A Comparison of Accessible e-Learning Projects for Improving of Digital Health Literacy

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Abstract. Access to the information and communication technology for people with disabilities as well as elderly people is an important prerequisite for their social inclusion. With the advance of the e-learning platforms and recent regulations of the European Union, which impose conformance to Web Content Accessibility Guidelines (WCAG) for web applications of public institutions, Learning Management Systems (LMSs) have to be accessible to enable people with disabilities to participate in the learning and educational processes. This article compares the accessibility of the following LMSs Moodle and ATutor for people with disabilities, according to the WCAG 2.1 standard criteria of different levels of compliance. The visual, hearing and motor impairments are included in this comparative analysis. The concluding purpose is to develop an e-leaning project that will increase e-health and medical digital literacy among population with particular emphasis on the people with disabilities, elderly people and children. The proposed project will be used as a reference for healthcare and educational institutions to identify the essential adjustments needed to integrate accessibility into their e-learning courses.

Keywords: Learning Management Systems, e-learning, WCAG 2.1 standards, e-health, digital health literacy.

1. Introduction

Numerous recent EU project activities were connected with assisted living concepts taking into consideration improvement of the living conditions of the EU population, especially for elderly population, children, people with chronical diseases and people with disabilities. EU population has the trend of aging, demanding more specified and accessible healthcare and social services. But, some vulnerable categories as elderly people, children and people with disabilities in some EU countries do not have the equal possibilities for healthcare and social services. For this reason, EU helps to get better condition financing projects which have to follow the corresponding standards in order

to improve the living conditions of the population, providing funds to increase the knowledge for digital health literacy, increasing opportunities of vulnerable categories of people to improve the health and social services, using emerging ICT technologies. One of such benefits is the distance learning, which provides accessible knowledge for all categories of citizens, as elderly people, children or people with disabilities. This article is focused on available e-learning systems that are accessible according to emerging WCAG (Web Content Accessibility Guidelines) standard 2.1 provided by W3C (World Wide Web Consortium). The WCAG 2.1 standard provides accessibility of the websites or the systems for all. The application of this standard in the improvement of health and social services is crucial for wider population, so that it can significantly contribute to increase the level of digital e-health literacy in the EU and worldwide.

In this article, we made a research and analyzed some respectable e-learning systems for W3C's Web Accessibility principles, defined by ISO 9241-171:2008 standard. According to this research, despite its personal characteristics and environment type, web assets as learning objects have to be accessible and to provide information for specific categories of people [1]. In the research, considerable attention was dedicated to the following four principles: Perceivable, Operable, Understandable and Robust in order to provide the basics of web accessibility with 12 guidelines for the authors [1]. For each guideline, we provided testing according to WCAG 2.0 for three levels of compliance: A (lowest), AA and AAA (highest) [2].

This paper examines the criteria with different levels of compliance according to WCAG 2.1 for Moodle and ATutor, as these two systems are particularly prominent in terms of availability for people with disabilities [3], taking into consideration the analysis tabled in [5]. Recommendations will be used to choose the best system for e-learning on e-health in order to increase the digital literacy of health of the population of the cross border area for which the project is intended.

The paper is organized as follows. Related works are described in Section 2. The new criteria included in the WCAG 2.1 standard are depicted in next section. A comparison of some WCAG 2.1 criteria of LMSs Moodle and ATutor, are provided in the Section 4. Last section gives a brief review of the research, providing concluding remarks and directions for further work.

2. Related Works

Learning management systems (LMSs) are considered as platforms for e-Learning, taking into consideration their capability and accessibility from different points of view. The accessibility in context of e-learning usually is regarded as some defined criteria for instructors, authors of the contents, specialists for e-learning

platforms and courses. But, when talking about e-inclusion and e-accessibility [3], there are many generally accepted definitions that have to be clarified as common visual, verbal and kinetic dysfunctions, affecting the learning style and especially the design of content accessible to everyone [4]. There are discussions among authors that there have to be many software tools that have to provide some alternatives for people with disabilities to understand and access to these contents [6]. Many people with significant impairment have difficulties when using a mouse or a keyboard to access to web contents. The people from this group will often rely on various keyboard technologies to access web contents, including a "large key" keyboard, an onscreen keyboard, or a scanning keyboard that is operated with a single switch or head mouse [4]. Some aspects of disability consider cognitive impairments as well as learning disabilities [10]. In this case, some material consistency, predictability, complexity, and memory, that have the ability to understand and match the subject is of particular importance are taken into consideration [4].

