combined together and immediately placed on an appropriate web site where the video can be retrieved later. The system is designed to take into account the needs of the deaf and hard of hearing.

The people who use sign language as their first language are unfortunately the most vulnerable population due to the low educational level, needing a translation of the text on the website. One option is through a continuous window, as we built it in the ECDL e-materials, but it cannot be added to existing and established websites. In this case, it turned out to be the right solution for the sign language interpreter to appear over the existing site, in terms of implementation of the additional web layer (the CPC Web Layer), while keeping the existing form of web pages. We named this approach a transparent sign language video or sign language module (SLIM).

With these instructions and practical examples of good practice, other web designers are provided with appropriate ideas and solutions for the implementation of more accessible web sites for the disabled and elderly, to enhance opportunities for increasing self-esteem and more active integration of this target population in an educational and social environment.

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References

1. Haualand, H., Allen, C.: Deaf People and Human Rights. World Federation of the Deaf and Swedish National Association of the Deaf (2009), http://www.wfdeaf.org [accessed January 12, 2010]
2. Marschark, M., Convertino, C., McEvoy, C., Masteller, A.: Organization and use of the mental lexicon by deaf and hearing individuals. American Annals of the Deaf 149, 51–61 (2004)
3. Hanson, V.L.: Computing Technologies for Deaf and Hard of Hearing Users. In: Sears, A., Jacko, J.A. (eds.) Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications, 2nd edn., pp. 885–893. Lawrence Erlbaum Associates, NJ (2008)
4. Straetz, K., Kaibel, A., Raithel, V., Specht, M., Grote, K., Kramer, F.: An e-Learning Environment for Deaf Adults. In: Conference Proceedings 8th ERCIM Workshop "User Interfaces for All", Vienna, Austria (2004)
5. Kronreif, G., Dotter, F., Bergmeister, E., Krammer, K., Hilzensauer, M., Okorn, I., Skant, A., Orter, R., Rezzonico, S., Barreto, B.: SMILE: demonstration of a cognitively oriented solution to the improvement of written language competence of deaf people. In: 7th International Conference on Computers Helping People with Special Needs (ICCHP 2000), Karlsruhe, Germany, July 17-21 (2000)
6. Vanderheiden, G.C.: Full Visual Annotation of Auditorially Presented Information for Users Who Are Deaf: ShowSounds. In: RESNA International Conference, Toronto, Canada, June 6-11 (1992)
7. Fels, D.I., Richards, J., Hardman, J.L., Daniel, G.: Sign Language Web Pages. American Annals of the Deaf 151, 423–433 (2006)
8. Hilzensauer, M.: Information Technology for Deaf People, pp. 183–206. Springer, Heidelberg (2006)
9. Debevc, M., Peljhan, Z.: The role of video technology in on-line lectures for the deaf. Disability and Rehabilitation 26, 1048–1059 (2004)

10. Signing Savvy (2010), http://www.signingsavvy.com (accessed January 12, 2010)
11. Olivrin, G.J.-L.: Is Video on the Web for Sign Languages. In: W3C Video on the Web Workshop, San Jose, California and Brussels, Belgium, December 12-13 (2007), http://www.w3.org/2007/08/video (accessed January 12, 2010)
12. United Nations: Convention on the rights of persons with disabilities. United Nations (2006), http://www.un.org (accessed January 12, 2010)
13. Olsen, M.G.: How Accessible is the Public European Web? (2010), http://www.mortengoodwin.net/publicationfiles/how_accessible_is_the_european_web.pdf (accessed January 12, 2010)
14. European Commission: Ministerial Declaration. European Commision, Riga (June 11, 2006), http://ec.europa.eu/information_society/events/ict_riga_2006/doc/declaration_riga.pdf (accessed January 12, 2010)
15. Caldwell, B., Cooper, M., Reid, L.G., Vanderheiden, G. (eds.): WCAG 2.0 - Web Content Accesssibility Guidelines: W3C Recommendation (December 11, 2008), http://www.w3.org/TR/WCAG20/ (accessed January 12, 2010)
16. European Commision: Web Accessibility. European Comission (September 15, 2009), http://ec.europa.eu/information_society/activities/einclusion/policy/accessibility/web_access/index_en.htm (accessed January 12, 2010]
17. Moores, D.F.: Cochlear implants: A Perspective. American Annals of the Deaf 154, 415–416 (2010)
18. WebAIM: The WebAIM Guide to Web Accessibility. WebAIM (2009), http://www.webaim.org (accessed January 12, 2010)
19. Debevc, M., Stjepanovič, Z., Povalej, P., Verlič, M., Kokol, P.: Accessible and Adaptive e-Learning Materials: Considerations for Design and Development. In: Stephanidis, C. (ed.) HCI 2007. LNCS, vol. 4556, pp. 549–558. Springer, Heidelberg (2007)
20. Sign Languages and European Written Languages in Virtual Vocational Education for the Deaf (January 2010), http://www.deafvoc.fi/ (accessed January 12, 2010)
21. Holzinger, A.: Usability Engineering for Software Developers. Communications of the ACM 48, 71–74 (2005)
22. Kirakowski, J., Corbett, M.: SUMI: The Software Usability Measurement Inventory. British Journal of Educational Technology 24, 210–212 (1993)
23. Debevc, M., Lapuh Bele, J.: Usability testing of e-learning content as used in two learning management systems. EURODL (Oslo) (2008), http://www.eurodl.org/materials/contrib/2008/Debevc_Bele.htm (accessed January 12, 2010)
24. Roberts, V.L., Fels, D.I.: Methods for inclusion: Employing think aloud protocols in software usability studies with individuals who are deaf. International Journal of Human-Computer Interaction 64, 489–501 (2006)
25. Kosec, P., Debevc, M., Holzinger, A.: Towards equal opportunities in computer engineering education: design, development and evaluation of videobased e lectures. Int. J. Eng. Educ. 25, 763–771 (2009)
26. Debevc, M., Kosec, P., Holzinger, A.: Improving multimodal web accessibility for deaf people: sign language interpreter module. Multimedia Tools and Applications (April 15, 2010), doi:10.1007/s11042-010-0529-8
27. Kosec, P., Debevc, M., Holzinger, A.: E-learning accessibility for the deaf and hard of hearing – practical examples and experiences. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) 12th International Conference, Computers Helping People with Special Needs, ICCHP 2010, Vienna, Austria, July 14-16 (2010)