ICTA'07, April 12-14, Hammamet, Tunisia

Exploring Usability and Accessibility of an E-Learning System for Improving Computer Literacy

Matjaž Debevc[1], Petra Povalej[1], Mateja Verlič[1], Zoran Stjepanovič[2]
[1]*University of Maribor, Faculty of Electrical Engineering and Computer Science, Smetanova ulica 17, SI-2000 Maribor, Slovenia, phone: +386 2 220 7105, fax: +386 2 220 7272*
E-mail: matjaz.debevc@uni-mb.si; petra.povalej@uni-mb.si; mateja.verlic@uni-mb.si
[2]*University of Maribor, Faculty of Mechanical Engineering, Smetanova ulica 17, SI-2000 Maribor, Slovenia, phone: +386 2 220 7945, fax: +386 2 220 7990*
E-mail: stjepanovic@uni-mb.si

Abstract

Use of ICT in education brings new opportunities for people with special needs. Web based learning and adapted e-learning materials provide an alternative way of learning comparing to traditional classroom learning. In this study deaf and hard of hearing persons were using an accessible and adapted e-learning environment for improving computer literacy which included also adapted streaming video with interpreter and subtitles. The process of adapting the materials required a new approach to properly displaying the video with interpreter and minimizing the time the users had to wait for the materials to load. The results of the pedagogical and usability study, based on the evaluation of the participants before taking the e-learning course and after completing it, have shown that deaf and hard of hearing persons can successfully, efficiently, and effectively use the advantages of e-learning. The work described originates from the largest project earmarked for the people with special needs in Slovenia.

1. Introduction

Link-up between the technology and humans having different abilities, requirements and needs opens new areas and trends that require use of scientific approaches to searching for new methods and solutions, as well as to stimulating the development. Information and communication technology (ICT) already penetrated deeply into the education area supporting the needs of students at different educational levels. This support is particularly important for students with special needs.

Numerous studies have shown that learning could be easier and more efficient, if it is supported by ICT and above all if hypermedia systems and applications are available [1]. In his research Kulik [2] among others stated that in some cases the students needed even 70% less time for such multimedia based learning when compared with conventional one. Furthermore, Chou and Lou [3] and Schulz et al. [4] have shown in their studies that distance learning using web-based virtual learning environment is applicable and efficient for use. However, some authors reported also about critical reactions regarding e-learning and e-learning materials. In their work, M.F. Theofanos and J. Redish [5] quoted that in order to truly meet the needs of all users, it is not enough to have guidelines that are based on technology. It is also necessary to understand the users and how they work with their tools. Design of e-learning materials is not a simple process. These materials should be well planned, designed and evaluated in order to assure efficient and simple use.

The evidence of efficiency of the ICT-supported learning leads us to raising the question if distance learning using ICT could be successfully used also for educating persons with special needs, for example for deaf and hard of hearing persons. Unfortunately the majority of deaf and hard of hearing persons today still shows worse reading/writing and mathematical abilities comparing to persons with normal hearing, although their mental abilities are generally at the same level [6].

One of the possible solutions to the problem related to increasing the educational level of deaf and hard of hearing persons can be providing additional education using the multimedia-supported materials on the World Wide Web. This kind of user interfaces can be found in other projects such as SMILE [7], BITEMA [8],

DELFE [6] and ECDL Barrierefrei [9]. The results of these projects have shown that multimedia systems additionally increased the success of learning.

In our research we wanted to find an answer to the question: How should e-learning materials be designed to be user friendly and thereby best serve unemployed deaf and hard of hearing persons when using ICT and methods of distance learning in the education process? There is also the problem of choosing the most appropriate form of distance learning that should be provided for unemployed deaf and hard of hearing adults in order to successfully study and communicate with the teacher and other colleagues. The paper therefore focuses on the following points:

- Explanation of the design of e-learning material and working principle of the system. As an illustration of the education system, a short description of an e-learning course to complete the ECDL modules (European Computer Driving Licence) will be presented.
- Explanation how we have considered the needs and demands of persons with special needs (with focus on the deaf and hard of hearing persons) and hereby enabled them accessibility to these e-materials.
- Description of adapted LMS system Moodle and working principle using an adapted version of ECDL materials.

2. ECDL modules and needs analysis

As mentioned before, the basis of the e-materials used in our project DISNET for education of unemployed adults was the curriculum that had been defined by the ECDL Foundation [9]. The ECDL Foundation is the global governing body of the world's leading end user computer skills certification programme. The European Computer Driving Licence (ECDL) or International Computer Driving Licence (ICDL), the latter is known especially outside Europe, are the global standards in end-user computer skills, offering candidates an internationally recognised certificate that is globally supported by governments, computer societies, international organisations and commercial corporations.