In order to obtain understandable materials for a wide community, it is also important to adopt them to the people's personality and problem solving, making influence to the users to remember and recognize the tasks that have to be solved. Also, the materials have to be written in a simple language, without sarcasm, idioms, metaphors, and other risky forms that lead to ambiguity. Also, e-learning systems have to be created according to the standards and specifications of actual WCAG 2.1 [8].

Some researchers [7] had considered the concept of cloud computing as a new inspiration for creative learning environment which provides a high level of accessibility, considering the usability of cloud technology for the third world countries and solving the problems with hardware and software [9]. These research summarize the main advantages and drawbacks of using cloud online learning, comparing services, assess risk and benefit and concluding that the concept saves a lot of efforts of organizations, overcoming the obstacles with internet connections [9] and giving opportunities for the inclusion of new technologies as Internet of Things (IoT) and Ambient Assisted Living, especially for vulnerable groups [10, 11]. In order to detect the accessibility problems in LMSs, a combination of accessibility expert and end-user evaluation is very useful.

3.   E-accessibility using WCAG2.1 standard

Following the concluding remarks and the directions for further work in [5], we compare the LMSs Moodle and ATutor, since these two platforms provide the best environment for people experiencing disability. In this paper the analysis made in [5] is enhanced with evaluation of the compliance of Moodle and ATutor with success criteria from WCAG 2.1. The accessibility testing and evaluation

using an analytical method was performed on the latest public version of the respective Learning management systems.

Moodle is one of the most popular open source LMS options available today. A simple interface, drag-and-drop features, and well-documented resources along with ongoing usability improvements make Moodle easy to learn and use. This open source Learning Management System also gives the ability to create mobile-friendly online courses and integrate third-party add-ons. As a highly flexible LMS, Moodle can be used to conduct courses online or to support face-to-face teaching, learning and training. It can also be extended with over 500 plugins for assignments, quizzes, grading, certification, and social and collaborative learning [12].

ATutor is an Open Source LMS, whose functionality and visualization can be extended with various modules and themes. It also offers a wide selection of themes to speed up the e-learning course development process, as well as e-learning assessment tools, file backups, analytics, and poll integration. Tutors can easily upload and manage the content which will be published for the students in a user-friendly environment. ATutor developed as a proof of concept that a fully inclusive e-learning environment was possible. Since its initial release, ATutor has continued to evolve, with a development focus on its accessibility and conformance with interoperability standards [13].

Web Content Accessibility Guidelines (WCAG) 2.1, as a newer standard, extends Web Content Accessibility Guidelines 2.0. WCAG 2.1 builds on and is backwards compatible with WCAG 2.0, meaning web pages that conform to WCAG 2.1 also conform to WCAG 2.0. WCAG 2.1 covers a wide range of recommendations for making Web content more accessible. Accessibility criteria are organized in four principles i.e. Perceivable, Operable, Understandable and Robust that should provide the basics of web accessibility with 13 guidelines for the authors [8]. Following these guidelines will make content more accessible to a wider range of people with disabilities, including accommodations for blindness and low vision, deafness and hearing loss, limited movement, speech disabilities, photosensitivity, and combinations of these, and some accommodation for learning disabilities and cognitive limitations. A big part of this update includes guidelines for mobile device accessibility, so these guidelines address accessibility of web content on desktops, laptops, tablets, and mobile devices [8].

WCAG 2.1 provides 17 new success criteria for different levels of compliance. Table 1 shows the five new success criteria for level A, which is the lowest level of conformance you can achieve (aka the easiest). In Table 2, seven respective criteria from Level AA, which is the mid-level conformance that can be achieved, are shown. Finally Table 3 presents five new criteria for Level AAA, which is the highest and also least common level of compliance.

Table 1. Criteria for level A of compliance (must have)

LEVEL A	Moodle	ATutor
2.1.4 Character Key Shortcuts	Yes	No
2.5.1 Pointer Gestures	Yes	Yes
2.5.2 Pointer Cancellation	Yes	Yes
2.5.3 Label in Name	Yes	Yes
2.5.4 Motion Actuation	Yes	Yes

Table 1 shows that Moodle and ATutor differ in the fulfillment of the first criterion. ATutor uses HTML access keys, which cannot be turned off or remapped. Probably the reason because of which ATutor is not compliant with this criterion is that WCAG 2.1 came after ATutor's last development cycle. Moodle automatically satisfies it, since there are no shortcuts that users can use. Similarly, the criterion Motion Actuation is automatically satisfied by both LMSs, because they do not have an action that is triggered by motion (such as shaking or tilting the device), so there is no need for an alternative of such actions. Both LMSs offer options to comply with the remaining three criteria. For Pointer Gestures, all functionality that uses multipoint or path-based gestures for operation can be operated with a single pointer without a path-based gesture. Examples include arrows used to access previous/next page (Figure 1), or horizontal slider (Figure 2) in Moodle and arrow up/arrow down (Figure 3) used instead of vertical swiping in ATutor.

