# Enhancing User Experience of Users with Disabilities

## Application to Open Educational Resources Websites

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***Abstract*— At present, User Experience (UX) is a recognized concept that appraises the quality of user interaction on websites. Despite the fact that users with disabilities face obstacles that hinder their experience in Web interaction, the UX concept has not been extended to include their specific requirements. This work proposes an empirical review of the aspects that impact on UX of users with disabilities, including not only the Usability and Information Architecture but also Accessibility issues. The context of the application is related to Open Educational Resources (OER) websites due to their importance for opening learning opportunities to all people around the world. Although the UNESCO Paris Declaration on OER (2012) recognized that "everyone has the right to education," people with disabilities are still excluded from full participation in OER-based learning because of design issues on OER websites. Further, we have considered the standards and best practices that should be applied to these aspects to recognize the problems that need to be addressed to improve the quality of the UX of users with disabilities, particularly in OER websites. The results of this work contribute to a better comprehension of UX from the perspective of users with disabilities in order to support the inclusive vision of the OER Initiative.**

***Keywords*— *Open Educational Resources; OER; User Experience; UX; Web accessibility; Web usability; Information Architecture.***

## I. INTRODUCTION

The statistics presented by the World Health Organization in the World Report on Disability (2011) [1] states that one billion people, about 15% of the world's population, live with some form of disability. Further, according to the United Nations [2], the population of older adults will increase from 841 million (11.7%) in 2013 to 2 billion (21.1%) in 2050. These data show the importance of this vulnerable group of population which, according to the United Nations, is still excluded from equitable access to educations, health, employment and social protection.

Concerning the Web, users with visual and hearing impairments, restricted movement of the upper limbs, cognitive issues, and problems related to aging, face barriers when interacting on the websites [3]. These issues are related to the lack of accessibility considerations in Web design.

On the other hand, at present, one of the bases for a quality Web design is the User Experience (UX). This is a broadly defined term that involves all the aspects that influence the interaction of a user with a website, including attainment of goals, and subjective aspects such as the satisfaction of non-instrumental (or hedonic) needs, and acquisition of positive feeling and well-being [4]. However, this concept has not spread to address the particular requirements of users with disabilities.

In this work, we propose an empirical review of the supporting aspects that influence the quality of UX, such as Web usability and Information Architecture, and, considering the particular needs of users with disabilities, we include Web accessibility as an essential aspect of UX.

In a complementary way, we propose standards and best practices for each aspect in order to define recommendations for improving UX quality of users with disabilities. This proposal does not consider a specific disability, but it presents recommendations related to some of the common disabilities.

Furthermore, the UNESCO Paris Open Educational Resource Declaration (OER) (2012) [5] recognized the worldwide impact of OER usage and the need for inclusion of all society groups, in particular, people with disabilities. The term OER was coined by UNESCO (2002) [6] to refer to digital contents that support education and has been released under open license to be used and re-purposed by others. These digital contents are stored in repositories available through websites at a global level [7] and include full courses, course materials, textbooks, and any other tool used to support access to knowledge [8].

Some OER websites do not consider essential aspects of UX, such as Web accessibility [9][10], and supporting aspects, such as Web usability and Information Architecture [11]. Since users with disabilities need to interact with OER websites, it is relevant to review how these aspects affect their UX.

Due to the importance of education as a fundamental right for all people, including people with disabilities, we have tackled the UX of users with disabilities in OER websites, because, the quality of UX for these users could encourage their inclusion in OER-based learning opportunities. As a demonstrative context of the aspects of

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UX that need improvement, we are referring to a large-scale OER website.

The structure of the paper is as follows. Section II describes the concept of UX and the main aspects of UX to be addressed. Each of these aspects is presented in the next sections. Section III discusses the Web accessibility concept and the accessibility guidelines; Section IV presents Web usability issues and their impact on users with disabilities, Section V presents the basis of Information Architecture. Finally, Section VI presents the Conclusion and Future work.

## II. USER EXPERIENCE

User Experience (UX) focuses on having a deep understanding of users, their needs and their limitations. This is a paramount consideration in relation to users with disabilities because they use the Web in a different way than other people.

According to the results of a survey that considers the point of view of researchers and practitioners, there is an agreement that UX is dependent on the context of the website and the individual interaction on the website. It means that UX is particular for a user and his own goals on a website [12]. This agreement matches with the definition of UX in the standard ISO 9241-210:2010 Ergonomics of Human-System Interaction [13]: "A person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service".

