E-learning Accessibility for Students with Disabilities

JIŘÍ GLOZAR – LUCIE KASTNEROVÁ – ONDŘEJ NEČAS –
SVATOSLAV ONDRA – PETR PEŇÁZ

Support Centre for Students with Special Needs
Masaryk University

January 2007

Index

1. General Principles of Accessibility

The Masaryk University Rector's directive No. 3/2002 aims at securing accessibility of all works published by the University for persons with special sensory disabilities such as a visual impairment, which hinders a common perception of published information, and hearing impairment, which hinders its understanding. The directive commits the Support Centre for Students with Special Needs (onwards referred to as the *Teiresias Centre*) to deposit copies of all Masaryk University publications in formats accessible to persons with sensory disabilities in a nation-wide accessible electronic library (http://library.muni.cz/katalogy-e.html). A substantial change arrived within less than five years after the issue of the directive: printed materials gradually ceased to be viewed as published study materials in the instruction practice while electronic materials which are regularly viewed as such. Unfortunately, it has also become a fact that a probability of an electronic work being accessible to persons with sensory disabilities was much higher five years ago. Paradoxically, securing electronic accessibility is a much more demanding task at present. The aim of this material is to inform the public, and especially the future creators of e-learning materials, about commitments MU has taken upon itself towards persons with disabilities. We understand that it is not always possible – either due to the character of a subject matter or the lack of time or technical possibilities on authors' part – to create a course accessible to everyone. It is no exception that such goal cannot be reached by any means at all. Still, it is our wish that authors of e-learning courses do not become accidental or unintentional producers of barriers, or remain unaware of steps expected from them by MU in areas where results of their work necessarily create barriers. As in the case of printed publications, this concerns the duty of mere notification: it is sufficient to send a short email to employees of the Library and Publishing section of the Teiresias Centre (with the necessary access rights) at the time of a publication of a new course. An employee of the Teiresias Centre then may attempt to make the course accessible (to create an accessible copy).

Generally it may be said that principles which secure the highest possible accessibility of persons with disabilities to any e-learning course as soon as it is created are, to a large degree, identical with requirements in general:

- an exact and clear course structure corresponding to a clearly expressed educational aim,
- clear and correct standard language, which is complicated in correspondence with the educational aim (thus not more complicated than it is necessary for the given aim),
- a proper technical solution, i.e. one in correspondence with valid norms for the source code.

It also holds for each electronic, and thus also a Web application that, with full respect to all these principles, it may contain elements producing barriers for a specific group of users. If we understand as e-learning such applications that use common Web tools for instruction (we deliberately speak about Web tools, not general electronic ones as it is only the Web which allows for a distance self-study as one of the key functions of e-learning) then issues of Web accessibility relate also to e-learning. An e-learning system, which is understood as such, may be divided into three closely interrelated levels:

1. The basic Web environment – an application which creates the main frame for a user's environment of an e-learning system (in the case of Masaryk University, these are most commonly the applications *Study materials* in the Information System and systems based on the *Moodle* application).
2. The content of courses in HTML, XHTML or CSS formats created by teachers. These courses are then in this form published either within the basic Web environment of an e-learning system (for example, a content of an interactive syllabus in the agenda of *Study Materials* in IS or *Moodle*) or externally.

3. Content of courses published in other formats than HTML. It is most frequently present in e-learning applications in the form of links to files with study materials and informative documents.

1.1. First Level – Basic Web E-learning Environment

Electronic courses are published and their operation is secured by a Web application which makes the frame of the e-learning environment from a user's perspective. In all courses published within an e-learning system, teachers and students work with a complex of Web pages of the same structure independently determined by the e-learning application. The *Study materials* system in the IS and *Moodle* represent the applications used at Masaryk University. The former includes agendas such as Interactive syllabus, Testing and File manager while the latter includes modules such as Lesson, Quiz, Assignment, and Study materials. Elimination of barrier elements on the first level is the basic condition for securing accessibility to an e-learning application as a whole for users with disabilities. As in most cases the basic frame of an application is based on the HTML technology (or XHTML, CSS, and JavaScript), its accessibility may be achieved by following the technical rules summarized in ch. 2.2.

It **is not in the competence of course creators** to secure accessibility of this part of an e-learning environment, as it depends on a development team and administrators of a particular system. In the case of Masaryk University, the Teiresias Centre is in touch with creators and administrators of e-learning applications and it gives them comments and suggestions aimed at improvements in accessibility.

1.2. Second Level – Course Content in HTML Format

E-learning applications allow their authors to publish their electronic courses, among others, as documents in the HTML format implemented into the frame of the e-learning application. In the practice at Masaryk University, it is typically a content of an Interactive syllabus to a course (in *Study materials* in the Information System) or the content of a course presented in the Lesson or Book module (in *Moodle*). An author of a course may also publish materials in the HTML format, which are published outside an e-learning application as an independent Web page or in the form of a file in the HTML format. These materials are connected with the e-learning environment through a link leading to them. In all cases, these are documents which are, unlike the previous ones, fully in their author's competence. Their authors may influence their contents, internal structure as well as accessibility for persons with disabilities, which can be secured by the following:

1. meeting technical criteria for publication in a given code, and
2. eliminating barriers resulting form psychological-perceptional limitations of a given disability (lucidity or language complexity).