In the year 2006, in total 20.000 people were educated within the frame of PHARE 2003 project; out of that number in DISNET project 337 people – 22 of them were deaf and hard of hearing persons.

The education process took place in the form of courses, following the method of blended learning [10]. At the beginning students met their tutors and had their first training in a computer room. Further training consisted of individual work through web-based learning material at their homes or special public ICT-equipped centres. For motivational reasons we set up a schedule defining the time-frame when a tutor was available through the system for additional help and possible questions. The web-based course was designed in the way that knowledge-evaluation took place at the beginning, during the learning process and at the end of the course. Distance learning was provided with the help of suitably adapted open-source Course Management Systems (CMS) Moodle [11]. Moodle was chosen for its user-friendliness, since it supports setup on different platforms and particularly because it implies the most vital pedagogical principles. At the same time its developers are trying to consider the recommendations for the accessibility and adaptability of e-contents for deaf and hard of hearing persons.

2.1. Guidelines for designing and implementing e-learning systems

The needs analysis of deaf and hard of hearing users was made in order to define the design guidelines. Here, the methodology adopted by the European Union for analysis in ICT projects was used [12]. This methodology includes personal interviews with end-users, questionnaires, as well as discussion panels using brainstorming and feedback.

As learned already from the past studies related to the use of multimedia in different applications, such as AIM »Adapted Interactive Media« [13], as well as established on the basis of our own needs analysis, we stated that in order to increase the availability of learning software for deaf and hard of hearing persons, one should consider at least the following ten guidelines when designing and implementing an e-learning system:

1. to present visually all audio information,
2. to assure the translation of spoken and written text into sign language using quality video picture,
3. to present subtitles under the video picture,
4. to offer at least two difficulty levels of text and graphics presentation (easy reading and more demanding material),
5. to offer a dictionary and glossary of terms,
6. to assure additional hyperlinks for gathering detailed information,
7. to assure a quick and understandable navigation inside the learning material,
8. to assure that web based e-learning material is structured in understandable and logical way,

9. to assure a simple and surveyable user interface in a learning management system offering the tools for user interface personification,
10. to assure that written language and explanations are relatively easy readable; use of more easily understandable terms regarding information/ computer science is preferred.

Video picture and subtitles should be especially underlined in the above guidelines. Namely, video picture of a translation of the spoken text into sign language must be of appropriate quality, without any additional information and present all the time.

2.2. Guidelines for video and subtitles for deaf and hard of hearing persons

When developing video materials we considered the main criteria for improved quality of video picture. These criteria have been determined by measuring the quality of video communication between deaf persons as well as according to the standardization of video picture for deaf persons, performed by Hellstrom [14].

The resolution of a video picture, which was used in our study, was in the frame of CIF format (352*288). The video was encoded for speeds at above 300 kbps. This quality of a video enabled us to capture all the details related to movements of hands, eyes and mouth, which was clear enough for recognition of a deaf person, although there could be some blurred movements.

The other request, set by the users, was immediate loading of the video, which resulted in use of markers in streaming video that enabled fast loading of respective video records on each page.

There are also important guidelines for subtitles. All text equivalents for spoken text, as well as other sound information (for example, signals of the operation system, phone ringing, etc.), must be presented. We decide to include subtitles inside the video picture in its lower part. During the needs analysis deaf and hard of hearing persons find this approach useful while following the spoken text and background sound (for example, rumble of thunder, music, etc.).

Furthermore, these accessibility standards were additionally considered when designing the user interface of the system:

- ISO Technical Report 16071—Guidance for Software Accessibility: »The usability of a product, service, environment or facility by people with the widest range of capabilities«
- ISO 9241–14: Ergonomic requirements for office work with visual display terminals (VDTs): Menu dialogues. Geneva, Switzerland
- Section 508 of the Rehabilitation Act of USA
- Web Content Accessibility Guidelines (W3C).

3. Description of e-learning system

Moodle was used for e-contents management and for supervising the activities and progress of the participants. Moodle contains tools and functions that represent the base support for e-learning, for example: multimedia support contents, forums, questionnaires, questioning, chat, e-mailing, news, etc. In our study we have used almost all offered tools and functions since they offer an alternative form of communication, which can be in most cases estimated closer and friendlier for deaf and hard of hearing persons. Having in mind the guidelines for designing and implementing e-learning systems for deaf and hard of hearing persons listed in section 2.1 we decided to present the e-contents in the form of simple web (HTML) pages. We intentionally kept the design simple and avoid the complex graphic elements in order to reduce the influence of disturbing factors that could distract attention form the content.

