Designing and implementing a framework and methodology suitable for creating accessible e-learning materials

ABONYI-TÓTH, Andor, HU

Abstract: The production of accessible educational multimedia materials poses a number of methodological as well as technical challenges to the developers. In this article I present a design-based research project for the creation of a framework (ELTESCORM) which effectively supports the development of accessible e-learning material.

Key words: design-based research, accessible e-learning materials, metadata

1   Introduction

"The Europe 2020 strategy calls for efforts to reduce to less than 10 % by 2020 the proportion of people aged 18-24 who leave education and training with lower secondary education at most. (...) in the EU as a whole the rate of early leavers from school and education was much higher for disabled people than for those not having a disability: 31.5 % compared with 12.3 %." [1]

In order to decrease the drop-out rate of students with disabilities, the principle of equal access shall be realised, that is, educational materials must be accessible for all people.

It is important to keep in mind that accessibility is not only important for disabled people, but for user groups being in a special position in terms of how they use technology. The majority of the students would like to learn using smartphones and tablets (besides traditional materials), but the existing e-materials are mostly unsuitable for their roles (e.g. less and less mobile phones support Flash animation), so students experience the same accessibility problems with them as their disabled mates.

In order to identify the problems arising in the development of accessible learning materials, to define the production process and to specify the solutions to be used, I set up a design-based research project.

2   About the Design-Based Research

Wang & Hannafin [2] give the following definition of design-based research:

…a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories.

Researchers give this approach different names in the literature: "design experiments", "design research", "design based research", "development(al) research", and "formative research" [3].
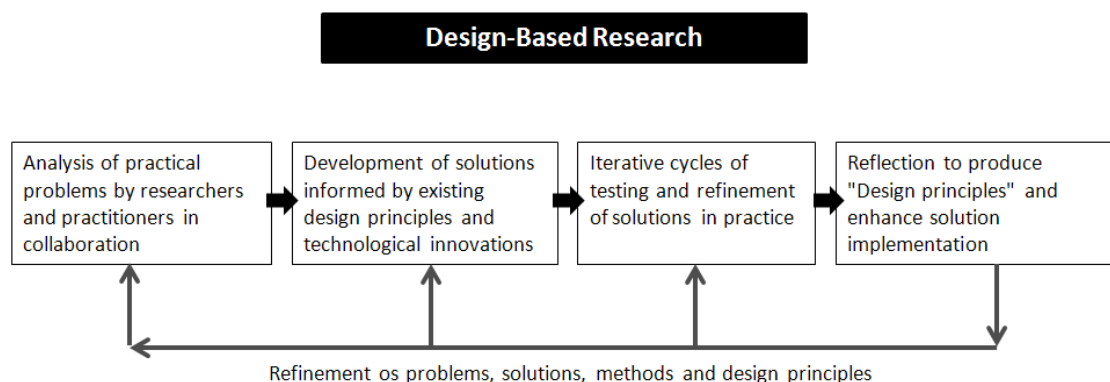
AMIEL & REEVES [4] find that design-based research integrates the solutions to problems experienced in the learning environment and the identification of reusable design principles. When introducing my own design-based research I described the phases of the above-mentioned process diagram in detail.

3 Phase I. Analysis of practical problems by researchers and practitioners in collaboration

In the first phase, we defined the problem at hand, started the communication with the participating practitioners, defined the research questions and processed the literature. After the general definition of the problem, several research questions were formulated:

— Can an accessible, HTML-based e-learning material format be created using the present client-side technology (e.g. JavaScript) that can ease or terminate the accessibility problems experienced in learning management systems (e.g. the difficulties blind users have with navigation platforms)?

— What meta-information should be collected for creating accessible e-learning material?

— What is the most effective way to collect this information from the authors of learning material?

— Can the development of e-learning material be automatized, and if yes, what requirements should be met and developments need to be carried out?

I reviewed the literature, and collected the standards, recommendations and methodological principles. Having processed these, I prepared the first version of the metadata description defining what information shall be collected for each component of the electronic materials (pictures, sounds, video, animation, etc.) so that they could be published in an accessible manner.

4 Phase II. Development of solutions informed by existing design principles and technological innovations

As most authors of educational materials are not necessarily experts of computing, the starting concept was to prepare simple word processor and spreadsheet applications, so that they could submit the necessary metadata in a simple way. I created an RTF template for the inclusion of textual part of the material, whereas an Excel spreadsheet serves for the definition of metadata concerning the media elements.

The template for the text of the learning material must include the title and authors of the unit, the description of the teaching objective and the contents, the preliminary knowledge necessary for understanding the material, the physical tools required for teaching it, the minimal and optimal requirements for students, the bibliography and the

keywords. The elements of the terminology index (terms and their explanations) can be supplied by filling in a table.