Each type of disability produced tasks of both types, technical and psychological, although generally it may be said that meeting technical requirements about the code correctness is crucial especially for persons with a heavy visual impairment (see ch. 2.2), while overcoming psychological and linguistic barriers is crucial for persons with a heavy hearing impairment (see ch. 3.1).

1.3. Third Level – Course Content in Other Formats than HTML

Within courses, it is possible to publish materials in virtually any electronic format (graphic objects, films, videos, sound objects, voice, music and multimedia). The only limitation is the requirement that all users should be able to open a file in the selected format and work with it. This it must be possible to open this file format with a freely available program equipment or with an equipment supplied by the author of the course.

Accessibility of these formats for persons with disabilities must be assessed separately in each individual case from various perspectives:

1. Accessibility of data as such is fundamental (blind users cannot use visual materials, deaf users cannot use audio ones).
2. Provided that a material content is accessible for persons with sensory disabilities, it is necessary that an application used for work with this material does not collide with other technical equipment crucial to the user with disabilities on which depend, contrary to the majority of students (screen readers in the case of the visually impaired and subtitling applications or sign language videos in the case of the hearing impaired).
3. The data structure is also important (the amount, complexity, importance, necessity for the course, and the like).

2. E-learning for Students with Visual Impairment

2.1. Examples of Psychological-Perceptional Limitations

A visually impaired person either relies on an assistance of a supportive software – a screen reader able to scan alphanumerical signs on the screen and interpret them either by the means of an electronic voice synthesizer (a voice output), or specialized hardware – a Braille display. It follows that the accessibility of e-learning documents primarily depends on technical parameters (see ch. 2.2 below). First, it is necessary to list some of the basic and typical limitations on the psychological-perceptional level:

1. Voice and tactile outputs are both linear; it is never possible to follow more pieces of information at the same time, only sequentially so, one sign after another. This way of perceiving may be in conflict with:

   a) cases, where it is necessary to simultaneously follow two parts of a text when working with a material (for example, in linguistic exercises aimed at filling gaps with listed answers or, in mathematics when comparing an expression before and after modification),
   b) an extensive, non-symmetrical table (i.e. such that is not defined by a simple distribution of columns and rows),
   c) information following from a mere closeness of words or objects on a screen (a seeing person automatically interprets objects which are displayed closely together or on the same level as related, parallel, equivalent, and so on, without any verbal commentary).

   The accessibility of a) can be solved by an appropriate labelling of structures (a beginning of a list of entries and a beginning of a text) by keywords or headings, which a user can use for quick navigation; it is possible to solve the case of b) by an adaptation of a table into a symmetrical form (the same number of columns and rows at all times) with a newly formulated cells in the head; and c) may be solved when words or objects with a corresponding content are not visually connected with technical means that in fact separate them (frames, columns, and others).

2. Neither voice nor tactile output can be used to grant access to graphical objects (including specialized symbols which are dealt with in ch. 2.4) or, by no means, to objects whose understanding is based on spatial imagination. A description or verbal commentary of such objects can partially substitute for them on an informative level. But if the aim of work with such material is to give a person with a visual impairment a similar effect as to others, it is inevitable to make a two-dimensional model (a sheet with tactile graphics) in the case of two-dimensional graphics and a three-dimensional model of an object in case of graphics visualizing spatial objects. Leaving aside the unrealistic nature of a large number production of such copies, working with them rarely creates an identical psychological impact (a perception of such objects is more complex than the perception of words).

2.2. Summary of Basic Rules of Accessibility to HTML, XHTML, and CSS Documents

Basic technical accessibility for visually impaired users (in fact accessibility of screen readers) may be achieved by following the following rules, which have been compiled as a synthesis of rules of accessibility to the Web in general based on available sources on the one hand and, on the other, on the basis of direct experiences of our department with the support of visually impaired students – e-learning users. Links to relevant parts of external sources supplement each of the rules for further details.

1. **All non-textual elements carrying a meaningful message have a defined textual alternative.**

    a) A textual alternative may be attributed to graphical objects with the help of the ALT attribute. It should express the content message of the graphical object and not its visual description.
    b) An alternative text of a graphical object which serves as page navigation (typically, a link consisting of an image or a graphical object as a substitute for standard form buttons) should describe the target of the link or the function of a form button.

    http://www.blindfriendly.cz/doc/bfw.php#kap2.1
    http://www.blindfriendly.cz/doc/bfw.php#kap3.1
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#images
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#forms-graphical-buttons
    http://www.webstyleguide.com/graphics/access.html

2. **Navigation objects created by scripts, applets and so on should remain accessible, even if the user does not use them.**

    a) They are built in such a way that the missing technology does not prevent a clear access to objects.
    b) In case point a) is not met, objects should have an accessible alternative.

