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INCREASE DIGITAL HEALTH LITERACY WITH THE PRACTICAL IMPLEMENTATION OF AN E-LEARNING SYSTEM ACCORDING TO WCAG COMPLIANCE STANDARDS

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Individuals with cognitive difficulties (CD) have very limited access to appropriate learning resources. Their unique individual needs and requirements prevent them from accessing traditional online formal and informal learning methods, and resources are usually inadequate. We develop an e-learning platform with health content as an opportunity for all to increase digital health literacy, including people with cognitive disabilities. The paper aims to present some feature's settings important for people with a wide range of cognitive disabilities.

Keywords: cognitive disability, accessibility, Learning Management System (LMS), ATutor, usability

CCS Concepts:

• Applied Computing∼Education∼E-learning

1. Introduction

One of the general principles that underlie the Convention on the Rights of Persons with Disabilities is *providing access to all aspects for all people on an equal basis.* It means “universal design”, design usable *by all people to the greatest extent possible without the need for adaptation or specialized design.*

Online educational platforms or e-Learning platforms, also defined as Web Based Training, enable users to learn whenever they want, wherever they want, and

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what they want – a wide range of topics including health topics. However, accessibility and usability are not often considered when designing e-Learning Platforms or other digital interfaces [27]. Taking into consideration the trend of an increasing rate of people with cognitive disabilities, it is necessary to have a more proactive role in the community to facilitate the accessibility of digital assets and web content.

Cognitive disabilities are term that refers to a broad range of limitations or challenges in performing one or more types of cerebral tasks. For instance, individuals with a cognitive disability may experience difficulty in understanding or processing information, solving problems or responding to stimulus. Center for Persons with Disabilities, Utah State Univ., WebAIM – Web Accessibility in Mind [19], suggests that cognitive disability is defined as having "greater difficulty with one or more types of mental tasks than the average person".

Cognitive disabilities include intellectual disabilities (significant limitations in both intellectual functioning and adaptive behaviour), pervasive developmental disabilities (delays in the development of socialization and communication skills), neurodegenerative disease (all types of traumatic brain injuries caused by external forces, and also brain injuries caused after birth by cerebral vascular accidents, and loss of oxygen to the brain), neurodegenerative disease (includes Alzheimer's disease, amyotrophic lateral sclerosis (ALS), Huntington's disease, and Parkinson's disease) and learning disabilities (neurological conditions that interfere with an individual's ability to store, process, or produce information) [14]. Cognitive disability can result in many different types of functional disabilities, so there can be no one-size-fits-all solution to ensuring access to learning material for all.

According to one of the aims of the Cross4all Project [2, 24], increasing health literacy, we develop digital health content "for all", including those with cognitive impairment [2–4, 26]. The paper highlights some important features for people with cognitive impairments and shows real implementation of the contents. The paper is organized as follows. Section 2 depicts cognitive disabilities, the impact of IT applications on the accessibility of information and knowledge for people with cognitive impartments, and the impact of web accessibility and how Web Content Accessibility Guidelines (WCAG) are suitable for people with cognitive impartment. Section 3 describes the e-learning system for increasing health literacy, which we developed within the project Cross4all, focusing on accessible interfaces or environments. Finally, the last section provides concluding remarks.

2. ICT access for people with cognitive disabilities

Accessible ICT – including accessible off-the-shelf ICT can assist a person by providing daily reminders, navigation assistance, and a means of staying in touch with support networks. Accessible ICT is very important for people with cognitive disabilities in education.

The repetition that ICT enables allows learners to engage for more extended periods. Moreover, mainstream devices, such as tablets, have successfully improved

not only students' knowledge and performance skills but also their motivation, communication, and social skills [4].

For years, technology for people with disabilities, including those with cognitive disabilities, centered on specialized assistive technology, was frequently expensive and hard to find. However, the most promising trend in today's ICT ecosystem is the movement toward equipment and software that is customizable to the specific needs and abilities of each user. DAC (Disability Advisory Committee of Federal Communication Commission (FCC)) Best Practices recommend that everywhere in the WWW, where it is appropriate, features and functions that allow personalization and customization that facilitate the accessibility and usability of ICT and applications for people with cognitive disabilities should be incorporated. According to the DAC, these measures would promote the principles of universal design and minimize the need for costly and difficult-to-find accessories [11]. The EU has taken measures to promote equal rights and opportunities for persons with disabilities through various directives, regulations, and initiatives. The European Disability Strategy 2010–2020 was one such initiative that aimed to promote inclusion and combat discrimination. It included measures to improve accessibility, employment opportunities, education, and social inclusion for persons with disabilities.