Then, the contents of the units shall be filled in the template. A training module can consist of any number of units. For each unit, the author must provide the following information: the title, a short, textual description, the requirements for the unit, the interactive exercises, self-check (multiple choice) questions, and the textual content of the unit.

The media used in the material shall be placed in a pre-created folder structure (animations, pictures, audio files, downloadable files, video files, tables, special elements) by the authors.

The metadata related to the media files and tables to be included in the materials are collected by a multiple-sheet excel table. The rows contain the references to the media elements, whereas the columns show the necessary metadata.

Before each element to be incorporated in the material, the table shows its unique identifier (e.g.{video_1}; {image_23}) The author of the material must place this identifier at the intended location of the element. This model makes it possible for several authors of the same learning material to work in parallel, as the framework used for the production of the material can handle several tables without the need to first interleave their contents manually.

5   Phase III. Iterative cycles of testing and refinement of solutions in practice

Based on the specification, the first version of the framework was created as a thesis by György, Sipos, a senior student of the Faculty of Informatics at ELTE University. The framework creates the web version of the learning material on the basis of the filled-in templates and external files.

During the development, I, the supervisor engaged in a very intensive communication with the student, as I had to test the results of each step for accessibility, which meant the testing of the materials with accessibility tools (e.g. screen reading software). As a result of the tests, the contents of the specification have also been refined. This process led to the first version (v.1) of the ELTESCORM framework that was eligible for practical use.

The framework itself was implemented as a web-based application, which makes it possible for several users to use the system with unique identifiers. Thus, authors with more advanced IT-skills can run the generation of the material themselves. This simplifies updating the learning material, but it must be ensured that the meta-information of the newly incorporated elements is defined precisely.

During the creation of the e-learning materials we implemented several unique functions, which enhance learning experience by putting ergonomic, technical, accessibility and methodological principles into practice.

The e-learning material generated by the ELTESCORM framework is HTML-based, so it can be stored and published on the local computer, a memory stick, a CD/DVD, a web server or in an LMS framework. Using my plans, my colleague, Dr. Győző Horváth (ELTE Faculty of Informatics, Department of Media and Education Technology) created the discrete JavaScript files implementing the principles. By these files several convenience features can be provided to the users which are usually implementable only through server-side programming. Examples of these are the accessible search within a page, the collection of terms on a page, and the immediate evaluation of self-check tests.

We followed the provisions of the HTML standard, and gave a fluid design to our pages, so that the material could be learnt on screens of different resolutions.

The majority of the video files are downloadable is several formats, so users can select the ideal format for their browsing platforms.

Users with visual impairment can select larger font sizes or high contrast with the help of icons. The materials are also usable for those who do not use a mouse, only a keyboard. Hot keys are associated with the functions to further simplify their use. They can be used to return to the previous or move forward to the next page, get back to the home page, access the site map, the help, etc.)

One of the core principles of generating the learning materials was their readability with screen reading applications. Therefore, the code of the generator was programmed to produce an optimal output for screen reading software. We tested the material with several screen readers (JAWS, NVDA), and we involved visually impaired students into the tests. We also noticed that the search within pages did not work as intended in browsers and for visually impaired users, so we incorporated the function in the learning material. Thus, visually impaired visitors can navigate between the expressions found within a page.

We paid special attention to make the textual description of media elements accessible for visually impaired students, be it a description of a picture or the detailed summary of a video.

We placed the explanations of terms in the learning material in a way that they could be readable with a click (or pointing) with the mouse. The function is available to users of screen readers and normal browsers alike.

The terms of a learning material can be listed on a separate page. This function is usually included in the functions of frameworks, but our solution provides direct access to the function without the support of the framework, by simply reading the material.

Self-check tests are also provided for the units of the material, and they are evaluated by the code as well. The answer options for the questions are listed by the browser in a random order, and users receive the evaluation after filling in the test.

The SCORM-compliant metadata is generated automatically by the framework (optionally by the 1.2 or SCORM 2004 standard), so after being loaded into an LMS, the navigation opportunities of the LMS will also be available.

It shall be noted that the existence of the framework is a necessary but not sufficient precondition of an efficient development of the material, as it does not guarantee success by itself. It is necessary to work out a development process, a methodology which summarises the roles (new ones in some occasions), the tasks, the input and output data, the hierarchy of processes and the development cycles of creating accessible e-learning materials.

At the beginning of the process, before stating to develop the learning material, it is imperative to train the authors in the form of internal trainings, in which authors can experience the infocommunications impediments experienced by people with disabilities, and they can gain insight into the special hardware and software tools that technologically disadvantaged users use in their daily lives, whether it's an on-screen keyboard, screen magnifier, screen reading software, etc.

