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Accessibility and Personalization in OpenCourseWare

An Inclusive Development Approach

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***Abstract*—OpenCourseWare (OCW) has become a desirable source for sharing free educational resources which means there will always be users with differing needs. It is therefore the responsibility of OCW platform developers to consider accessibility as one of their prioritized requirements to ensure ease of use for all, including those with disabilities. However, the main challenge when creating an accessible platform is the ability to address all the different types of barriers that might affect those with a wide range of physical, sensory and cognitive impairments. This article discusses accessibility and personalization strategies and their realisation in the SlideWiki platform, in order to facilitate the development of accessible OCW. Previously, accessibility was seen as a complementary feature that can be tackled in the implementation phase. However, a meaningful integration of accessibility features requires thoughtful consideration during all project phases with active involvement of related stakeholders. The evaluation results and lessons learned from the SlideWiki development process have the potential to assist in the development of other systems that aim for an inclusive approach.**

I. Introduction

OpenCourseWare (OCW) platforms have been widely used for sharing Open Educational Resources (OER) but there is little information about their accessibility for users with disabilities [1]. Accessibility is one of the main objectives that has to be considered when developing an OCW platform such as SlideWiki (https://slidewiki.org), that should be inclusive and easy to use by a wide range of users.

Accessibility and Design for All refer to the creation of products, environments, programs and services that can be used by all people, to the greatest extent possible, without the need for adaptation or specialized design [2]. A number of accessibility standards and guidelines are available to direct the development of accessible systems such as W3C Web Content Accessibility Guidelines (WCAG) 2.0 [3] or the W3C Cognitive and Learning Disabilities Accessibility Task Force (Cognitive A11Y TF) [4] and Easy-to-read [5] guidelines. Some guidelines have been specifically designed for the development of accessible e-learning systems, for example, IMS AfA [6]. However, there is no guarantee that aligning to accessibility standards and guidelines will result in a web service that is usable and provides content that is easy to reach. Nevertheless, research has shown that a development methodology that follows an inclusive approach i.e. involving a range of potential users, including those with disabilities, at the beginning of a project can provide a deeper insight into the requirements to ensure ease of use [7].

The uniqueness of the SlideWiki platform is the manner in which it provides online multilingual courses that offer authors the chance to create slides, organized in modular hierarchies with embedded multimodal and dynamic content as well as self-assessment questions. It aims to provide a structured and organized interface that blends accessibility and usability, while catering for individuals at the top end of academia as well as for those working at entry and mid levels of education. The platform also offers access to content that is compatible with assistive technologies, such as screen readers, text to speech, magnification, and alternative input devices.

This article presents the development approach that was adopted to implement the accessibility requirements of an OCW system and discusses the lessons learned from the three-year SlideWiki project, with special emphasis on the accessibility requirements of two types of user groups: (1) visually and (2) cognitively impaired users.

The remainder of the paper is organized as follows: Section II defines the main accessibility requirements of an OCW system. Section III describes the SlideWiki platform and its functionalities. Section IV explains how accessibility was managed and considered throughout the project development life cycle. Section V illustrates how accessibility was evaluated technically and via running trials. Section VI describes the functions designed to address the needs of users with visual and cognitive impairments. Section VII summarizes how the accessibility of the platform was evaluated and provides lessons learned to implement accessible OCW and related systems. Section VIII concludes and suggests future work.

II. Accessibility Requirements of OCWs

In general, accessibility requirements are defined by the web accessibility guidelines (e.g., WCAG) where developers are provided with a series of Success Criteria and best practices that support the implementation of an accessible web service. These guidelines describe general accessibility requirements

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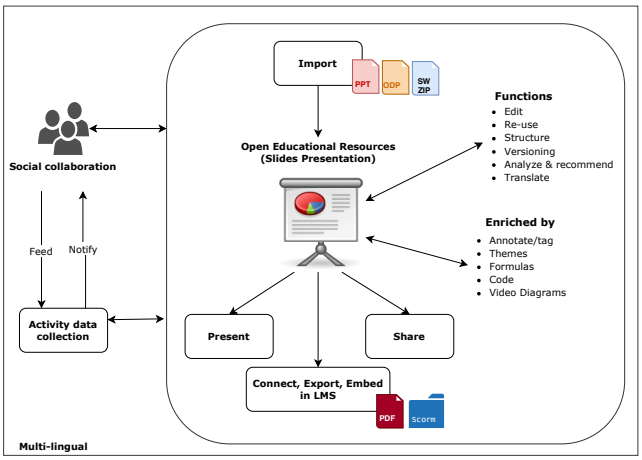

