ACCESSIBLE E-LEARNING

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Abstract: The emergence of information and communication technologies has increased opportunities for successful integration of students with disabilities in education. These students can thus gain new knowledge and skills during their studies regardless of the type of disability. However, it requires good knowledge of the requirements and needs of students with disabilities that must be considered in design of the study materials. This paper presents various requirements of students with disabilities, legal aspects and reasons why universities should provide better support to students with disabilities. We also provide examples of good practice, such as transparent video and e-learning portal for deaf and hard of hearing people.

Keywords: E-Learning, Distance learning, Accessibility, Disability, User Experience, Deaf, Blind, Partially Sighted

1. INTRODUCTION

With the help of information and communication technologies (ICT) as well as with simultaneous social, societal and educational changes the students with disabilities can gain new possibilities and opportunities for equal inclusion in education, working and social environments. With its remote services the internet has at a very early stage offered the opportunity for easier inclusion, especially through the World Wide Web, videoconferencing and the cooperative learning environment. In social and e-learning environments there is no longer important, if there is a person with disability on the other end. However, collaboration, knowledge and ability to learn with the help of ICT have become more important.

Despite the fact that there are new possibilities for better integration of students with disabilities available, it can still be noted that according to data presented by the European Disability Forum [1], only 9% of Europeans with disabilities go to University. Even if it is estimated that about 16% of the people in Europe have some form of disability, it can be argued that the participation rates of students with disabilities in higher education are still low [1].

The reasons for this are the barriers in the understanding of requirements and needs of students with disabilities, as they are specific users with special needs what make subjects difficult to adjust [2]. That is why it is very difficult to implement a universal e-learning environment for this target audience, which could be concomitantly used by all students with disabilities. Moreover, according to the mentioned Annual Report of the EDF [1] it was concluded that 95% of all public websites are not accessible for Europeans with disabilities.

In order to solve this difficult situation a wide range of conventions, declarations and legislations are available on the global and European scale. The most important accessibility legislation documents are:

- United Nations Convention on the Rights of Persons with Disabilities (CRPD) from 2006 [5],

- UNESCO: Education for All goals [6],
- Conclusion from the Council meeting of Ministers of Education on the Social Dimension of Education and Training of May, 2010 [7],
- Riga declaration from June 11, 2006 [8],
- Brussels Declaration on Sign Languages in the European Union [9],
- Conclusion of the Council of Ministers of Education from May 2012 [10],
- EU Guiding principles in e-accessibility [11].

Accessibility legislation differs across European countries [12]. Some countries provide greater support for persons with disabilities, such as the UK, Finland, France and some others, while in countries, such as Romania and Bulgaria, there is still room for improvements in this field.

In the field of education, equal opportunities are addressed in the Conclusion of the Council of Ministers of Education [7] where it is stated that social inclusion through education and training should ensure equal opportunities for accessing quality education as well as equity in treatment, including the adaptation of provisions to individuals' needs.

When it comes to the web, the problem is that the level of compliance with web accessibility guidelines is still very low and web sites often fail in the second attempt of checking the accessibility. This means that in the update process terms of accessibility are often neglected and thereby worsening the level of compliance. In this case the standardized instructions could help, such as the Web Content Accessibility Guidelines (WCAG) [13], with guidelines and criteria for setting basic instructions for web accessibility and thus indirectly for e-learning environments as well.

Consequently, there is an urgent need for research, design and development of accessible e-learning to provide

appropriate, usable and accessible education for people with disabilities in order to improve their reading ability and education level as well as prepare them for job competition.

2. CHARACTERISTICS AND BARRIERS OF PERSONS WITH DISABILITIES

According to the EDF Annual Report [1], only 29% of all Europeans with disabilities are employed. Due to lack of competitiveness and unemployment in the labour market the number of students with disabilities is increasing. Problems which the students encounter during their studies are not only health and socio-economic issues, but they also refer to the lack of motivation and limitations in accessing support in the academic process.

Therefore there is an exceptional need to encourage students to study and to use ICT for these purposes to the highest possible extent. Due to the different types of disability teachers' knowledge of the needs and requirements of individuals with disabilities is necessary and must be taken into account in developing or in transition to e- learning materials. Teachers can face with the following types of disabled students: deaf, hard of hearing, visually impaired, mobility disabled and persons with mental disorders.

Deaf. Deaf people have lower educational level compared to hearing people, which leads to a lower professional rank [2]. Our experiences show that the number of deaf persons who have completed university education is extremely low; in Slovenia it comes up to about one to two per year. The reason may be communication specifics of this social group, since born deaf persons use sign language as a first language and written or spoken language as a second language. Our previous study thus substantiated that they need a sign language translator live or remotely, audio transcriptions and video captioning [1].