The different definitions of UX emphasize different aspects. For example, one of the precursors of this term states that UX implies all aspects of the users' interactions within the website, considering their expectations about the attainment of their goals [14].

Other authors complemented this definition pointing out that the concept of UX embraces efficiency, effectiveness, and task accomplishment satisfaction [15]. While other authors [4] proposed, a holistic approach of UX that includes subjective aspects, such as the feeling of control, the appreciation of the pleasant look of the website, and positive aspects such as happiness or engagement. Thereby, UX can be conceptualized in a holistic approach aiming for a balance between pragmatic aspects related to task fulfillment and other non-task related aspects (hedonic and aesthetic, enjoyment).

There is not a shared understanding of the fields pertaining to UX. Different approaches from academics and practitioners highlight some different elements and aspects. The most common aspects are usability and Information Architecture.

Garret [14] considers elements of UX, such as user needs, the functional specifications and content requirements, the interaction design, and Information Architecture that provide the basis for navigation design.

In a similar way, Fenn and Hobbs [16] prioritize the importance of Information Architecture for UX. Roto [17] emphasizes the role of usability in three blocks that configure UX, the context, the system and the user.

Nevertheless, the specific case of users with disabilities is not mentioned. Hobbs, Fenn, and Resmini [18], and Tokkonen and Saariluoma [19] agree in considering usability and the Information Architecture as the aspects implied in UX, in addition to other aspects, such as user, product and company, for a corporative vision of UX.

Other authors [20] [21] use the concept of UX to guide the software development process. They also include considerations about usability and Information Architecture as part of the requirements definition.

In the literature review we have not found a reference of Web accessibility as an aspect involved in UX. Hence, in this work, we propose to add Web accessibility as a key aspect of UX from the perspective of users with disabilities. For this reason, the improvement of the three aspects: Web accessibility, Web usability and Information Architecture enables enhancing the UX for all users including user with disabilities.

## III. WEB ACCESSIBILITY

Web accessibility is an inclusive practice and hence an essential aspect that needs to be addressed to ensure access and interaction with the website by people with disabilities. Web accessibility aims to remove barriers that prevent people with disabilities in participating equitably in Web activities [3].

The Web Content Accessibility Guidelines (WCAG) 2.0 [22], recognized as an International Organization for Standardization (ISO) standard (ISO/IEC 4500) [23] in 2012, is the most spread reference standard that guides the accessible Web design.

This standard is structured under four principles with guidelines associated to each one.

1. Perceivable. Enable users to perceive the information being presented.
2. Operable. Enable users to operate the interface.
3. Understandable. Enable users to understand the information as well as the operation of the user interface.
4. Robust. Enable to maintain access with technologies advance.

Each guideline has a set of verifiable success criteria that are not technology-specific. Each criterion is associated with a conformance level A, AA, AAA, which indicates its impact on accessibility. To ensure minimal conditions for accessibility the AA level of compliance is required.

Web accessibility cannot be reliably ensured because it depends on the user and his context; i.e. the kind and degree of disability of the user and his expertise level in using assistive technology [24].

However, accessibility can be improved if the website meets an accessibility standard. In this work, we propose the use of the method called "conformance review" to verify if an OER website meets WCAG 2.0 requirements. This method can identify a larger range of diverse accessibility problems than other methods [25].

Further, it can be supported by the use of automated tools that reduce the time and effort of the compliance evaluation [26]. These tools are software applications or online services that check the success criteria that are machine-testable.

Nevertheless, not all success criteria can be tested automatically, and some require the expert human judgment.

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Further, these tools can produce false or misleading results, such as false-positives or failures in identifying issues [27].

By way of illustration, we show the evaluation of OER Commons, a prestigious large-scale OER website, with two accessibility evaluation tools. The evaluation for both tools is configured to WCAG 2.0 level AA. Figure 1 displays a fragment of the screenshot that highlights the accessibility review results with AChecker [28]. These results show zero (0) for Known Problems, Likely Problems, and Potential Problems.

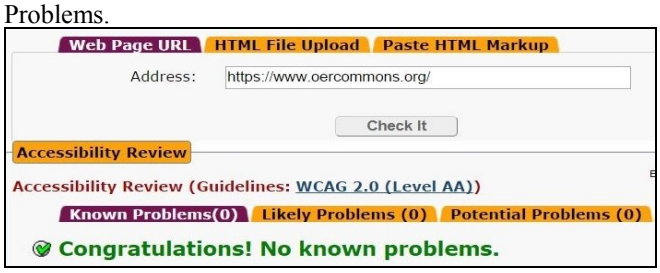


Figure 1. OER Commons Accessibility evaluation with AChecker.