In addition, the authors proposed a classification of technologies for cognition based on the International Classification of Functioning (ICF), allowing a more straightforward identification of what technology could be helpful for a specific cognitive function impairment [17]. Moreover, this will help solutions to be much more generalizable across the heterogeneity of cognitive impairments. More detail can be found at [11]. However, the applicability of specific recommendations depends on any applicable laws or policies in EU countries.

On the other hand, in the domain of education, global and specific cognitive impairments/learning limitations have negative outcomes on the school performance and the achieved level of professional qualification [8]. Hence, this creates the necessity to increase accessible learning environments for people with cognitive impairments. Therefore, e-learning is expected to be one of the critical tools for improving access to education and aiding social inclusion for people with cognitive disabilities.

According to the systematic literature review in [9] there is: a lack of e-learning studies addressing the issue of accessibility for people with cognitive impairments. These studies are mainly focused on design guidelines rather than effectiveness assessment. They identify five families of accessibility function: adaptive systems, game elements, accessible content, virtual agents and accessible interfaces or environments.

In the distant 1997-year Tim Berners-Lee emphasizes the importance of removing the World Wide Web (WWW) accessibility barriers for all people with disabilities. Since then, more efforts have been made to improve Web accessibility. These efforts have generally consisted of three approaches: 1) developing screen readers, 2) specialized Web browsers, and 3) Web design guidelines. Despite these efforts, there is still much to do in this field [9].

WCAG 1.0 were officially published by the World Wide Web Consortium, Web Accessibility Initiative, in 1999 to encourage Web accessibility [30]. In 2009 W3C recommended new and updated content, WCAG 2.0, in 2018 new and updated content WCAG 2.1 and most recently W3C Candidate Recommendation Draft WCAG 2.2 (01.2023) [29]. Following these guidelines will make content accessible to a broader range of people with disabilities and make Web content more usable to users in general. WCAG 2.0 as standard is classified as the ISO/IEC 40500 standard and contains three implementation levels, 'A', 'AA' and 'AAA'.

According to the Federal Communications Commission, the specific functional needs of many people with cognitive disabilities are: functional difficulties in memory can impact the ability to recall what a person has learned over time; organizational deficits to perform tasks at the appropriate times; various ways of processing information; functional difficulties in problem-solving; difficulty focusing attention; a broad spectrum of difficulties in understanding a text, ranging from mild reading challenges to illiteracy; difficulties in describing their physical locations [14]. According to their extensive literature review, the authors of [16] point out that during the past several years, many steps have been taken to address Web accessibility for people with cognitive disabilities. However, despite this progress, Web accessibility for users with cognitive disabilities lags far behind the general population and behind Web access for other disability groups. Some of the reasons for this lack of progress are the variety of needs specific to the types of disabilities encompassed by the definition of cognitive disabilities. A list of top web access design recommendations for users with cognitive disabilities based on frequency cited by existing web design guidelines are given. The top 22 ranked design recommendations covered text size and shape, consistency of navigation and page design, icons, pictures, text writing, style, margins, hyperlinks, line spacing, and screen layout.

2.1. Learning management system for cognitive disability

The learning management systems, such as ones compatible with life-long training and ones allowing people to gain new skills and knowledge, provide excellent opportunities for creating learning environments for people with disabilities, notably those with cognitive impairments and limited learning activities. These systems offer flexibility so users can adapt their training program to meet their needs. Choosing the most suitable Learning Management System (LMS) for people with a cognitive disability is very important. Over the past few years, commercial LMS vendors, and open-source communities have invested significant resources into making their products more accessible. At the same time, accessibility remains a challenge for users with disabilities and older people [3].

In [25] areas for design considerations which should be taken into account when creating web content that can be used by users with cognitive impairment, are emphasized. They include:

1. The navigation is standardized and unambiguous; Headings, subheadings, and lists for structuring the information are used; menus are short and easy to understand;

2. Provide information in multiple formats, with emphasis on visual format; Supplemental media such as illustrations, icons, and video;

3. Short, simple, unambiguous phrases are easier to understand than long, complex, ambiguous ones;

4. The layout, which covers the availability of screen elements, form or announcement, needs to be consistent on pages, fonts, colors, and locations of page elements; high contrast between text and background needs to be present.

Proactively seeking out and maintaining collaborative relationships with people with cognitive disabilities (either individually or through organizations) that have established expertise with or represent these individuals are essential in all phases: research, design and development of communications products and services [21].