    http://www.blindfriendly.cz/doc/bfw.php#kap2.2
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#scripts
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#objects
    http://www.webaim.org/techniques/javascript/

3. **Tables should only be used for structuring data; it is not recommended to use them to modify a page layout.**

    a) Trivial data should not be organized in a table if it is simple to express them in a textual form.
    b) All that belongs to one cell given the content should be defined as such also in the source code of a table and vice versa – data belonging to different cells given their content should also be separated in the source code.
    c) Width and height of cells should be defined in relative terms and not in absolute units.

    http://www.w3.org/TR/WCAG10-HTML-TECHS/#tables
    http://www.blindfriendly.cz/doc/bfw.php#kap2.3
    http://joeclark.org/book/sashay/serialization/Chapter10.html
    http://www.webaim.org/techniques/tables/data.php

4. **If possible, use clickable client-side type maps and define an alternative text for each area.**

    http://www.blindfriendly.cz/doc/bfw.php#kap2.4
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#image-maps

5. **The content of a Web page only changes when a user activates an element.**

a) When the content of a page changes due to a manipulation with form controls, it does so after a user’s command – by activating a confirm button.
b) If possible, avoid automatic refresh of page content.

http://www.blindfriendly.cz/doc/bfw.php#kap2.5
http://www.w3.org/TR/WCAG10-HTML-TECHS/#directly-accessible-scripts
http://www.w3.org/TR/WCAG10-HTML-TECHS/#script-refresh

6. **A definition of potential frames should not prevent from adjusting their size and displaying their content in case of a less common monitor output resolution and it should include a frame description.**

a) A frame size should be defined in relative terms. Scrolling and size adjustment should not be forbidden.
b) Each frame should have a defined title expressing its meaning and content and its relation to other frames.

http://www.blindfriendly.cz/doc/bfw.php#kap2.6
http://www.w3.org/TR/WCAG10-HTML-TECHS/#frames
http://joeclark.org/book/sashay/serialization/Chapter10.html
http://www.webaim.org/techniques/frames/

7. **It is not recommended to use colour for important information, and if so, then they should be available as an alternative.**

http://www.blindfriendly.cz/doc/bfw.php#kap2.8
http://joeclark.org/book/sashay/serialization/Chapter09.html

8. **Letter sizes should not be defined in absolute units.**

Letter sizes should be defined relatively (e.g. in CSS key words `xx-small`, `x-small`, `small`, `medium`, `large`, `x-large` and `xx-large`, per cents or em and ex units).

http://www.blindfriendly.cz/doc/bfw.php#kap2.10
http://www.w3.org/TR/WCAG10-CSS-TECHS/#units
http://www.webstyleguide.com/interface/access.html

9. **The code of the Web page corresponds with some published final specification of HTML or XHTML and CSS.**

http://www.blindfriendly.cz/doc/bfw.php#kap2.11
http://joeclark.org/book/sashay/serialization/Chapter05.html
http://www.w3.org/TR/html4/
http://www.w3.org/TR/xhtml1/
http://www.w3.org/TR/CSS21/

10. **Formatting tools should only be used in order to achieve the necessary look and layout of a page. The following are considered incorrect:**

a) empty graphical objects used for indentation, and
b) table cells used for spacing.

http://www.webstyleguide.com/interface/access.html

11. **The source code should correctly use elements of HTML (XHTML) to label semantic meaning of individual parts of a page, such as:**

a) headings following a correct hierarchy, and
b) lists and their items following a correct hierarchy of sub-lists.

http://www.blindfriendly.cz/doc/bfw.php#kap2.13
http://www.w3.org/TR/WCAG10-HTML-TECHS/#lists
http://www.webstyleguide.com/type/structure.html
http://joeclark.org/book/sashay/serialization/Chapter07.html
http://www.webaim.org/techniques/semanticstructure/

12. **Each form control has an assigned apt description which is bound to it in the source code.**

    The tag <LABEL> may be used in HTML to bind a description with a form control.

    http://www.blindfriendly.cz/doc/bfw.php#kap2.14
    http://www.w3.org/TR/WCAG10-HTML-TECHS/#forms-labels
    http://joeclark.org/book/sashay/serialization/Chapter12.html
    http://www.webaim.org/techniques/forms/

13. **The main message should be present at the beginning of a Web page.**

    This requirement need not collide with an author's artistic intention when the cascading style technique is appropriately applied. If it is still not possible to meet this requirement, an internal link (anchor) to the main message should be present at the beginning of the page.

    http://www.blindfriendly.cz/doc/bfw.php#kap3.2
    http://www.w3.org/TR/WCAG10-CSS-TECHS/#style-alignment
    http://www.webaim.org/techniques/skipnav/

14. **If a link leads to a document in other format than HTML (XHTML), this information should be included in the link.**

    http://www.blindfriendly.cz/doc/bfw.php#kap3.2

15. **Links should only open in a new window in justified cases and this fact should be included in the link. Automatic openings in new windows such as *pop-up* are not recommended.**

    http://www.blindfriendly.cz/doc/bfw.php#kap3.2

There is no point in this brief document to attempt at a general overview of problematic barriers which cannot be removed by a technical adjustment of the HTML code, nor to continue the listing. Our centre offers help to authors of electronic courses in such difficult situations.