On the contrary, Figure 2 displays a fragment of the screenshot that highlights the accessibility review results with TAW [29]. These results show 47 problems and 396 warnings. The failures identified in this accessibility conformance review need to be solved to improve website accessibility. It is advisable to review the techniques that provide guidance to Web content authors on meeting the success criteria of WCAG 2.0 [30].


Figure 2. OER Commons Accessibility evaluation with TAW.

These are not necessarily contradictory results because each tool performs the accessibility review with different coverage, completeness, and correctness. Therefore, it is recommendable to use more than one tool to complement and compare the evaluation results, improving their accuracy. There is a wide availability of these evaluation tools [31], but not all of them can verify the compliance with WCAG 2.0.

## IV. WEB USABILITY

According to the standard ISO 9241-11: 1998 Guidance on Usability [32] usability is "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Therefore, Web usability refers to the ease of use of the website, besides, the effectiveness, efficiency and satisfaction of goal achievement [15]. Effectiveness means the reliability and completeness in the goal achievement. Efficiency represents the effort and the resources expended by the user in the goal achievement. Satisfaction refers to the extent to which the expectations of the user are met.

Further, Web usability is closely related to Web accessibility; both have similar goals, and some guidelines overlap significantly [33]. Best practices of Web usability contribute to better UX of users with disabilities and without disabilities. Some general usability practices are also included in accessibility guidelines because they can be barriers for people with disabilities. For example, a good practice for usability is the operation of the interface without a mouse, and it is also an accessibility guideline that states that all functionality must be available from a keyboard. This condition is helpful for users with mobility impairment or blind who experience difficulties to operate a mouse.

The standard, ISO 9241-151:2008 Ergonomics of human-system interaction -- Part 151: Guidance on World Wide Web user interfaces [32] provides a set of guidelines for usability. It is important to verify if the website is compliant with these guidelines in its design to improve usability. Due to the lack of space, we only present a description of the main topics covered in each category and how these guidelines could affect the UX of users with disabilities in OER websites.

The categories are presented as main and secondary according to the topics that they address and their impact on OER websites. Table I shows the main categories that impact the achievement of primary tasks, i.e. searching and retrieving of resources, and Table II presents secondary categories that are complementary to the achievement of the primary tasks.

By way of example, we review the usability on OER Commons website. On this website, we found a menu for adjusting preferences that improve usability and hence the UX. Figure 3 highlights a design resource that allows the modification of visual presentation of the interface with these characteristics: Text and Display (text size, text style, line spacing, and color & contrast); Layout and Navigation (table of contents); Links (larger, bold, and underlined); and, Inputs (larger for buttons, drop-down menus, text fields).

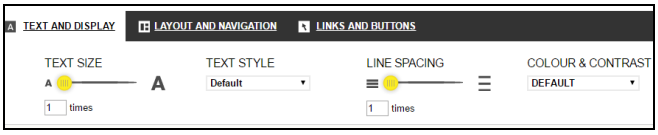


Figure 3. OER Commons Learner Options to enhance usability.

Another good practice of usability enables the user to know how many results were retrieved and customize the number of results per page, as we can see in Figure 4.

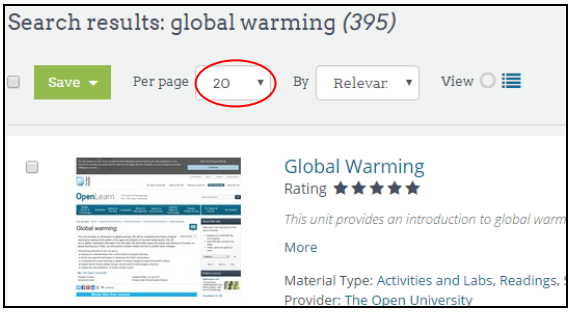


Figure 4. OER Commons display search results per page.