Fig. 1: Overview of SlideWiki features

(e.g., color contrast, headings order) and some of them are now supported by the HTML and CSS definitions (e.g., alt-text, aria-role) to address different needs of users and assistive technologies when interacting with web applications. However, more accessibility requirements can be defined depending on the functionality of the system. These requirements emerge when users start to interact with the system; as people with disabilities use different tools and techniques for performing tasks. For example, users with visual impairments receiving information through audio require a reduced presentation interface that allows them to reach the main functionalities in a less confusing manner and to avoid information overload; these users use the keyboard as input and to have a flexible interaction, they require headings and descriptive texts [8]. Addressing the accessibility requirements for SlideWiki functionalities can be found under the various Success Criteria, but not all developers are aware of the technical nuances of some of the requirements. Therefore, a direct interaction and evaluation of the proposed system from the very beginning of the planning and design stages, by users with disabilities, allows for the detection of any potential barriers that need to be overcome.

III. The SlideWiki Platform

SlideWiki is an OpenCourseWare authoring platform that aims to foster the creation and sharing of qualitative, rich and engaging, multilingual educational content following the 5R principles of OER (Retain, Reuse, Revise, Remix, Redistribute) [9]. Figure 1 illustrates the main features of the platform [10]. The platform targets three types of users: 1) authors who create and edit content, 2) educators who reuse and remix content, and 3) learners who consume and interact with content. The platform uses hierarchical and modular slide decks as the main OERs. These are made up of slide presentations for use in many learning contexts because they provide a comprehensive means for communicating knowledge in a short, concise, and illustrative form. Further, the platform supports social activities where users can share slides/decks or comment on them. Users can receive recommendations for slides/decks that might be of interest to them based on their browsing history and preferences. The SlideWiki platform is open-source (https://slidewiki.github.io) and the content is licensed under the Creative Commons CC-BY-SA to encourage others to contribute and reuse.

TABLE I: Survey responses and average scores in 3 years

Year	# of responses	SUS	Task score	Usefulness
2016	37	56.9	41.025	54.575
2017	296	55.5	56.2	59.4
2018	1179	61.2	61.2	66.4

SUS: System Usability Scale standardised score to measure software usability [11].
Task scores measure the easiness and difficulty of performing tasks.
Usefulness measures usefulness of viewing, creating/editing and presenting slides.

The project has been evaluated in an iterative manner with trials which covered a wide range of users and provided a large number of OERs that significantly guided the implementation of the platform functionality. Table I represents the results of the survey evaluations that were carried out each year. The number of responses increased each year providing a solid evidence base for the functional approaches taken by the development team. This article only reports on a three year period of intensive development on the project (2016-2018). However, the platform is still running and being maintained with new features being added all the time. By January 2020, the platform had 10,422 registered users and 25,140 decks. Of these decks, 2,662 have been forked and 5,492 have been edited by more than one author.

IV. Managing Accessibility

The SlideWiki project adopted accessibility in all its components; this means that texts, images, forms and navigation should be accessible and understandable by as many people as possible with or without disabilities, in order to experience the best possible interactive experience. The platform was optimized to meet the accessibility WCAG 2.0, level AA (ISO/IEC 40500:2012) and the team also applied the requirements of the European standard EN 301 549 V1.1.2 (2015-04).

Managing digital accessibility throughout the project allowed for its inclusion to be directly embedded into the agile development process; which supported the response to user feedback during each sprint (i.e., a sprint is a fixed period of time during which a specific task has to be completed). The development team was provided with resources to foster accessible development approaches and collaborated with accessibility experts to improve this aspect of the build. Feedback from the different trials was continuously collected and communicated to the team, and tasks were planned for the following sprints accordingly. This allowed accessibility to be managed across all project phases.

*1) **Planning**:* As mentioned, WCAG 2.0 accessibility requirements were incorporated into sprint planning, designing the technical architecture as well as features and interfaces. This helped the team to select technologies that supported accessible development and to develop accessible design patterns, as well as to highlight areas of development that needed

to be prioritized due to accessibility and ease of use. For example, a responsive CSS framework was customized with an accessible color palette to provide a consistent user interface that met color contrast requirements.

*2) **Development**:* During each development sprint, accessibility expertise was available to assist with code-reviews and acceptance testing. As developers enhanced their accessibility skills they were able to ensure that issues were identified as early as possible in the development cycle. For example, developers could request accessibility testing of different prototypes to identify which would provide the most accessibility support.