2.3. Materials in Formats Other than HTML

As it was stated in ch. 1.3, accessibility of these formats for the visually impaired must be assessed from several perspectives:

1. Accessibility of the data as such: a blind user cannot observe, for examples, photographs or graphical objects (two- or three-dimensional). Materials of this kind, in case they are necessary for a course (and if it is possible due to an object's nature) need to be substituted with a textual version. A text in a graphical form inserted into a file is of course inaccessible, too, although the rest of the file may be accessible (for example, a paginated image of a scan of an originally printed work or an MS Word document saved as a PDF file).
2. An application, which is used for work with a file in a given format, must not be in conflict with supportive technologies. The application should have a standard user interface with regard to the operation system platform, which will secure its better accessibility by screen readers as well as accessibility in non-standard settings of the video output. It should further meet the following requirement: crucial controls should not be represented in a graphical form only but they should be present as text, and it should be possible to fully control the application with a keyboard.
3. The data structure is important, too, even if they are in a potentially conceivable format. Naturally, it holds that no information can be expressed graphically only (by the font size, colour, and the like) and the requirement for a linear reading of a file mentioned in the introduction must be met.

The following is a list of formats and files most frequently used for a presentation of study materials. They are accompanied with brief commentaries about their accessibility for the visually impaired. Accessibility of various formats is considered primarily from a technical perspective, i.e. such techniques of use of a given format are mentioned which eliminate basic barriers for working with them disregarding psychological-perceptional limitations of a disability. This list of formats is by no means complete; it is necessary to consider possibilities and limits of accessibility of the less frequent ones individually.

Plain Text

It is often used for publishing technical data where further formatting does not make sense, for example program source codes. In case of texts of other characteristics, these do not create a fundamental barrier for a visually impaired person when the content structure is simple and there is only insignificant semantic information about the text, which this format cannot keep with the text.

MS Word Document and Compatible Formats

The vast majority of accessibility technologies (screen readers, magnifying programs) primarily emphasizes the level of accessibility of the MS Word application and its documents among word processors. From the perspective of technical accessibility, no fundamental barriers appear for a vast majority of files in this format when a document is correctly structured (for example, styles with an appropriate level are used for structure labelling, *bullet* and *number lists* and *footnote* functions are used to label objects of the given type, and so on) and graphical objects are equipped with a textual label (see [19] for more information). A further limitation for an MS Word format file accessibility may result from a psychological-perceptional limitation of a visually impaired person – see ch. 2.1; a visually impaired person's knowledge of and experience with possibilities of supportive technologies in accessibility of the MS Word application is a factor which is no less important because it influences the accessibility of documents individually.

MS Excel Table and Compatible Formats

From the point of view of accessibility, it is always more appropriate to present data with table structure in the table format rather than attempt to interpret them in another way, such as a purely textual one where, for example, there is no unambiguously available information about the current cursor position, the cursor navigation does not respect cell areas, and data can only be followed by the row. It naturally holds that a document cannot express information in a graphical form, such as through various colours in the cell background. The accessibility condition for MS Excel format is the same as in the case of the preceding one – personal experience with possibilities of supportive technologies for work with the MS Excel application.

Adobe PDF Document

Although this format is often considered as utterly inaccessible for the visually impaired, it is possible to eliminate its basic technical barriers by observing the rules which are explained in detail in [6], [8] and [22]. PDF documents are often protected against copying and cutting of their content or, moreover, content cutting allowing accessibility may be disabled. Such security settings present the first barrier of accessibility for the visually impaired and should not be applied for this reason. When these criteria are not met, which is the more frequent case with published files, blind users can follow the content in the PDF format with great difficulty and at most the textual component void of structural information is accessible. Furthermore in practice, only some supportive applications are able to make accessible the content of PDF documents which excludes a certain user group from the use of PDF and requires advanced user knowledge and experience from the rest. Except for very simple documents where there is usually no principal reason to use the PDF format for publication, the PDF format cannot be recommended due to the above mentioned facts.

PostScript document

Most of what has been said about the PDF format is valid for the PostScript document and, furthermore, programs for work with this format are not as widespread. PostScript is often used to publish documents created in *TeX* and, in such case it may be considered whether the source file could be useful for blind students in a course, who could use it to have at least a general idea about the document content.

Macromedia Flash, SWF

A publication of content in this format creates a barrier for the blind as well as other users who cannot or do not wish to enable this format on their computers. This format primarily serves to present graphical effects which are useful when the subject matter needs to be enlivened but a course should always offer the possibility to turn off these effects without loss of information. Although it is possible to create an accessible document in the Flash format [7], it is not easy. For the reasons given above, a creation of a user interface and interactive elements in the Flash format or SWF cannot be recommended.

Audio file

All audio formats present no fundamental barrier for the blind if they meet the requirement that an accessible application for opening a given audio format is available (see the second point in the introduction to this chapter). However, it presents a fundamental barrier for the hearing impaired.