TABLE I ISO 9241-11 MAIN CATEGORIES OF USABILITY

| Category (ISO 9241-151:2008) | Users' disability | Impact on users with disabilities |
|---|---|---|
| **Home Page** The content of the home page is focusing on users' tasks; the major options are explicitly represented through navigation menus that are organized in a logic order in a task-oriented manner. All the core tasks are reachable from this page. | Blindness | Options to guide the main tasks (search or browse the resources) on the home page simplifies the amount of information that users who use a screen reader need to listen before to take a decision. |
| | Cognitive | The clarity and pertinence of the information encourage the comprehension by users with cognitive disabilities. |
| **Task Orientation** The number of screens for task completion has been minimized; there are minimal requirements of scrolling and clicking for task completion; the key tasks are easy to carry out; the metaphors and icons are understandable by users; the interface is easy to learn for novice users. | Blindness | These guidelines are valuable for blind users because it reduces the amount of information that they need to listen for task achievement. |
| | Low vision | Users with low vision who use screen magnifiers do not lose the vision of all context because of the scrolling requirements. For example, a list of resources that need vertical scroll. |
| | Cognitive | The use of common icons and metaphors and a simple interface encourage the comprehension by users with cognitive disabilities. |
| **Navigation** The navigation is predictable and convenient to users' goals; the navigation includes global and local navigation, wizard navigation, breadcrumbs, site map; the information that users are most likely to need is easy to reach from most pages; navigation tabs are located at the top of the page; the navigation system is broad and shallow (many items on a menu) rather than deep (many menu levels). The use of the keyboard is enabled to operate the navigation. | Blindness | A blind user needs to identify the structure of a menu. Many levels on a menu affect its comprehension. For example, the categorization of the resources should be available through a different mechanism than a menu. Also, breadcrumbs help blind users to know where they are and where they come from. |
| | Upper limbs impairment | The use of the keyboard to operate navigation instead of the mouse is the alternative for users with movement restriction on upper limbs. |
| | Cognitive | The simplest and logical presentation of menus enables better comprehension of the choices to users with cognitive disabilities. |
| **Information Architecture** The categorization of content is visible and useful to users; the category labels accurately describe the information in the category; the content organization allows the grouping, filtering, and sorting of resources. | All | The categorization of the resources is a critical aspect of improving usability in OER websites. It implies a logical grouping of resources that facilitate their searching and retrieving. |
| **Search** The search box and advanced search are clearly distinguishable on the home page; the search results page is helpful to the user, it shows how many results were retrieved, ranked by distinct parameters, and allows the user to configure the number of results per page. The advanced search allows the searching refinement based on simultaneous parameters; the search results page displays useful meta-information that include accessibility characteristics and format of the resource, the creator or provenance of the resource, the educational level, and creation date. | All | The primary goal in OER Websites is the search and retrieve of the resources, indeed the searching facilities support the effectiveness and efficiency in this objective. For example, if the search and search advanced features are located in the home page, the users can execute this tasks immediately. The searching refinement on simultaneous parameters enables the accuracy of the searching of the resources. |
| **Forms and Data entry** The forms are designed so users can complete simple tasks by entering only essential information; the pull-down menus, radio buttons and check boxes are used in preference to text entry fields; the fields on forms contain default values when appropriate; the fields contain example or model answers to make the expected input evident; there is a clear distinction between required and optional fields; the forms allow users to navigate with keyboard and distinguish the field with focus; the labels are close to the data entry field and meaningful. | Blindness | The simplification in form entry helps to blind users to avoid errors. For example, the labels of the fields, and default values or example values, also the identification of optional or required. |
| | Low vision | Because of the use of screen magnifier, the users with low vision need to distinguish the field with focus, and the labels of the fields. |
| | Upper limbs impairment | The forms need to be operated with the keyboard instead of the mouse. |
| | Cognitive | The context help in forms, such as default values or model answer as well as the labels for fields encourage the comprehension by people with cognitive disabilities. |

Nevertheless, on the same website, we found a usability failure in search results display.

Figure 5 shows that, at the bottom of the search results display, only the option "Load more" appears; it is proven to be inefficient for several hundreds of results.

The lack of pagination to display a list of resources is a usability failure because users cannot navigate inside the subsets of search results (pages) to select what they need. The list of hundreds of resources becomes a very long vertical scroll. This also impact on the comprehension of the results, because they are presented out of the context of the option to refine the search.

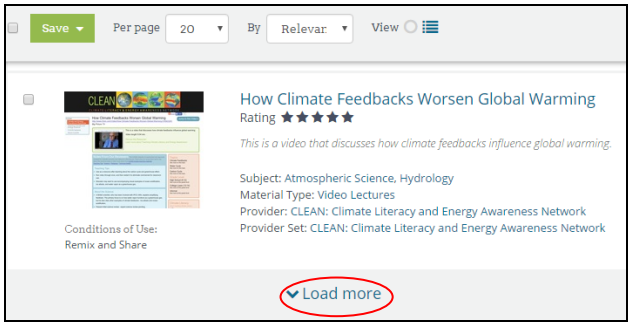


Figure 5. OER Commons usability failure..