*3) **Testing**:* Components were tested prior to being merged into the platform as part of the Quality Assurance (QA) stage. In this stage components were reviewed to ensure they conformed to functional and accessibility requirements. Issues raised in the QA phase were addressed by developers prior to merging them into the platform or new tasks were created for future sprints, if significant work was required. For example, if not all interactive components were keyboard accessible, this would be noted during QA testing.

*4) **Release**:* Prior to any new release of the platform, the development team undertook a range of testing tasks to confirm that it performed as expected. These testing tasks were written based on the expected performance and user documentation. This allowed updated components to be tested within the platform, as often accessibility issues were found only when tested using a task involving several steps. Issues identified during the testing tasks were either addressed immediately (bugs), logged for future improvement (non-critical issues) or, if significant issues were identified, code was removed from the release and an alternative solution was planned. For example, the component library for the user interface was found to have bugs when supporting screen reader access in some drop-down menus. This required a separate research task, prototype and the testing of an alternative component library.

V. Evaluating accessibility

Feedback from trials was embedded within the development cycle allowing for early evaluation of the functionality of the platform. The accessibility of the platform was evaluated by technical and manual tests, as well as running trials.

A. Technical and Manual Tests

The W3C Website Accessibility Conformance Evaluation Methodology (WCAG-EM) reporting system [12] was used to provide a more in-depth assessment. This provided the authors with a way of evaluating a sample set of web pages as advised in the European Commission Web Accessibility Directive Expert Group (WADEX) [13]. These checks were compared to the functional approach used by Web2Access [14]. The WCAG-EM system provides individual results for each Success Criteria (SC) under the four principles of WCAG 2.0 (ISO/IEC 40500:2012) for each chosen page; an overview of the results is shown in Table II. The Web2Access approach has been used throughout the agile development process of SlideWiki as a way of evaluating the dynamic aspects of the service. However, it has been found that neither method is ideal for informing issues that arise with individual components on the site. These had to be logged in an Excel spreadsheet and submitted using the Zephyr capture feedback form on Jira [15] that alerted the development team of ongoing problems.

Manual checks were used throughout the development of SlideWiki to evaluate any hidden accessibility issues that could not be caught by the use of automatic accessibility checkers such as WAVE [16], Tenon [17] and the Visual ARIA browser extension [18]. The free screen readers NVDA [19] for Windows-PC and VoiceOver [20] for iOS tablets, phones and Mac OS provided information related to the code and the way the browsers/user agents interacted with the platform.

TABLE II: Overview of WCAG-EM results

Principle	Perceivable	Operable	Understandable	Robust	**Total**
Level A	8/9	6/9	4/5	1/2	**19/25**
Level AA	3/5	1/3	4/5	0/0	**8/13**

B. Running Trials

Among a total of sixty eight trials relating to the evaluation of the accessibility of the platform, three involved disability user groups: one trial for visually impaired users, and two trials for intellectually impaired users in vocational and professional training centers. Table III represents the number of contributions for each type of trial. The accessibility checks focused on the main functionalities of the platform, which were used by the trial participants: 1) *accessing the homepage and searching*, 2) *creating and editing decks/slides* and 3) *viewing slideshows*. Aside from the accessibility guidelines and checks, these trials provided additional accessibility requirements and highlighted issues which affected the development and redesign of various components of both the SlideWiki platform and the content of the slide decks.

TABLE III: Summary of trial contributions

Number of	**Authors**	**Decks**	**Slides**	**Trainers**	**Trainees**
Visual Trial	4	8	94	2	5
Cognitive Trials	16	46	1,390	6	10

1) Visual Impairment Trial: Authors who specialized in creating material for visually impaired users and trainees, who were themselves visually impaired. Face-to-face meetings were conducted between authors and the development team, and the platform was tested and evaluated by visually impaired users using their assistive technologies (e.g., Braille display and screen readers).

2) Cognitive Impairment Trials: Authors and trainers of this trial were specialized in *Easy-to-read* methodology and trainees were users with intellectual disabilities. The platform was tested and evaluated by the authors and trainees. Table IV represents examples of the suggested requirements to improve the functions of the platform for visually impaired (VI) users and those with cognitive impairments (CI).