Video

Blind users can only follow an audio component of a video recording. A visual component needs to be substituted with a sound track describing it or at least a textual summary of the whole video file.

2.4. Blind Users and Special Symbols

Texts with special symbols (most frequently mathematical, physical and chemical formulas) present a specific type of texts which cannot be processed in HTML. Unfortunately, there is no general recommended procedure even for seeing users in e-learning courses of the Masaryk University Information System (IS). This casts two problems which need to be dealt with:

1. publishing of prepared formulas (as a part of an HTML page or in an external file), and
2. inserting formulas as part of common work online (e.g. as test answers).

An ideal state is such when both types need not to be distinguished because they will unite with an operative way to write formulas correctly in work online, which will be also used for publishing (as it is the case with writing common alphanumerical characters). Presently, there is no such way at hand.

2.4.1. Publishing of Formulas

Mathematical texts, which are a part of a Web page, can be displayed in several ways. Jiří Kosek identifies the oldest and least suitable one in [16] as "a formula created with the help of God and tables". It is a combination of formatting HTML labels such as <SUB> and <SUP>, positioning with tables and styles, characters from special fonts, graphical lines and small pictures. A formula which is created this way is utterly unintelligible to blind users and it is hardly readable for users who work with magnified fonts. Moreover, in most cases it is displayed incorrectly after minimal changes in a browser's settings. The use of this method can be declared absolutely inappropriate.

Another possibility, which is probably the most frequently used one, is to publish a formula on a page as a picture acquired from a mathematical editor export (e.g. from *Matlab* or *TeX*). In this case, an author can be certain that a formula will be displayed correctly on all computers. However, in case font size or screen size is changed, undesirable changes in text arrangement on a screen may occur. Naturally, a picture is inaccessible for blind users and if such a formula is to be accessible, it must be accompanied by an ALT attribute with its alternative textual version.

A third way to display a formula on a Web page is to use the MathML language which is designed for noting mathematics. This language is based on XML, so it is possible to insert it into a page directly. Unfortunately, it is presently supported only by some browsers and these are not united. A generally available tool for the blind which would enable them to read documents in MathML does not exist, but as MathML represents a format, which is suitable for machine processing, it is generally considered to be a prospective solution and a creation of such a tool can be expected soon.

The last, fourth way of displaying mathematics is based on the use of external display tools (applets). A code of a formula in an appropriate language serves as an input, while the output is a formula in a form of a picture. This way would be useful for blind users only if the picture included a textual label, which would need to be handled by the applet.

None of these ways offers a possibility of creating Web pages with formulas which could be accessed by the blind without further modifications. It is always necessary to supplement a formula with an alternative version available to the blind – either as the ALT attribute or available as a link. The part 2.4.3 describes what this alternative version of a formula should look like. The issue of how this alternative version should be supplemented has not been exactly solved; the Teiresias Centre is planning a development or, more precisely, implementation of tools which will allow to display Web pages with mathematical formulas in tactile form. It is therefore necessary that authors of e-learning courses use, ideally, such a format that will allow for the conversion when noting formulas. *MathML* and *TeX* may be currently recognized as such tools.

IS offers a tool to insert mathematical formulas inside tags <M> and </M> in mimeTeX coding (description of the mimeTeX language is in [20]) as a part of its environment for creation of test questions. Formulas which are inserted by this method are changed into pictures with an ALT attribute including the source text in mimeTeX. This possibility is available in testing questions only and it is not yet possible to insert formula in a format for a tactile display. Still, to a certain degree this format allows a blind user to work and its use may be recommended.

Another possibility is not to insert formulas into a Web page but to place a link there leading to a material in another format enabling a display of formulas. This method is more common at the present. A mathematical text is most frequently published in the PostScript and PDF formats which are exports from TeX or other system of specialized text typing.

Unfortunately, these in principle graphical formats remain practically unusable for the blind – although screen readers allow for reading PDF to a degree, they usually cannot handle mathematical formulas. Interactive graphical materials, such as flash presentations or external mathematical systems applets, are even less suitable for blind users – user interfaces of these applications are usually non-standard, so it is impossible to use a screen reader.

Unfortunately it holds that graphical and interactive formats are recommended for courses as accessible for the deaf, but if a course is also to be accessible for the blind, it is necessary to publish materials in another, convertible format along with these document.

2.4.2. Inserting Formulas as Part of Common Work or as Answers

A solution to a situation where a user is supposed to insert a formula (typically as a test answer) is another issue. This has not been satisfactorily solved for seeing students either. If a student is supposed to insert a text which includes a formula, e.g. in an answer sheet in the IS, they can only do so with a use of plain text which must encode mathematical symbols in some suitable way. The existing practice is that the coding is specified separately for each case (usually as part of instructions to the solution).

As this method is based on plain text, it is equally well usable for the blind, but it has many disadvantages – inserting takes a long time, it is not well arranged and it is difficult to automatically assess answers (an insubstantial change, such as a different order of brackets, may result in an answer evaluation as false). Also the fact that different code may be used in different courses is unpleasant and untenable for the future. Given the decrease of opportunities to encounter standard notation in practice, an awareness of the sheer existence of a standard is violated for a whole generation.