3.1. The structure and functionalities of the system

The contents within individual topics were divided according to two defined levels: basic and advanced. The basic levels were designed for users having only basic computer skills or even complete beginners. It was logical to provide them in the very beginning only the most essential knowledge in order to avoid too much new information. The advanced level was designated for users, experienced in basic work with the computer with a goal to upgrade their knowledge with new information. In order to avoid the discrimination of different kind of users, we decided to offer all of them both basic and advanced level. The advanced level was clearly marked.

Revision of the learned knowledge can be stated as a key factor for successful and effective learning. Therefore, at the end of each lesson we put short questions. The answers were not registered and the user could answer the questions several times. After answering, the system responded whether the answer was correct or not. Simple and usable navigation inside of e-learning material is of significant importance for deaf and hard of hearing persons. Moodle enables a simple navigation between individual system levels and activities. Navigation is enabled by hyperlinks in the form of: list of modules, list of chapters, list of tools inside the modules, and path/locator, which

changes dynamically according to the chosen link in the hierarchy. The interpreter is not present at this level since a great part of the programming code of the Moodle system would have to be changed for this functionality; also the main window would be overfilled. Introduction to Moodle, its functions and usage was therefore made by tutors/mentors at first personal meetings with participants/users. Inside a certain lesson, the user can navigate using the buttons on the right side of the window. Unfortunately, in materials with interpreter it was not possible to include the list of all sub-chapters, which was realised in materials without the interpreter. Free space for presentation of contents was namely limited with Moodle navigation, video player window, size of the screen and resolution of the computer monitor. Therefore, a compromise was needed.

We designed the materials in such a way that particular web page (sub-chapter) involved at the most two screens (Figure 1). Because of this compromise, the navigation was enabled by three buttons: previous topic, list of contents and next topic. The user can consecutively browse the topics forwards and backwards. Enabled is also to use a button for list of contents, which returns the user to the first page of a certain chapter with a list of all the sub-chapters or topics, respectively.

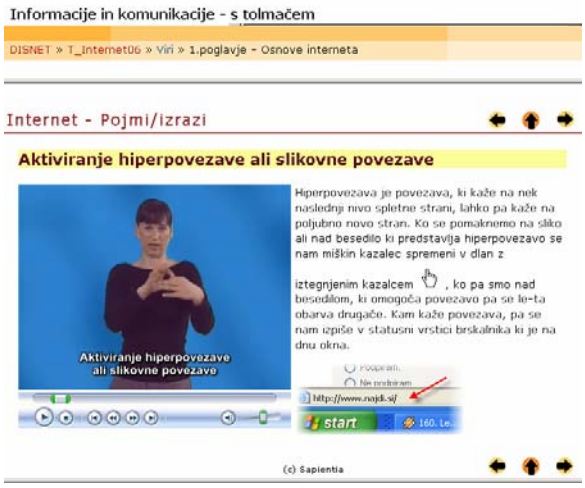

Figure 1. ECDL for deaf and hard of hearing persons

Another advantage is the loading speed of web pages. It was very important to avoid any unnecessary processing of web pages because the movie with the interpreter had to be loaded as fast as possible. Video with interpreter was encoded as streaming media and put on dedicated server to speed up streaming time.

However, the same video can be put on CD-ROM or DVD-ROM and run from it without problem. Special marker tags were inserted into video with interpreter. With inserted markers video was segmented in smaller sections that correspond to the units the material was divided into. Markers enabled even faster loading of video with interpreter for loaded unit of material in Internet Explorer, however they introduced some problems with viewing the video with interpreter in other web browsers.

4. Pedagogical and usability tests - results

Twenty-two hard of hearing trainees were included in learning course. They used adapted ECDL e-learning materials that included video with an interpreter as discussed above. We tested the pedagogical efficiency of learning and the trainees' usability satisfaction with e-learning materials and platform.

4.1. Efficiency of learning

In order to evaluate the efficiency of e-learning, the following steps had to be taken:

1. *Pre-exam*: before e-learning of each module a trainee was tested for his/hers prior knowledge.
2. *E-learning* of one module.
3. *Post-exam*: after the trainee finished the course.

Each trainee had one week for learning each module. The pre-exam results were compared to post-exam results in order to establish how much did the trainees learn in one week. The results showed that heard of hearing trainees demonstrated very good response to using e-learning materials. On the average all 22 deaf and hard of hearing participants improved their knowledge for 25,5 % through all four modules. The best results were obtained in practical modules (Word processing and Windows) where the average result on final exam was almost 80%. The trainees experienced some difficulties in theoretical module (concepts of information technology) since the interpretation of many basic notions in sign language were very difficult. Therefore the average result was almost 70%. In all modules the gain of knowledge was significant.