Authors of [23] suggest that courses should be designed to be accessible from the beginning. Implementing universal design principles at the outset avoids costs caused by the need to engage in a digital retrofit and serves to include those students who would otherwise be excluded by an unwillingness to request accommodations. Following [12], access for users with a disability needs to be built into the design process at the beginning, not retrofitted.

Technologies such as web-based lecture systems are valuable for students with disabilities and the broader student population [13]. The text is made available as an audio file and can be listened to in different settings. Subtitles can be used to read the content of a video presentation when sound is not appropriate. Information that is less fixed to a specific format can be accessed in multiple ways and is more easily searchable [20].

Despite the various possibilities offered by LMS to overcome the functional difficulties of people with cognitive disabilities and despite adopting a compliance approach WCAG 1.0 and WCAG 2.0 from the W3C, there is still a tendency to see accessibility as an afterthought or a potential legal liability to overcome. The authors of [10] critiqued learning management systems for adopting a one-size-fits-all approach to accessible e-Learning through adopting a compliance approach WCAG 1.0 and WCAG 2.0 from the World Wide Web Consortium (W3C). Regarding web accessibility, the work produced by the W3C Cognitive and Learning Disabilities Accessibility Task Force is an interesting approach for improving accessibility for people with cognitive impairments.

Part of the problem related to accessibility through LMS is that some LMS allow each person designing a course to set out their own web interface. For example, the user can overwrite inconsequential images with alternative text that clutters the page unnecessarily. Therefore, on the page, there are many unnecessary elements that make navigation difficult. In addition, the learning methods implemented by e-Learning platforms are not always practical for people with functional cognitive disabilities. People with disabilities may require different ways to interact with digital content in courses on e-Learning platforms. In [15] it is pointed out that even with an accessible basis for the LMS, the course content hosted through these

LMS may have accessibility issues. According to [18], "disabled students can access the e-learning platform but not contents, resources, activities, collaboration and interaction tools".

In [7] it is emphasized that the basic accessible framework is underpinned by the seven principles of Universal Design (UD), the three principles of Universal Design for Learning (UDL), and the four principles of the Web Content Accessibility Guidelines (WCAG). UD is defined by the Center for Universal Design as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [7]. Principles for the UD of any product or environment include the following: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and appropriate size and space for approach and use.

To overcome the limitations, an ability-based design framework is presented in [28]. The framework is built on three principles:

1. STANCE: Designers should focus on what a person can do instead of what a person cannot do and address accessibility issues by designing flexible systems that can be adapted to people without having to alter their bodies, knowledge, or behavior.

2. INTERFACE: User interfaces may be self-adaptive or user-adaptable to ensure the best possible match between user's abilities and the required use.

3. SYSTEM: Through the monitoring of user actions, the system may model and predict changes in user performance depending on the context and adjust their parameters to compensate [28].

3. Cross4all e-learning system for increasing health literacy

In order to meet IPA2 (Interreg IPA CBC EU Programme) – Cross4all project aim to increase e-health and digital health literacy [24], we used e-learning platform with accessibility and all previously stated conclusions in mind. The application of the WCAG provided by the W3C in the improvement of health and social services is crucial for the broader population as it can significantly contribute to increasing the level of digital e-health literacy [3].

Although there are many easy-to-use, user-friendly developed LMS algorithms to help make choosing the best LMS easy, choosing the appropriate LMS in accordance with the WCAG standard, that aimed to increase the digital and health literacy of the population of the cross-border area in Cross4all project of IPA2, was a challenging task. We have done more research on relevant literature and practical research and analysis to answer this challenge. We studied and used known standards in healthcare [4, 22] to use a practical LMS for this purpose. More details for this analysis can be found in [3, 4].

Firstly, we analyze five Learning Management Systems (Moodle, Eliademy, Docebo, Sakai and Atutor) that are most used by the community according to Gartner,

which does not mean that they are the best for all e-learning areas. We aimed to analyse the accessibility of LMSs for people with disabilities considering the criteria with different levels of compliance in accordance with the WCAG 2.0 standard [5]. We realize that each of the analysed LMSs is with unique features. Each LMS has core features that cannot be modified and variable features which can be adapted for the specific accessibility requirements of people with disabilities. According to our conclusions, all of the evaluated LMSs except Docebo satisfy the criteria according to WCAG 2.0 standards for Level A. Regarding WCAG 2.0 standards Level AA only Moodle and ATutor fulfil the established criteria. This analysis was expanded in accordance with the additional demands of WCAG 2.1 standard, which includes 17 new success criteria: five for Level A, seven for Level AA and five for Level AAA of compliance. Most of the criteria are fulfilled [6]. The comparison tables can be seen at [5, 6] as well as the explanation why the ATutor platform is chosen.