It is therefore highly desirable to establish a unified format for inserting formulas in the IS (and possibly to modify the editor), preferably such that would also allow the visually impaired to work with it – so it should not be based on a graphical representation of a formula but rather on an open and unambiguous system of coding of mathematical as well as other symbolic expressions.

2.4.3. Formats Accessible for the Blind

The issue of mathematical and other symbolic notation in tactile writing is quite extensive. Notations are always dependent on a specific national environment. Currently, mathematics and other specialized symbols are noted according to a generally available norm [11] in a six-point system of tactile writing in the Czech environment (each Braille character is constituted by one to six tactile points, thus having 64 characters – Unicode 2800-283F), and this format is in essence suitable for tactile print. A Czech mathematical norm has not been established for the eight-point Braille system (a character of this system consist of one to eight tactile points, thus having 256 characters – Unicode 2800-28FF), which is a notation common for computer tactile displays. All complicated characters and symbols of a common notation need to be coded as a sequence of more Braille characters as part of a work with the six-point system. A Unicode coding of a Braille text, which would be the most unambiguous solution, is not used in practice yet. It is possible to electronically notate a text intended for a six-point print or a six-point tactile display as plain ASCII text consisting of just 64 characters corresponding to six-point Braille characters (in the Czech environment, there are 41 Braille characters for letters of the Czech alphabet, 15 characters for punctuation and other symbols and 7 special characters). Czech characters must be conventionally coded for a correct interpretation (typically Windows 1250), special Braille characters which serve as switches (prefixes) are a more complicated task – they have no fixed conventional equivalent in visual representation and they are coded according to the output device in use.

The Teiresias Centre offers a service of study materials transfer from TeX to a tactile print format; this serves for a now traditional creation of printed study materials. It is possible to gain plain ASCII text through another conversion and documents prepared in this way can be published in an e-learning course.

However, a seeing person experiences difficulties with reading and editing of a text which is coded in this way. Furthermore, at this point there is no widely used editor which would enable to process texts for the six-point Braille system or to convert them from other formats. Still, there are tools which can make a creation of such documents easier. *BlindMoose* is one of such tools. It is based on Bachelor's theses at the Faculty of Informatics, Masaryk University [2] and [10], and it is further developed in the Teiresias Centre. It is an MS Word set of macros enabling the creation and editing of basic mathematical texts for the blind as well as seeing users; the output is a standard MS Word file, which can be read on any computer (after an installation of a special font family or a screen reader coding table). An automatic conversion from an external format such as TeX and MathML is not available.

Among the generally more widespread and complex tools for text processing for the blind, there are, for example, the Lambda editor developed by a consortium of 14 research institutions under the auspices of the European Union [17], a commercial editor and typesetting system *Duxbury Braille Translator* [9], and others; unfortunately, none of these supports the Czech Braille norm.

There are many other norms for coding mathematics for a Braille notation in other national environments, such as the *Nemeth code* [1] widespread in the USA. These norms are not taught at Czech schools and their acquisition by Czech users is complicated.

3. E-learning for Students with Hearing Impairment

As the Internet offers textual and visual material much more often than audio (leaving aside legal and illegal trade with music itself), the hearing impaired are often regarded as users who have no difficulties using the Web. This is not quite so. The following points summarize general recommendations for accessibility to e-learning courses and, perhaps, the Web as such, for this group of users.

3.1. Psychological-Perceptional Rules

What serves as a common denominator of these rules is the fact that for a majority of people with a severe hearing impairment it is a **sign language**, not a **national majority language** which is mostly natural for them. The impossibility to perceive a language as frequently and readiness leads to a lack of linguistic experience – there are incomparably fewer texts in sign languages, even more so due to the fact that these are often not notated, and their users represent a narrower variety of social and professional attitudes than it is the case with spoken languages as a result of a long lasting discrimination. Besides, the Czech Sign Language (the word "Czech" in this case refers only to the area of use, not to a linguistic relation) is, for example, typologically and structurally different from Czech to such degree that its native speakers experience difficulties with an analysis of texts in Czech (and independent expression of sentences in this language) fully comparable with other linguistic foreigners who use a typologically completely different linguistic code (that is to say those who speak other languages than Indo-European). As a result, it is difficult for the hearing impaired to perceive information in spoken as well as written, textual form.

1. A course as a whole and primarily its textual part must have a **rigid structure** (e.g., use lists and similar textual organizing elements) and its crucial parts must be highlighted relatively to others.
2. In case a text includes **marginal vocabulary expressions** (historicisms, poeticisms, colloquialisms) or little frequent scientific terms which are not explained as part of the course, it is suitable to include some form of dictionary into the course. Linguistic elements mainly used in spoken communication (social conversation, telephone calls), high frequency of adjectives and others create a serious barrier.
3. It is recommended to provide a course with **visual and interactive elements**. Graphs, animation, pictures, and interactive presentations supplement the main part of the course and they have an irreplaceable role in the didactics and teaching methods of the hearing impaired, they illustrate meaning of words and make a conveyed information more interesting and, first of all, easier to understand and accept; this actually holds for the hearing, too. On the other hand, this usually presents an insuperable obstacle for the visually impaired, so there is no format suitable for both types of impairment.
4. **Inductive method of instruction** should take priority over **deductive methods** where this is possible according to a topic and nature of a subject matter; also, it is necessary to build definitions of abstract terms on concrete ones. It is also a good idea to double check the orientation in vertical structure of terms in use (hyponyms

and hypernyms) as the hierarchy of terms need not be *a priori* clear to a sign language speaker.