Hard of hearing. Hard of hearing persons are also visually oriented and use technical devices for listening, such as hearing aids. Since hearing aids unfortunately have a limited range (a few meters), they need FM systems or T-coil systems for listening to audio devices or lectures. Just like the deaf they also need audio transcriptions and video captioning.

Visually impaired. Blind students prefer different styles of learning and have a tendency to more audible and sometimes kinaesthetic interactive environments in regard to touch and voice commands. E-learning environments designed for visually impaired people should be based on written text, and should contain descriptions and text-based tools to facilitate their work with the help of screen reader systems [14] and Braille displays. In any case, they require textual descriptions for all graphics and video files. Partially sighted people need options to resize the screen or fonts on the display to change colours and contrasts.

Deaf-blind. This is the most neglected group of persons with disabilities, which has the most difficult requirements regarding the relevant devices for communication and information transmission. This is also a group which is often wrongly ignored when developing products for persons with disabilities. They are subject to a combination of the above described requirements and needs of the deaf and blind persons who need special tactile devices.

Mobility disabled. In the mobility disabled group we encounter various physical disabilities, ranging from partially motoric difficulties to a complete paralysis. Each level of physical disability requires different adjustments. These adjustments may include keyboard adjustments, use of alternative or extended keyboards, systems for sound entries, a system for entries through eye movement, a stick to scroll on the screen (joystick) and other adjustments. Regarding the e-learning materials it is necessary to enable easy targeting of commands and navigation aids.

Persons with Mental Disorders. Due to the large number of different mental disorders it is often necessary to consider individual treatment and individual, personalized adjustment of e-learning materials.

Other problems, faced by people with disabilities, are first of all barriers to social inclusion in the study process, because in the real, direct environment they are often stigmatized and excluded. With the help of ICT, this barrier can be significantly reduced, as people do not always have the feeling that there is a person with disability on the other end.

Secondly, their right to communication and education is often limited, which is in opposition to their rights. Especially ICT with its social networks and communication aids can in this case improve their right.

Thirdly, there is a lack of professional staff skills in educational institutions which would be able to provide professional support for people with disabilities. In this case an intense awareness and training of the staff involved in working with them would be necessary. It is also important that each institution has its own section that is dedicated to assisting people with disabilities and to the staff.

Fourthly, each educational institution, especially libraries, should have technical support for studies that could provide information in a correct way (sign language, audio description, Braille support, scanners for blind and partially sighted).

Finally, the ability of appropriate rearrangement and adjustment of learning materials is one of the most significant problems in the transition from traditional to accessible e-learning materials. Original e-learning materials should have the whole range of interactive and demonstrative elements for each type of disability. In practice this could mean creating at least six different materials for each type of disability separately, being theoretically possible, but not applicable in practice due to high financial, human resource and time requirements.

This problem can be solved by **personalization and adaptation of e-learning materials**, so that **modularization** would enable the addition or adaptation of modules, required for different types of disability. For instance, in the e-learning system for a deaf student videos with sign language interpreters would be included subsequently as a translation of the e-learning material. For a blind student audio clips for images and videos could be included in the appropriate places.

The image below shows two examples of e-learning material. To the left, there is inappropriate material, which does not reach the accessibility compliance, while the material to the right does. As one can see from Figure 1, a simpler navigation, less text and the integration of the interpreter's videos with captions are emphasized.
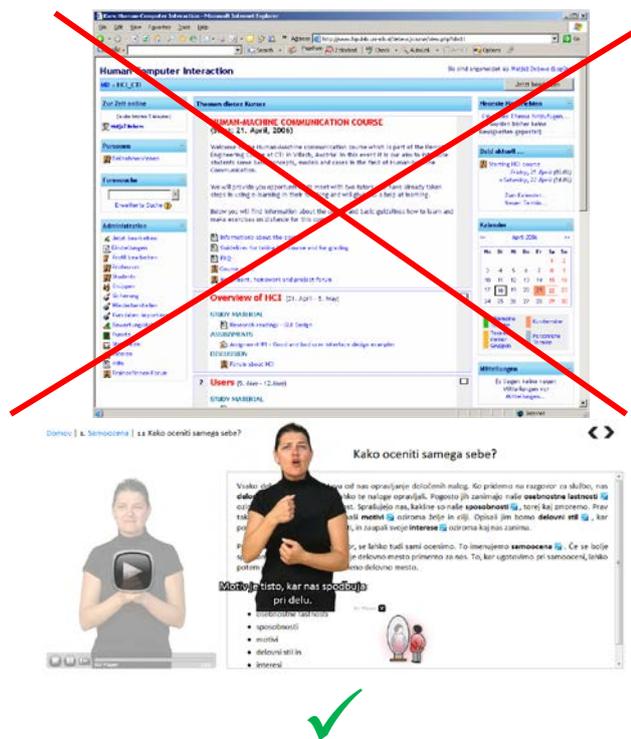
a) inaccessible   b) accessible