4.2. Usability evaluation of e-learning materials and e-learning environment

The usability of the system was tested by 10 hard of hearing trainees who were willing to take part in Software Usability Measurement Inventory (SUMI)

evaluation [15]. According to SUMI guidelines, a sample of 10 or more users per system being evaluated satisfies the requirements, respectively, is required to get stable statistical results. Four participants were males and six of the participants were females. All participants had no basic computer and web browser experience before joining the e-course.

SUMI is a questionnaire to assess the usability of software systems. Results from any individual SUMI questionnaire are scored against a standardization database [15]. The SUMI questionnaire includes 50 items and results are separated on the following five usability subscales (Efficiency, Affect, Helpfulness, Control and Learnability). Once questionnaires were completed, a dedicated software program named SUMISCO scores results and compares them to the standardization database. A system that achieves a score in the 40-60 range is comparable in usability to most of successful commercial products (the standardization database does include scores below and above that range).

4.3. SUMI questionnaire results

The results shown in Figure 2 are presented in terms of the mean, the 95% upper and lower confidence levels (UCL and LCL). These descriptive statistics are given for the global usability scale and each of the five usability sub-scales.

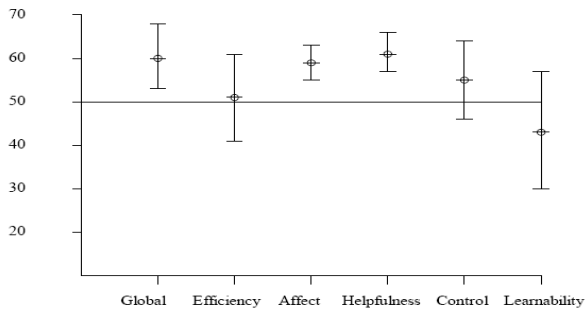

Figure 2. Comparison of global and subscale usability scores (SUMI – evaluation)

The global scale, the most reliable of all the SUMI scales, indicated that the usability of our user interface is comparable to successful commercial systems. In terms of the usability, sub-scales show that results are in general consistent, and nearly all fall within the desired range. The exception is a learnability sub-scale which falls under the desired range as can be seem from Figure 2. That shows that the participants are of the opinion that it is not so easy to learn how to manage the system and to be in control of its features in the first place.

Participants did not share the same opinion about application's efficiency, and had some problems with control of the application. Lower efficiency level shows that users may not always know what to do next or the software may sometimes work in a strange, inconsistent way. High helpfulness level on the other side shows that this application communicates clearly, users can understand the way it works and it gives them helpful hints and instructions.

An outcome of SUMI questionnaire confirms our statement, that the system is usable for integration into educational process. Detailed analysis of answers to questions leads to conclusion, that once the users overcame the initial difficulties with the system, they found the experience of working with it a relatively pleasant, with helpful support and reasonable performance. In order to improve the score, particularly with regard to initial learnability, control and efficiency, the system should be evaluated by participants that already possess some basic computer skills and web-browser experience since they really need that experience for e-learning.

In general, not only results but also behaviour of participants of the survey showed users' interest in the application and use of it as a part of educational process could be a challenge for many students. There are many areas where e-learning courses with interpreter could make learning easier and challenging for heard of hearing people, without the presence of a live interpreter or additional training.

5. Conclusions

In this work an adapted e-learning environment was presented for people with special needs especially for deaf and hard of hearing persons. We incorporated ICT and multimedia materials in a web-based virtual learning environment making it simple but powerful enough for this special group of users. One of the aims was to increase computer literacy among unemployed deaf and hard of hearing persons by using ECDL/ICDL e-learning materials. Results of the tests participants took before and after the courses show that participants were able to successfully use the e-learning environment with adapted materials and learn from them.

The adapted e-learning environment is platform independent, because it is based on Moodle that can be installed on different platforms. In our case the basic requirements for effectively using the adapted materials with this e-learning environment were broadband internet connection, Microsoft Windows

operating system with appropriate version of Internet Explorer and Media player installed to display materials. The main advantages of this tools in comparison to other systems using interactive animation or fully scripted pages was that the web browser and media player are already included in the basic configuration of the operating system. Another advantage in ECDL e-learning materials was the loading speed of video picture inside of the web pages. For faster loading of video with sign language interpreter the video was encoded as streaming media together with marker tags. When compared with other related work, it must be underlined that described e-learning material is the most comprehensive one designed especially for deaf and hard of hearing people. It resulted from an innovative project in the form of interactive video sign language with subtitles for each and every learning unit. Innovative solution using special marker tags inserted into video with interpreter enables almost immediate loading in Internet Explorer. Contrary to some other webcasting systems, such as Goodmood, Virage, Noterik, that use Powerpoint slides, our system uses concrete multimedia supported texts and additional animations.