TABLE II ISO 9241-11 SECONDARY CATEGORIES OF USABILITY

| Category (ISO 9241-151:2008) | Users' disability | Impact on users with disabilities |
|---|---|---|
| **Trust and Credibility**<br>The content of the website denotes to be up-to-date and reliable; each page follows the pattern design of the website; there are no grammatical, spelling or typographic errors | All<br>Blindness<br>Cognitive | The absence of writing errors encourages the comprehension of users with cognitive disabilities and allows an accurate recognition of the word by the screen reader. |
| **Writing & Content quality**<br>The text is concise; the information is organized hierarchically; headings and subheadings are straightforward and descriptive; each page is clearly labelled with a meaningful title that makes sense to users; the links have descriptive titles and match the title of destination pages. | All<br>Blindness<br>Cognitive | The structure of the information helps to users who use screen reader and users with cognitive disabilities to understand the content.<br>The precise description of the links is helpful to users to take the decision about where they can go on the website. |
| **Page layout & Visual design**<br>Each page has a layout consistent with the website style; the page does not need horizontal scrolling; the fonts are readable; the most frequently used topics, features and functions are placed in a highlighted position on all pages; the website has an attractive appearance. | All<br>Low vision | Users with low vision who use screen magnifiers can lose the context vision if there is horizontal scrolling on the page. Also, they require readable fonts.<br>All users with disabilities require that the most frequently used topics, such as search or browse of the resources are located in highlighted position on all pages. |
| **Help, Feedback & Error tolerance**<br>The website provides context-sensitive help and feedback about errors; the website uses appropriate selection methods (e.g., pull-down menus) as an alternative to typing; pages load in five seconds or less; error messages are explicit about the nature of error and the next action; the user is warned about slow-loading pages. | All | The context-sensitive help is a usability characteristic that facilitate the interaction of all users including users with disabilities. |

## V. INFORMATION ARCHITECTURE

The Information Architecture in the context of Web environments is related to data storage and its structure [16]. In this work, we have adopted the concept of Information Architecture by Morville & Rosenfeld [34] that defines it as the relationships between the website content and its functionality. Information Architecture involves the underlying organization, labeling, search, and navigation system within the website.

In OER Websites, Information Architecture enables a comprehensive and integrated structure of information available about resources for their searching and retrieval. This is achieved through the use of classifications, taxonomies, and metadata that enables the classification and description of each resource.

A key aspect of Information Architecture in OER websites is the metadata standards used to describe and categorize the resources. Some OER websites use a non-standardized way to label the resources instead of the metadata standard

This issue affects the ability to find resources; without a common system of identification, users cannot easily search the resources [11]. Indeed, users often cite this issue as a major stumbling block hindering their more widespread use of the resources [35].

The most important metadata standards that include accessibility and educational field descriptor are Institute of Electrical and Electronics Engineers (IEEE) Learning Object Metadata (LOM) [36], and Learning Resource Metadata Initiative (LRMI) [37]. Not all metadata standards include these descriptors, therefore, they fail to identify resources for users with disabilities [38].

Furthermore, there is a lack of agreement about metadata usage; while the main OER websites use a metadata standard, others describe resources using their own methods such as XML-based schemas or heterogeneous taxonomies [39].

The main recommendation about Information Architecture to improve UX is the adoption of a metadata standard that enable meaningful categorization and classification of the resources in OER websites.

This enables better navigation system and search system on these websites.

## VI. CONCLUSION AND FUTURE WORK

Although the concept of UX has a broad view that implies subjective aspects inherent to users, in this work, we have focused on the aspects that are controlled by Web designers to improve the UX of users with disabilities.

The context of the analysis has been the OER websites considering the searching and retrieving of resources as the primary users' goals. We have reviewed the extent of the application of standards and best practices related to Web accessibility, Web usability, and Information Architecture that positively impacts on UX of users with disabilities, but this benefit is also extended to all users.

The outcomes of this review contribute to a better understanding of the challenges and barriers that users with disabilities face and that hinder them from taking advantage of this educational opportunity. Further, these outcomes can be used by Web designers and Web masters of the OER websites to make the corrective actions towards enhancing the UX for all users, including users with disabilities.

In our future work, we are planning to address the UX depending on assistive technology and the type of disability. It is important to clarify that cognitive disabilities need a particular approach to the UX because of each user condition and require a joint effort with other areas such as medicine or psychology.

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Finally, in this research, we have reviewed the UX on OER websites, but we have not explicitly included the UX of resources themselves, which require a more broad study that includes aspects related to pedagogical and didactic of the resource to be suitable for users with disabilities.

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