Figure 1: Examples of the e-learning material

3. IMPLEMENTATION GUIDELINES FOR PROVIDING ACCESSIBILITY

To comprehensively solve the problem of transition of learning materials from classical to accessible e-learning materials in educational institutions, it is necessary to consider the following four steps:

Step 1: **Awareness**
Step 2: **Analysis and evaluation**
Step 3: **Implementation**
Step 4: **Accessibility integration**

Step 1: Awareness. Awareness is required in each institution to recognize the requirements and needs of students with disabilities. Here it is necessary to identify and determine the stakeholders, participating in the entire process, and predict the number of students with disabilities.

Afterwards, we assign a team leader, who focuses on students with disabilities and has business lines with greater infrastructure impact. Next, a working team is established. This team determines the objectives and tasks of the transition from classical to accessible e-learning.

Step 2: Analysis and evaluation. The next step is to check and make an assessment of the current situation as well as to find opportunities for improvement. The first part presents the use of iterative design principles, which includes prototype development and testing by using a mock-up or computer generated prototype.

Next, appropriate content is to be ensured. Ideally, the e-learning materials could include three levels. The first level would include PowerPoint materials. The second level would include PowerPoint materials, expanded with texts and commentaries, including interaction elements, such as simulations, animations or videos. The third level would then be the entire textbook with all the detailed data.

With these three basic levels it may be possible to reach better personalization and level lessons. Level lessons refer to teaching, where students with different abilities get materials from various difficulty levels. To be more precise, based on our own experiences deaf students often need textual material with a lower difficulty level.

Within the analysis it is then necessary to determine the methods for a quick response and the reliability of the e-learning content, so that planners right at the beginning receive the main instructions for the implementation of simple navigation (left-right, text menu) and structuring of the material.

The next move in this part is setting-up the accessibility goals, such as how many clicks do we need to get the required information.

At the end of this section, evaluation methods for the verification of technologies, pedagogical suitability and usability should be set.

Step 3: Implementation. Implementation is the most challenging part of the development or the transition of e-learning materials. At first, it is necessary to develop an accessibility integration roadmap, which will determine timing and starting points for creating accessibility modules.

Then we find and use the accessibility compliance standards for the web, documents and other elements of e-learning. With the help of these standards we prepare an accessibility checklist, which helps us in coherent creating and testing of the new and improved accessible materials. In this phase we have to set up an appropriate accessibility web portal, which must be stable and quickly

accessible. For this purpose we can use cloud technologies; if we find that the amount of material and the number of accesses to the portal is increasing and decreasing dynamically.

Finally, an update on technical aids (Braille displays, alternative keyboards, joysticks, head-mounted sensors, hearing instruments, etc.) must be carried out.

Step 4: Accessibility Integration. The last step is the accessibility integration, where we specify the subject matter expert resource in key IT projects and with their help integrate and ensure that in all future implementations the compliance processes for increasing accessibility will be taken into consideration.

In this section we first identify these processes and integrate them into existing processes in the software development life cycle. We must precisely specify touch points in this development process, so that engineers can plan when and where the accessibility experts should be integrated. We also define the accessibility checklists, guidelines, techniques as project artefacts, which shall in the future be used in the same way, in order to prevent the materials to upgrade without checking for accessibility.

The last move in this step is the execution of the training for analysts, developers, document producers, university teaching staff and also, if necessary, for students with disabilities on using and considering accessible e-learning.

An important part is also ongoing, written information on new developments in the field of accessibility for all participants where we also include online social networking tools to achieve personalization of e-learning materials.

4. "QUICK & DIRTY" DESIGN TIPS

There is a large number of instructions and rules about how to prepare and create websites and e-learning materials for students with disabilities. The most used are the WCAG 2.0 instructions [13], which include 12 guidelines, 65 success criteria and 3 levels of compliance. Other popular instructions are Web Accessibility in Mind (WebAIM) [16], which provide simple principles of accessible design, including alternative texts and transcripts for media.