TABLE IV: Examples of trial requirements

1. Accessing the homepage and searching
- Providing large images and icons representing the main functions and facilitating ease of use (CI)
- Providing a quick access to the search of decks (CI)
- Dropdown or any list fields should appear in alphabetical order (CI)
- Providing descriptive images whenever possible to make the functions easy to understand. (CI)
- Provide a simpler version (i.e., concise text) with a clear access to the main functions (VI)
- Search results display is redundant and too complex to understand (VI, CI)
2. Viewing, creating and editing decks/slides
- Providing a simple editor version for blind users; visually impaired users were typically not interested in formatting the content on the slides but in creating and accessing the slide content using their assistive technologies. (VI)
- Allowing action buttons to be positioned in the upper part of the page in order to be easily reachable by screen readers rather than going through the whole page to find the buttons. (VI)
- Improving the importing function as preservation of text format and images is especially important when importing *Easy-to-read* presentations(CI)
3. Viewing slideshows
- Providing live share/presentation rooms where the trainer can share the slides and the trainees can follow the navigation (VI)
- Providing shortcuts for moving through slides in presentation mode and making sure that these shortcuts do not contradict their assistive technologies. (VI)
- Text to speech in presentations (CI)

(VI) Visual Impairment - (CI) Cognitive Impairment

VI. Platform Personalization

Personalization in SlideWiki was carried out by analyzing and including the accessibility needs of the different user groups included in the trials. Some of these needs were addressed over the whole platform (i.e., supporting screen readers), and others were addressed by allowing customization to the platform features (i.e., searching for Easy-to-read materials). Feedback from the trials was collected at regular intervals in order to gather accessibility requirements which were then analyzed and reassigned as tasks for further development. The following sections define the main functions of the platform and the design decisions taken to meet the particular needs that arose from the disability user group trials, in order to make the platform accessible and easy to use. Due to paper size limitation, old and new design images have been made available in an online document ***http://tiny.cc/5re1iz***.

A. Homepage and Search

The homepage was initially designed with a decorative homepage which included a carousel (i.e., a slideshow for cycling through elements) that is available with 'easy to reach' text alternatives fulfilling certain criteria mentioned in WCAG 2.0. In the original design it was possible to pause the carousel and reach all the other elements on the page, with a set of informational text documents in the footer. However, the carousel was disturbing users with intellectual disabilities and the middle part was crowded with information with less focus on the main functions of the platform (i.e., searching for content). These elements made the homepage too complex for those with intellectual and visual impairments and they found it hard to access the decks and slides on the platform. The homepage was redesigned, as shown in Figure 2, by removing the carousel and instead, a large UI component was included to access the search feature, and large icons were added to indicate what is available on SlideWiki; more pictorial components were added to make the content and functions of the platform (e.g., adding flags to the language selection field) easier to understand. Some text on the homepage was replaced to make complex concepts easier to understand and reformatted with respect to the *Easy-to-read* guidelines. For example, the terms 'courses' and 'attach' were used instead of 'presentation' and 'append', because it was found that these words were not familiar to users with intellectual disabilities.

The previous search feature was not totally successful, so the interface for the search results was redesigned to include a left hand collection of filters for language, owners, subjects, education levels, tags and 'Easy to read'. These extra features provided lists of decks or slides as soon as a word has been typed into the search field.

B. Viewing, Creating and Editing Decks/Slides

The deck view is composed of a tree component on the left side with two options; either to view the slide name, or a thumbnail in order to represent an easy overview of the slide content, as requested by the cognitive impairment trials. The navigation is easy, and a screen reader user hears all the complete titles. A user can fork (i.e., reuse and extend) an existing deck or create a new one. The platform uses the CKEditor toolbar, an accessible code library for authoring content that provides positive interactions with assistive technologies. Using accessible libraries has saved time and provides added benefits to all users. However, many of the unique features have required innovative coding and this has meant that ongoing accessibility testing has taken up a considerable amount of time. Most of the editor features have been relocated to a left hand menu system that has clearer choices and offers easy access to the word-processing toolbar without covering the top menu buttons. The editor was redesigned to be simpler including the most commonly accessed tools and different editing modes, such as Markdown-based syntax to make it easier for visually impaired users to use the editor. In addition, authors of content are prompted to add alternative text to images as these are uploaded, to provide support for screen reader users. It is particularly important that an author completes this task because only they understand the context of their image and may have a specific audience in mind.