We chose ATutor as an e-learning platform for health topics. Besides the accessibility features, which are the most important attributes for people with disability and older people, it has the best communication tools with a user-friendly interface and encapsulates multimedia help of the Handbook. Moreover, ATutor has the user-friendly JavaScript WYSIWYG editor, which is appropriate for a wide community of users and many valuable features different from others, such as a glossary, users online and search bar, latest discussion topics on forum and sitemap with an ARIA tree [3].

The implemented e-learning platform[1] contained much public content: manuals about the new workflow and mobile applications, tutorials, technical support, and health content. All contents are available in three languages: English, Macedonian and Greek. The users can register themselves, log in on Cross4all LMS and improve their e-health literacy in many areas such as cardiology, psychology, diabetes, how to use gadgets for measuring vital signs, and so on. The selected content can be viewed online or exported/downloaded and viewed offline.

While setting up ATutor and creating web content, which will be used by the users with cognitive impairments, we consider different guidelines and the proposed four design main areas: Navigation, Functionality, Content and Text and Page layout [4].

ATutor has features to add skip-to-content shortcuts so learners can easily access the main content area without repetitive navigation actions when using a keyboard. For example, we considered this when we designed health courses. Also, we made navigation standardized and unambiguous; we used headings, subheadings, and lists for structuring the information; we used short menus that were easy to understand with limited options to prevent cognitive overload (Figure 1).

We provide information in multiple formats. An accessible e-learning course should have different formats of content. Learners with cognitive disabilities might find focusing on long-form written content hard and tiring. These learners can benefit instead from video content. ATutor allows recording or uploading videos easily (Figure 2). The uploaded videos also contain subtitles or transcripts to ensure

[1] http://atutor.cross4all.uklo.edu.mk/login.php

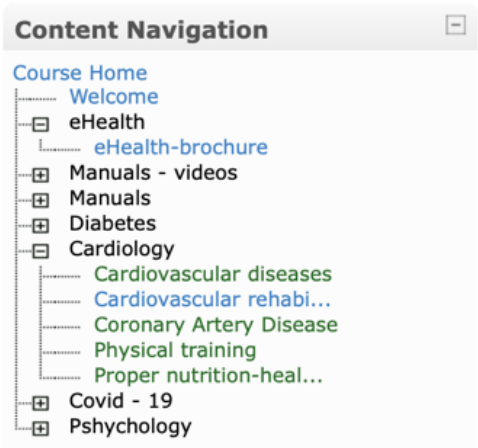

Figure 1. Standardized and unambiguous navigation in Cross4all e-learning system

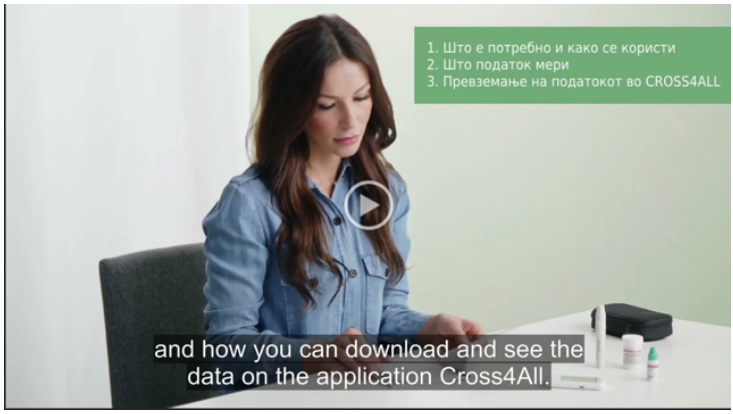

Figure 2. Video contents in Cross4all e-learning system

additional opportunities. Furthermore, we add icons and audio files, which have the potential to significantly enhance the accessibility of web content for people with cognitive disabilities (Figure 3).

Audio content is also an essential element of accessible e-learning courses. ATutor allows uploading audio files easily. This way, learners who cannot follow written content can listen to health-related content.

Screen readers are important when designing accessible e-learning courses. These features are incorporated into ATutor. If a learner with a cognitive impairment needs additional help following the learning content, the screen reader can be activated.