According to our experience in developing e-learning materials, we eventually gathered a group of the most important instructions for the implementation, which we have called "Quick & Dirty" design tips. These instructions are:
- Think about the technology being used.
- Think about colour and visual effects.
- Organize materials in a simple and logical order.
- Include simple navigation.
- Provide simple texts.
- Always provide text alternatives for images and videos.
- Make links understandable.

- Caption and transcript all audio and video.
- Add real text to PDF's.
- Add styles to Word documents.
- Use software for producing accessible HTML documents from Word.

Think about technology being used. The first step is to define the ICT equipment for students with disabilities, enabling them easier integration into the e-learning system.

Above all, deaf students need video based technology along with chat programs, while hard of hearing students need hearing aids and hearing aids accessories for listening from a distance or for the use with audio equipment.

Blind students need Braille input and output devices and speech output systems. Partially sighted students need possibilities to change size of both text and graphics and to change the background and foreground colour. Voice output systems are also used.

Mobility impaired students need in particular alternative input devices and adjustments of the working environment. These adjustments may include keyboards adjustments, alternative or extended keyboards, sound systems for entries, a system for entries through eye movement, a stick to scroll on the screen (joystick) and other adjustments.

Think about colour and visual effects. As already mentioned, for partially sighted students it is necessary to have the possibility of colour-exchanging due to high rates of colour blindness. Ten per cent of men in population are colour-blind. We shall avoid using flashing elements, which may further deteriorate the observation of the screen, since flashing elements always attract our eyes.

Organize materials in a simple and logical order. Simplicity, brevity, clarity and transparency of the text along with the images are criteria of primary importance for deaf and hard of hearing students. They need less demanding texts with less unknown words. For deaf and partially sighted students the most important elements to be considered are transparency of text and easier navigation between sections and paragraphs.

Include simple navigation. On the right side of Image 1 one can see an example of simple navigation with no other elements but the button forward, back (on the right side of the screen) and the listed chapter titles (on the left side of the screen). In this way we actually limited the useful options, however, achieved greater security, stability and robustness of the system and above all consistency throughout the text.

Provide simple text for deaf people. Unfortunately, born deaf people do not understand the written word well enough, as written or spoken language is a second language. In some environments up to 80% of deaf people do not understand the text read [17]. Thence it is

necessary to design clear lecture notes or additional descriptions of PowerPoint slides. The text should include a glossary with a sign language interpreter for further explanation of difficult words.

Always provide text alternatives for images and video. The main problem of blind students is that they cannot see the image, therefore, they need further textual explanation. For this purpose an alternative HTML tag (ALT) must be used with the text, describing the image and/or the video.

Make links understandable. Links should be clearly marked and it should be already evident from the text what is behind the link. Do not use "click here" as link text.

Caption and transcript all audio and video. There is a general misconception that there is no need to include captions for audio and video. However, captions and transcript are important not only for deaf and hard of hearing students, but also for other disabled people because it is easier for them to follow the text compared to a single channel. Deaf persons are even able to see better in the peripheral part of the vision, allowing them to more easily than people with normal eyesight observe the sign language interpreter on the screen as well as the captions [17]. Captions also significantly contribute to a better understanding of the given information, even up to 40% better than without captions [17].

Adding Real Text to PDF's. For online reading the PDF format for the preparation of texts is mostly used. Texts in PDF may or may not be present. In the case where there is no text present, but it looks like a picture, each optical character recognition will have difficulties in identifying the text from the image. So it is better to add real text to the PDF, thereby allowing the reader for the blind people simpler and more accurate reading of the text.

Adding Styles to Word Documents. Using styles, necessary for screen readers, that differ from the formatting buttons in the top of the window is substantiated to increase accessibility [18]. Styles and formatting can easily be found in the toolbar of the Word program.

Students use skim with the help of software for reading all headings and subheadings styles. Once the right heading is found, the user points it to the text that follows it and reads that next. If a document does not have styles, it is impossible for the technology to skim a document.

Use software for producing accessible HTML documents from Word. On the market there are some tools that can be used as plug-ins for Microsoft Word [19]. Their main advantage is that they enable an easy creation of well-structured, accessible e-learning content without specialist graphic design tools and often not requiring knowledge in HTML design. Another advantage is that they generate simple navigation links and that their HTML web pages automatically comply with the instructions of the WCAG [13]. Good tools also allow the

storage into the SCORM package, enabling the transfer of e-learning material into various learning management systems. This additionally ensures the consistency of presentation, which can be customized by using style sheets. An example of such a tool is Wimba Create [19].