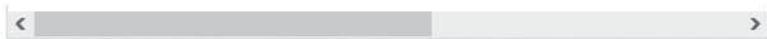**Figure 1** - Single pointer without a path-based gesture (arrows) - Moodle

Figure 2 - Single pointer without a path-based gesture (horizontal slider) - Moodle
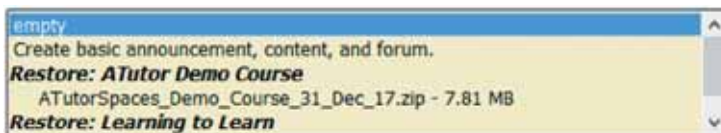

Figure 3 - Single pointer without a path-based gesture
(arrow up/arrow down) - ATutor

Speech input users can navigate by speaking the visible text labels of menus, links and buttons that appear on the screen. The intent of the success criterion

Label in Name is to help ensure that people with disabilities who rely on visual labels can also use those labels programmatically. Users have a much better experience if the visible text labels of controls match their accessible names. In Moodle and ATutor, for user interface components with labels that include text or images of text, the name contains the text that is presented visually (Figure 4 Moodle and Figure 5 ATutor). The compliance with this criterion has also been proven successful using Screen reader and Speech Recognition Systems.

Figure 4 - User interface components with labels - Moodle

Figure 5 - User interface components with labels - ATutor

Table 2 gives an overview of some criteria recommended to meet Level AA of compliance. The first success criterion Orientation is crucial for people with certain types of impairments. Some websites and applications automatically set and restrict the screen to a particular display orientation and expect that users will respond by rotating their device to match, but this can create problems. The intent of this criterion is to ensure that content displays in the orientation (portrait or landscape) preferred by the user. Since Moodle and ATutor meet the criterion people with impairments can benefit in many ways such as: users with dexterity impairments, who have a mounted device will be able to use the content in their fixed orientation; users with low-vision will be able to view content in the orientation that works best for them, for example to increase the text size by viewing content in landscape, etc.

Table 2. Criteria for level AA of compliance (should have)

LEVEL AA	Moodle	ATutor
1.3.4 Orientation	Yes	Yes
1.3.5 Identify Input Purpose	No	No
1.4.10 Reflow	Yes	Yes
1.4.11 Non-Text Contrast	Partial	No
1.4.12 Text Spacing	Partial	Yes

1.4.13 Content on Hover or Focus	Partial	Partial
4.1.3 Status Messages	Yes	Yes

The only criterion that is not satisfied by any of the platforms is Identify Input Purpose. The autocomplete attribute is set to "off" in Moodle (Figure 6) and is not used in ATutor (Figure 7).

Figure 6 - Identify Input Purpose (autocomplete attribute) - Moodle

Figure 7 - Identify Input Purpose (autocomplete attribute) - ATutor

The success criterion Reflow requires support for the reflow of content (also known as 'Responsive Web Design') and is very important for people with low vision, since enlargement and reflow enable perception of characters and tracking. Both Moodle and ATutor allow reflow of content and meet this criterion. Another criterion which is supported by both LMSs is Status Message. In ATutor the technique role="alert" is used, as shown below in Figure. 8. In Moodle, after submitting a form and leaving a required fill blank, error is shown as inline text and it receives focus automatically, so there is no need of additional techniques such as attribute role="alert", since they are used only when the list of problems does not receive focus.

Figure 8 - Technique role="alert"used for status message - ATutor

The fulfillment of the criterion Non-text Contrast in Moodle and ATutor is evaluated as Partial and No respectively. The contrast of the colors of active and inactive buttons is lower than the required level in both platforms. The reason because it is evaluated as Partial in Moodle is that users can choose their custom colors, which would satisfy this criterion, while ATutor does not provide this option. If the criterion Text Spacing is taken into account, Moodle is evaluated as

Partial because it does not provide a way to meet the required specifics, but the user can add custom CSS. In ATutor spacing would depend on the theme being used and can be easily adjusted to meet the criterion. The criterion Content on Hover or Focus is evaluated as Partial, since the content that shows or hides from hover or focus in both LMSs is persistent, but not dismissible and hover able, as required in WCAG 2.1.