5. A course should include more parts devoted to **practising acquired knowledge**, its following **testing** and regular **repetition**. Given the effort a deaf person must make to understand a text and the structural difference of the code spontaneously worked with, the pedagogical impact of information in Czech (or any other spoken language) is never as permanent as in the case of hearing students.
6. Key passages in a text (for example definitions and propositions in mathematics) and extended text passages should be accompanied with a **translation to a sign language** (i.e. with a video recording of an interpretation of a given text into Czech Sign Language by an interpreter). This is similar to the situation when audio files are included – see next chapter.

3.2. Technical Devices of Accessibility

Observing these rules is absolutely necessary for a course accessibility for students with hearing impairment.

1. **All audio recordings need to be supplemented with a textual alternative directly in the present file** or at least with a brief description of the content. Furthermore, if the recording is crucial for understanding the lecture, it is highly recommended to provide it with subtitles or an equivalent (transcription, description and explanation) in a sign language. In this case a course creator can ask the Teiresias Centre to provide them with a technical realisation – the Centre will translate the text, make a video recording of the translation and implement it technically into the course upon an agreement with the author. The author then may offer the modified copy to students as a part of their course or hand over the work on the modified course to lecturers from the Teiresias Centre.
2. All audiovisual recordings crucial for understanding a given subject matter (typically recordings of lectures) need to be provided with **subtitles or translation into a sign language** as in the case of video files. In the latter case, the Teiresias Centre will perform the realisation. The result will be a video file. A link to this file may be placed conveniently next to the original with a note that this recording is in the Czech Sign Language. Hearing students will thus have the opportunity to watch the original recording without being disturbed by a signing interpreter; students with hearing impairment may use the modified recording with an interpreter.

The choice between a technical solution with subtitles or video recording with an equivalent in a sign languages depends on many factors which are primarily related to the content of the material as such. Subtitles are suitable for such recordings, where the spoken word does not have the main role but only supplements a visual action (films, music videos and other audiovisual works) or when it is a recording of a rather simple dialogue (audio recordings). On the contrary, sign interpreting is irreplaceable in those cases, where the recording is based on a long monologue with no support of a visual component.

4. E-learning for Students with Motor Impairment

In case of students with motor impairment, the capability to perceive e-learning courses is usually not influenced as the majority are paraplegic and quadriplegic with a dominant disability of the lower extremities. In such cases, e-learning courses represent an important contribution to overcoming barriers because they make accessible the instruction with minimal requirements of getting around. However, limitations in the use of hands (shaking and damage of finger motor capacities) or their complete exclusion may radically modify their possibilities to use computers. Such cases mostly need to be taken care of by supportive hardware devices (special mouses, keyboards, adapters, and eye-typing). A relatively low number and great variety of these cases makes it impossible to formulate generally applicable rules of accessibility – it needs to be achieved on an individual basis.

Works Cited

[1] *An Introduction to the Nemeth Braille Code for Mathematics.* Dotlessbraille.org. Last update 2002-02-27. [online] Available at: <http://www.dotlessbraille.org/NemethIntro.htm>. [cit. 2006-11-21]

[2] BOČEK, Jan. *Aplikace pro zápis matematických textů na elektronickém záznamníku nevidomého II*. Brno 2004. Bakalářská práce (Bc.) Masarykova univerzita, Fakulta informatiky.

[3] BOS, B., ÇELIK, T., HICKSON, I., Hakon Wium Lie (eds.). *Cascading Style Sheets, level 2 revision 1 : CSS 2.1 Specification* [online]. Revision 1, World Wide Web Consortium, W3C Working Draft 06 November 2006 [cit. 2006-12-16]. Available at: <http://www.w3.org/TR/CSS21/>.

[4] CALDWELL, Ben; SLATIN, John; VANDERHEIDEN, Gregg (eds.). *Web Content Accessibility Guidelines 2.0* [online]. W3C c2006. Available at: <http://www.w3.org/TR/WCAG20/> [cit.2006-12-02]

[5] CLARK, Joe. *Building Accessible Websites : Serialization* [online]. Updated 2005. 12. 16 [cit.2006-12-14]. Available at: <http://joeclark.org/book/sashay/serialization/>.