5. PRACTICE EXAMPLES

In the course of our work in the field of internet technologies and partly with the support of the European Union under the Lifelong Learning Programme in Deafvoc project [20] and the Slovenian national programs, we have developed several successful, even on a European scale awarded accessible e-learning solutions.

Video-based E-Lectures for All Participants (VELAP). Considering accessibility, a recording system was developed as the largest project [1]. The primary goal was to provide live streaming of lectures. The main features were:

- automated recording of lectures with additional materials (presentation slides, video captions, table of contents) for live and on-demand web presentations;
- inclusion of additional media streams (supplementary video, audio, screen capturing);
- inclusion of:
  - sign language video and captions for deaf and hard of hearing users,
  - audio captions, text enlargements, background/foreground colour corrections and JAWS compatibility for visually impaired users;
- personal customization of the user's view;
- interactive questions.

The advantage of this system over others is that we enabled the simultaneous live transmission of up to five video/audio/text streams (Figure 2). With the help of automated post-production an online lecture is immediately available to a wider audience. Subsequent adding of individual streams is also possible.
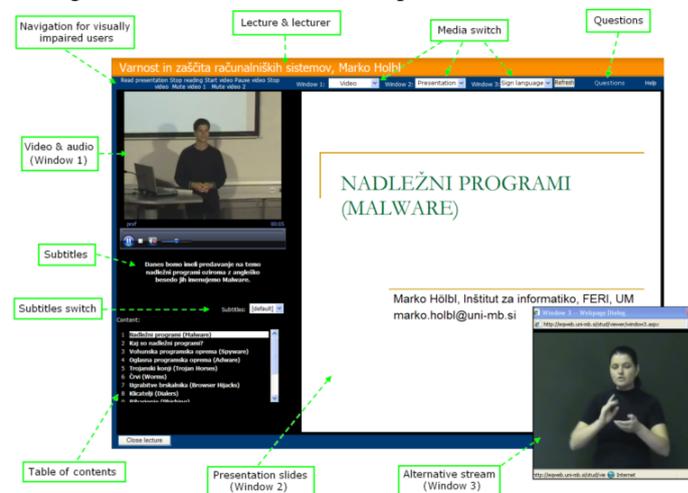

Figure 2: Video recording system for students with disabilities

Sign Language Interpreter Web Based Video Module (SLI module). For deaf and hard of hearing sign language

users we have developed a transparent video sign language interpreter. The innovation of this system is that the display combines video, audio, captions and navigation aids on an existing website as a translucent video on request of the user, i.e. deaf or hard of hearing person (Figure 3).

E-learning Portal for Deaf and Hard of Hearing. This is a portal intended for deaf sign language users as well as partially sighted persons. The content is primarily text-based, containing also several sign language interpreter videos (Image 1, to the right). It comprises the narrative section as well as the communication part, where in addition to the textual chat, an innovative video forum and a video-collaboration tool also appears [1], [15].

Figure 3: Transparent Video for
Deaf and Hard of Hearing

Other examples of the successful use of the ICT, which can be found elsewhere, are as follows:

- **Audio and Multimedia tour guides**
    - e.g. museums (with transcript)
- **Virtual Reality tours**
    - e.g. 3D - Louvre Museum [21]
- **Touch tours for blind and partially sighted**
    - e.g. Museum of Modern Art, New York [22]
- **Augmented Reality for accessibility**
    - e.g. MapAbility [23], Google Glass [24]
- **Inclusion of online social networking services**
    - e.g. Online Presence for Learning project (OP4L) .

6. CONCLUSION

In this paper we presented an overview of the requirements and legal aspects of the development of accessible e-learning. Additionally, we showed what needs to be done in order to successfully create accessible materials and substantiated it with examples of best practice.

Persons with disabilities definitely have the right to equality and equivalence in education and work. If they have been marginalized in the social environment until now, they finally receive more attention. In this regard ICT and e-learning can significantly contribute to improving the situation. The borders are already increasingly blurred, enabling everyone an equal integration into the social, societal and working environment, regardless of the type of disability.

What is needed is just the will, energy and proper project management with regard to accessibility guidelines, such as WCAG [13] and WebAIM [16] and a good knowledge of the requirements and needs of persons with disabilities. In addition, it is necessary to raise the awareness of accessible technology and equality on any school level.

With further development of ICT and e-learning in the direction of accessibility our aim will be to help improve literacy, increase employment among people with disabilities and at the same time increase their competitiveness and self-esteem on the labour market.

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