Table 3. Criteria for level AAA of compliance (may have)

LEVEL AAA	Moodle	ATutor
1.3.6 Identify Purpose	Yes	Partial
2.2.6 Timeouts	No	Yes
2.3.3 Animation from Interactions	Yes	Yes
2.5.5 Target Size	No	No
2.5.6 Concurrent Input Mechanisms	Yes	Yes

Table 3 systematizes the five new success criteria from WCAG for level AAA, which is the highest conformance that can be achieved. For the purpose of the first criterion, in content implemented using markup languages, the purpose of User Interface Components, icons, and regions can be programmatically determined. The intent of this success criterion is to support personalization and preferences in order for more people to use the web, communicate, and interact with society. In this context, Moodle uses ARIA landmarks (Figure 9) and the user can add custom icons in the "Theme settings" sections, which makes Moodle compliant with this criterion. On the other side, ATutor uses ARIA landmarks (Figure 10), but does not support personalization and adding custom icons, so it is evaluated as Partial.
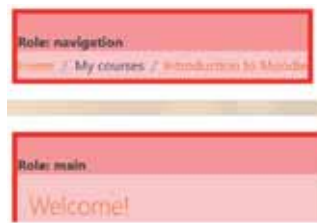

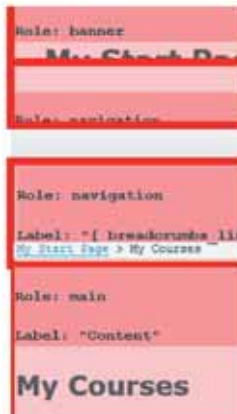**Figure 9** - ARIA landmarks - Moodle

Figure 10 - ARIA landmarks - ATutor

The usage of timed events can present significant barriers for users with cognitive disabilities, as these users may require more time to read content or to perform functions, such as completing an online form. The user may not be able to complete the process in one sitting and may need to take a break. As required in the criterion Timeouts, users should be warned of the duration of any user inactivity that could cause data loss, unless the data is preserved for more than 20 hours when the user does not take any actions. In terms of this criterion, there is a difference between the LMSs we analyzed. In Moodle the session is over without previous warning, while ATutor informs the user about the session timeout and provides a way to continue the session (Figure 11).

Figure 11 - Information for user about the session timeout - ATutor

There is only one criterion from AAA Level of compliance that is not met by any platform i.e. Target Size. Testing done by measuring the touch target size on the device when focus borders are displayed showed that the size of the target for pointer inputs of some elements is less than required. Furthermore, the criterion Animation from Interactions is satisfied by both LMSs, due to the circumstance that animations are not usual for Moodle and ATutor, so there is no need of way to turn animations off. The intent of the last success criterion is to ensure that people can use and switch between different modes of input when interacting with web

content. Users may employ a variety of input mechanisms when interacting with web content. Compliance with this criterion by both platforms can be noted by many examples, such as: a speech input user navigates content using voice commands which translate to simulate mouse (and keyboard) commands. When talking with a colleague, however, the user turns speech recognition off and uses the mouse instead; a user opens a menu with a mouse, and then navigates between the menu items with arrow keys etc.

4. Concluding Remarks

The paper's purpose is to analyze the additional demands of WCAG 2.1 standard and to enhance the research made for evaluation of e-Leaning platforms and their suitability for implementation in increasing of e-health and digital health literacy for the project of IPA2 - CROSS4ALL. The analysis of this paper complements the research in [5]. It is in accordance with the complementation of the WCAG standard and includes 17 new success criteria i.e. 5 for Level A, 7 for Level AA and 5 for Level AAA of compliance. The improvements are in terms of accessibility for certain disabilities, as well as application of mobile devices. The aim is to perceive some features that cannot be modified and variable features that can be adapted for the specific accessibility requirements of people with disabilities. According to the CROSS4ALL requirements, the criteria from WCAG 2.0 Level AA of compliance need to be satisfied.

These analyses are made in real environment, on public accessible latest versions of e-learning systems Moodle and ATutor, evaluating the new criteria for WCAG2.1 standard. Some perceptions from the practical use of these LMSs are given in this paper in order to highlights the improvement of WCAG standard with a new version and consider if they are more suitable for the project activities of CROSS4ALL IPA2. The selected system needs to provide the most suitable website with e-leaning system that has to satisfy the demands of elderly people, children, people with chronic diseases as well as people with disabilities in order to increase e-health and medical digital literacy for the cross border region, including all partners' contribution.

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