[6] CLARK, Joe. *Facts and Opinions About PDF Accessibility*. In: A List Apart for People Who Make Websites [online]. No. 201, August 22, 2005 [cit 2006-12-16]. Available at:<http://www.alistapart.com/articles/pdf_accessibility>

[7] *Creating Accessible Macromedia Flash Content*. In: WebAIM (Web Accessibility in Mind).[online]. Center for Persons with Disabilities, Utah State University c1999-2006 [cit. 2006-12-13]. Available at: <http://www.webaim.org/techniques/flash/>

[8] *Creating Accessible PDF Documents with Adobe Acrobat 7.0. A Guide for Publishing PDF Documents for Use by People with Disabilities* [online]. Adobe Systems Incorporated c2005. Available at: <http://www.adobe.com/enterprise/accessibility/pdfs/acro7_pg_ue.pdf>

[9] *Duxbury Braille Translator*. Duxbury Systems, Inc. c2006-11-09. [online] Available at: <http://www.duxburysystems.com/dbt.asp>. [cit. 2006-11-21]

[10] ENDL, Martin. *Aplikace pro zápis matematických textů na elektronickém záznamníku nevidomého I*. Brno 2004. Bakalářská práce (Bc.) Masarykova univerzita, Fakulta informatiky.

[11] GONZÚROVÁ, Wanda. *Příručka pro přepis černotisku podle normy bodového písma*. První vydání. Praha : Knihovna a tiskárna pro nevidomé K. E. Macana 1997.

[12] GYBELS, Guido. *Deaf and Hard of Hearing Users and Web Accessibility* [online]. Royal National Institute for the Deaf c2004. Available at: <http://www.ictrnid.org.uk/docs/webacc.pdf>. [cit. 2006-12-02]

[13] CHISHOLM, W., VANDERHEIDEN, G., JACOBS, I. (eds.). *HTML Techniques for WebContent Accessibility Guidelines* [online]. Version 1.0, World Wide Web Consortium, W3C Note 6 November 2000 [cit. 2006-12-14]. Available at: <http://www.w3.org/TR/WCAG10-HTMLTECHS/>.

[14][S3] CHISHOLM, W., VANDERHEIDEN, G., JACOBS, I. (eds.). *CSS Techniques for WebContent Accessibility Guidelines* [online]. Version 1.0, World Wide Web Consortium, W3C Note 6 November 2000 [cit. 2006-12-14]. Dostupné z : <http://www.w3.org/TR/WCAG10-CSSTECHS/>.

[15] KOCUR, Pavel. *Multimédia v práci s ha*[*n*]*dicapovanými lidmi* [online]. Západočeská univerzita v Plzni c2006. Available at: <http://www.pef.zcu.cz/pef/kvd/cz/materialy/multihandi/index.htm> [cit. 2006-30-12]

[16] KOSEK, Jiří. *HTML – Tvorba dokonalých www stránek: podrobný průvodce*. Vyd. 1. Praha : Grada 1998. ISBN: 80-7169-608-0

[17] *Lambda Project. European Union*, IST – Information Society. [online] Available at: <http://www.lambdaproject.org/ASP/>. [cit. 2006-11-21]

[18] LYNCH, Patrick, HORTON, Sarah. *Web Style Guide* [online]. 2nd edition, Last updated 12 July 2005 [cit. 2006-12-14]. Available at: <http://www.webstyleguide.com/>.

[19] *Microsoft Word*. In: WebAIM (Web Accessibility in Mind). [online]. Center for Persons with Disabilities, Utah State University c1999-2006 [cit. 2006-12-13]. Available at: <http://www.webaim.org/techniques/word/>

[20] *mimeTeX quickstart*. John Forkosh Associates, Inc. c2002-2006 [online] Available at: <http://www.forkosh.com/mimetex.html>. [cit. 2006-11-21]

[21] PAVLÍČEK, Radek. *Blind Friendly Web : Dokumentace zásad přístupnosti webových stránek pro těžce zrakově postižené uživatele* [online]. Verze 2.3, Sjednocená organizace nevidomých a slabozrakých ČR, datum vydání 31. 3. 2005 [cit. 2006-12-14]. Available at: <http://www.blindfriendly.cz/doc/bfw.php>.

[22] *PDF Accessibility*. In: WebAIM (Web Accessibility in Mind). [online]. Center for Persons with Disabilities, Utah State University c1999-2006 [cit. 2006-12-13]. Available at: <http://www.webaim.org/techniques/acrobat/>

[23] RAGGETT, D., Le HORS, A., JACOBS, I. (eds.). *HTML 4.01 Specification* [online]. World Wide Web Cosortium, W3C Recommendation 24 December 1999 [cit. 2006-12-16]. Available at: <http://www.w3.org/TR/html4/>.

[24] *WebAIM (Web Accessibility in Mind). Articles* [online]. Center for Persons with Disabilities, Utah State University c1999-2006 [cit. 2006-12-13]. Available at: <http://www.webaim.org/articles/>.

[25] World Wide Web Consortium. *XHTML™ 1.0 The Extensible HyperText Markup Language (Second Edition) : A Reformulation of HTML 4 in XML 1.0* [online]. W3C Recommendation 26 January 2000, revised 1 August 2002 [cit. 2006-12-16]. Available at: <http://www.w3.org/TR/xhtml1/>.