There is still some work that needs to be done. We are working on a general solution to display streaming video of interpreter with markers regardless of the web browser used. Some further improvements can be done in Moodle, for example a special plug-in that would enable to display video with interpreter anywhere in the Moodle framework. The next step could be an adaptive user-interface that would guide users with special needs and suggest them the most appropriate way to go through the materials. For the time being, e-learning materials only exist in Slovenian language, which can be stated as limitation of the system. However, plans exist for translation to English within forthcoming international projects. SUMI evaluation showed that more attention should be given to exclusive help tutorials, also supported by sign language video.

Acknowledgement

This work has been performed in the framework of European PHARE 2003 project DISNET entitled: "Improvement of computer literacy of unemployed adults" run in the year 2006 and in the framework of EQUAL Project "Equal Study" run in the period 2004-2007. National co-financier was the Slovenian Ministry of Labour, Family and Social Affairs. Fundamental to the study was the close collaboration with Maribor Adult Education Centre (AEC Maribor).

6. References

[1] Begoray, J. A., "An introduction to hypermedia issues, systems and application areas", *International Journal of Man-Machine studies*, 33, pp. 121 – 147, 1990.

[2] Kulik C. C., Kulik J. A., Shwalb B. J., "The Effectiveness of Computer Applications: a Meta-Analysis", *Journal of Research on Computing in Education*, 27, pp. 48-61, 1994.

[3] Chou S.W., Liu C., "Learning effectiveness in a Web-based virtual learning environment: a learner control perspective", *Journal of Computer Assisted Learning*, 21 (1), 2005.

[4] Schulz-Zander R., Büchter A., Dalmer R., "The role of ICT as a promoter of students' cooperation", *Journal of Computer Assisted Learning*, 18 (4), pp. 438, 2002.

[5] Theofanos M.F., Redish J., Bridging the gap: between accessibility and usability, Interactions, Issue 6, Volume 10, pp. 36 – 51, 2003.

[6] Drigas A.S., Kouremenos D., "An e-Learning Management System for the Deaf people", *WSEAS Transaction on Advances in Engineering Education*, Issue 1, Volume 2, pp. 20-24, 2005.

[7] Kronreif G. et al., "SMILE: demonstration of a cognitively oriented solution to the improvement of written language competence of deaf people". *Proceedings of the 7th International Conference on Computers Helping People with Special Needs - ICCHP'2000.* 17-21 July, Karlsruhe, Germany, 2000.

[8] Debevc M., Zorič-Venuti M., Peljhan Ž., "E-learning material planning and preparation", *Report of the European project BITEMA (Bilingual Teaching Material For The Deaf by Means of ICT)*, source: http://www.bitema.uni-mb.si/Documents/PDF/E_learning_material_writing.pdf, Maribor, Slovenia, May, 2003.

[9] Carpenter D., Dolan D., Leahy D., Sher-Wood-Smith M., *ECDL/ICDL: a global computer literacy initiative, Proceedings of Conference on Educational Uses of Information and Communication Technologies (ICEUT)*, Beijing: Publishing House of Electronics Industry (PHEI), 2000.

[10] Osguthorpe, R. T., Graham, C. R., "Blended Learning Environments: Definitions and Directions", *Quarterly Review of Distance Education*, (3) 2003.

[11] Dougiamas, M., Taylor, P., "Moodle: Using Learning Communities to Create an Open Source Course Management System". In P. Kommers & G. Richards (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2003* (pp. 171-178). Chesapeake, VA: AACE, 2003.

[12] Smith C, Mayes T., "Telematics Applications for Education and Training: Usability Guide". *ICBL*, January, 1996.

[13] Mazaik, C., *Guidelines for Producing Accessible Multimedia for Deaf and Hard-of-Hearing Students*, WGBH Educational Foundation 1993.

[14] Hellström G., "Quality Measurement on Video Communication for Sign Language". *Proceedings of the 16th International Symposium on Human Factors in Telecommunications*, 12-16 May, Oslo, Norway, 1997.

[15] Kirakowski J., Corbett M., "SUMI: The Software Usability Measurement Inventory", *British Journal of Educational Technology*, 24 (3), 1993, pp. 210-212.