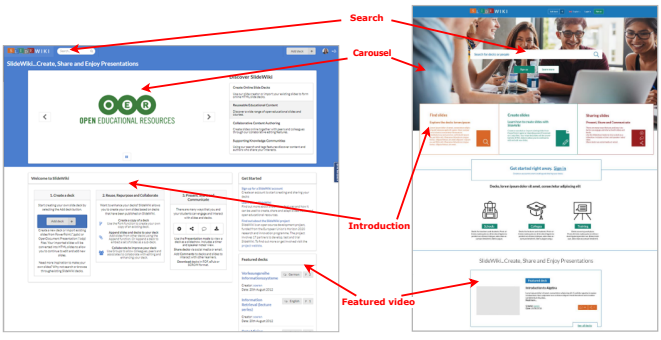

Fig. 2: SlideWiki homepage old and new design

C. Viewing Slideshows

The slideshow presentation mode opens a new tab that allows the user to see the slide in full screen with a navigational button to move sequentially through the slides. The addition of a menu providing a deck view enables users to jump to different slides when in presentation mode. This has helped usability and screen reader access, along with the addition of slide numbers. On the deck view page, the deck activity can be viewed via a live session for the deck to which participants can be invited. All aspects can be reached with keyboard access; this was requested by trainers of visually impaired users to facilitate the teaching process in their session (i.e., users can follow the slides at the same time as their trainer is working through the presentation).

VII. Evaluation Results & Lessons Learned

WCAG 2.0 guidelines were incorporated into the evaluation results as well as feedback regarding the accessibility barriers encountered by users with visual and cognitive impairments in the early stages of the SlideWiki development life cycle. This included all design decisions (i.e., designing UI and compatibility of functions to assistive technologies) that affected the development process over the three years. The above practices and considerations helped in the process of selecting technologies that would support accessible development and accessible design patterns as well as highlighting areas of development that needed to be prioritized due to accessibility, ease of use and inclusion requirements.

The accessibility of the platform was analyzed against WCAG 2.0 recommendations, as the latest version of WCAG 2.1 was not available at the time. Manual checks were used as well as automated accessibility testing tools, but in essence it was the feedback from the trials that highlighted issues that could not have been foreseen just using the guidelines and accessibility checking processes. So, although the project was targeting WCAG 2.0 AA overall, some *Operable* principles at level A and AA failed in places. This was due to the incomplete accessibility of fields (i.e., some drop down lists and automatically generated text options) caused issues for NVDA screen reader users.

Towards the end of the project a survey was undertaken to evaluate the final changes that were carried out in accordance with the trial findings. The survey evaluated the main functional alterations using levels of satisfaction and data was collected from the trial leaders rather than users. This was due to the fact that the latest release of the project occurred after the user trials had finished. The interface changes were accepted by all the participant with over 50% satisfaction. However, some comments and improvements were also included as feedback.

Involving users in the inception of the design process and the evaluation of a prototype or any simple representation of the platform interface, has the potential to help to improve the guidance of the design and development process and can in turn avoid any reworking. However, despite accessibility being prioritized from the very beginning of the SlideWiki project and special considerations being made when selecting components and code libraries, there remained accessibility challenges during implementation phases. Time can also be wasted when slight changes are made by developers without reference to the impact their changes may have on accessibility. There may also be the need for the reworking and redesign of components if there is a lack of involvement of those with disabilities in the initial design phase. This was a lesson learnt with the first version of SlideWiki, though it had many users.

In addition to primary platform functionality, editors should encourage and provide guidelines for authors to help the production of accessible OERs. This is a general lesson to be learnt, but in the case of SlideWiki efforts have been made to validate slide decks when they have been saved, to ensure that they have included accessibility requirements such as, checking the existence of slide headings, headers for table rows and columns and alternative text for images [21]. Due to time constraints this work was not integrated into the platform during the time of the project, however a prototype of this service was implemented as a trial and exists on the GitHub (https://github.com/slidewiki/accessibilitycheck-service).

VIII. Conclusion

The paper has shown how accessibility, usability and personalization have been handled throughout the development life cycle of the SlideWiki project processes including planning, development, testing and release. The involvement of users with disabilities, from the first phase of the development process, affected many of the design decisions taken during the project's lifetime and in more recent times. There have been discussions about recognised accessibility guidelines that have been used to address and evaluate the accessibility of the platform and the fact that compliance does not necessarily mean every part of an online platform will be accessible or easy to use. Among the lessons learnt, were that more effort should be made to evaluate the accessibility of code libraries and new technologies before they are published. This would save much development time and reworking. Knowledge gained from the changes made to ensure accessibility should also be shared with the community. Future work on the SlideWiki platform will include those additional functions that need to be added to the slide editor to ensure that authors provide accessible content alongside, checks for complexity of text, based on the *Easy-to-read* methodology with suggested improvements.

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