Different fonts and colours make content easy to read and follow for all learners. Zoom-in functions supported in ATutor allow learners to increase the texts and images until they clearly understand the content. Moreover, the text is split into

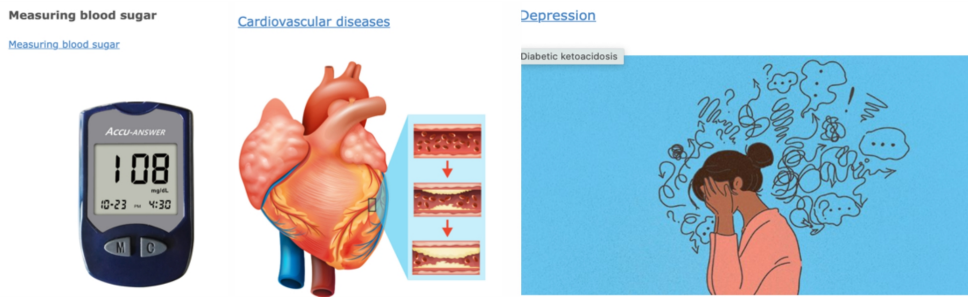

Figure 3. Icons and audio make easier accessibility content's in Cross4all e-learning system

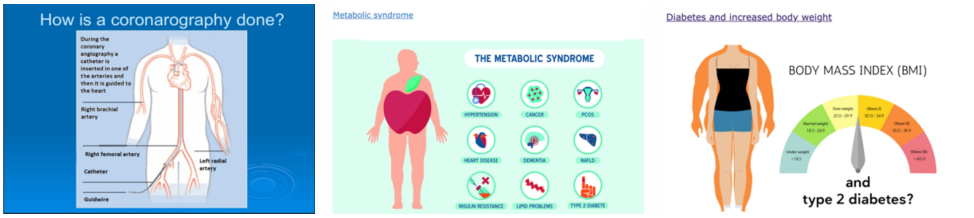

Figure 4. Cross4all e-learning system: contrast, readability, distinguish the words from the background

paragraphs to avoid large chunks of text and to make the text more readable. Finally, fonts that make the text easy to understand and background options that do not make it hard to distinguish the letters are chosen.

We care about contrast; it is not only important for aesthetic reasons. It is also key to making content more readable. Therefore, we choose high-contrast themes, so the learner can easily distinguish the words from the background (Figure 4). Also, we take care of streamlining page design.

Additionally, the users can change their profile elements, enrol in courses they are interested in, and control which versions of content are displayed if, for example, the primary version is not accessible to them, or they prefer an alternate format. Also, users can develop a network of contacts, create and participate in social groups, develop a social profile and use different gadgets (a user can add some of the available applications to their Social Networking environment that provide a whole range of potential networking functionality) and they can create "My Contacts" – a list of people in their social network [1].

4. Conclusion

E-learning is a growing area, and this teaching practice holds great potential to be an avenue of inclusion for people with cognitive disabilities. Although different LMS have different approaches to accessibility, how different platforms and networks are structured will influence and how they can be adapted for greater accessibility.

With the consciousness that an e-learning platform should be accessible to all, all our efforts were put into it. We used an LMS system to increase e-health digital literacy using the WCAG-compliant e-learning platform ATutor for the aims of Cross4all project. We presented some capabilities for people with cognitive disabilities to use the ATutor e-learning platform [1, 3–5], considering some urgent conditions from internal medicine, COVID-19 condition, and psychological conditions. Many other possibilities can be developed in the future, creating some content that provides cognitive help with other methods and techniques.

With opportunities different fonts, zoom-in functions, background options supported in ATutor and with use high-contrast themes and streamlining page design we made content easy to read and follow for all learners. Additionally, we made the text more readable with split the text into paragraphs and avoid large chunks of text.

We provide information in multiple formats. The learners can benefit from video content, subtitles or transcripts, icons, and audio files. All this opportunity has the potential to significantly enhance the accessibility of web content for people with cognitive disabilities. The course content is logically organized and presented in a structured manner. We use clear headings, subheadings, and sections to divide the material. This allows students to easily locate and access specific health topics within the course. Consistency in navigation elements throughout the course is present. The visual cues, such as bolding, colour, or icons, we have used to draw attention to important information or actions. The highlighting key points or navigation options we have used to make them more noticeable and easier to locate. The connection of this system with other digital libraries is also just one of the opportunities to enhance our e-learning platform for increasing digital health literacy, especially for people with cognitive diseases.

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