In my experience, the more we succeed in sensitizing the authors to the materials about the ICT problems experienced by disabled users, the more enthusiastic and precise the authors become in supplying the necessary metadata, and the more motivated they are to find the most optimal solutions. The participants of the trainings are instructed about the necessary metadata to be supplied for the production of accessible training materials. Authors have the opportunity to use the templates serving as the input sources for the

framework in the early phases of compiling the learning materials, but they can also fill in the templates after the materials have undergone specialist editing and linguistic review.

When the templates have been filled, the accessibility expert reviews the metadata supplied by the authors, and -- if necessary, in collaboration with the author -- corrects errors and supplies the missing data. It is worth re-checking the modifications by the linguistic reviewer, then the learning material can be generated.

Afterwards, authors and the accessibility experts once again review the material, correct any errors, and repeat this step until all errors have been eliminated.

We always intend to take authors' special requests into account, for example in highlighting specific parts of the texts as sources, tasks or source code. This process improves our framework as well, which necessitates the preparation of newer versions and updating the documentation.

As early as possible, we test the prepared e-learning material with students, in the form of a test training. In this training, students can make comments on the material (in anonymous surveys or face-to-face interviews).

The authors can update the e-materials by incorporating the latest changes. The new version can be generated and published very quickly.

6   Phase IV. Reflection to produce "Design principles" and enhance solution implementation

The ELTESCORM v.1 framework greatly simplified the material development process, but newer and newer demands had to be met and practical problems had to be solved, which necessitated the improvement of the framework. A practical problem was the production of foreign-language materials, which meant that significant changes had to be made in the framework to make the surface available in those languages.

It involved updating the specification, the documentation of the framework and the templates alike. When the first version of the framework was completed, I started to develop the system, and created the second, improved version (v.2), which is enabled to generate foreign-language materials, supports the generation of materials by different templates, and provides for their easy conversion.

The process of specifying the newest version (v.3) of the framework has also started. This version will support the definition of the markup language used to generate the learning material (XHTML or HTML5), and will provide on-line editing functions to authors.

Conclusion

The ELTESCORM framework and the corresponding development methodology of learning materials have proven to be useful and practicable. We succeeded in ensuring the accessibility of the e-learning materials in a way that enables authors to create their materials with tools they use regularly, without the need to familiarize themselves with new, complicated authoring systems.

A direct reference of the materials can be given to students who would otherwise be unable to access the materials because of the accessibility weaknesses of the LMS-system, or the materials can be copied to memory sticks or optical discs.

The work of accessibility experts is simplified as well: the metadata is available in an easily reviewable table format, which makes specialist editing quick and efficient.

Using the framework also facilitates the updating and modification of the materials, as authors have the opportunity to make subsequent modifications, and materials can be re-generated with different designs or by different standards.

The freedom and simple extendibility of the ELTESCORM framework makes it possible to integrate elements in the materials which are not supported in other frameworks, including SVG animations, Google Maps entries or Mashup applications.

Bibliography

[1]   EUROSTAT: *Disability statistics - access to education and training - Statistics Explained* http://ec.europa.eu/eurostat/statistics-explained/index.php/Disability_statistics_-_access_to_education_and_training#Disabled_people_leave_education_and_training_earlier [Accessed on: June 14, 2016].

[2]   WANG, F., & HANNAFIN, M. J. (2005). *Design-based research and technology-enhanced learning environments.* Educational Technology Research and Development, 53(4), 5-23.

[3]   HERRINGTON, J., MCKENNEY, S., REEVES, T. & OLIVER, R. (2007). *Design-based research and doctoral students: Guidelines for preparing a dissertation proposal.* In C. Montgomerie & J. Seale (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007 (pp. 4089-4097). Chesapeake, VA: AACE.

[4]   AMIEL, T., & REEVES, T. C. (2008). *Design-Based Research and Educational Technology: Rethinking Technology and the Research Agenda.* Educational Technology & Society , 11 (4), 29–40.

[5]   György Sipos: *A WCAG és SCORM szabványnak megfelelő, akadálymentes weboldalak előállításának automatizálása (Szakdolgozat). / The Automatization of Accessible Webpages Compliant with the WCAG and SCORM standards. (thesis).* ELTE Faculty of Informatics, 2012.

Lectured by: Erika Jókai, Dr. Ph.D.

Contact address:

Andor Abonyi-Tóth, Dr. Ph.D.,
Department of Media and Educational Informatics, Faculty of Informatics,
Eötvös Loránd University, H-1117 Budapest, Pázmány P. sétány 1/C, Hungary,
phone: +36-1-372-2500 , e-mail: abonyita@inf.elte.hu