User Experience for Disabled Users in Open Educational Resources Websites

Rosa Navarrete and Sergio Luján Mora

***Abstract* —Open Educational Resources (OER) are digital materials for teaching-learning purpose released under an open license that are available through websites. In the last decade, some governments have encouraged the development and using of OER in order to contribute to the achievement of the right to education for everyone, a fundamental right included in The Universal Declaration of Human Rights. Besides, inclusion of people with disabilities is a global concern that need to be addressed in all living aspects including education.**

In this research we address the user experience in OER websites —considering the perspective of users with disabilities— in order to recognize possible barriers in web design. The conformance criteria considered for this reviewing are mandatory aspects of user experience in relation to Web accessibility and Web usability.

***Index terms* —Open Educational Resources, User experience, Web accessibility, Web usability, Disabilities.**

I. Introduction

THE concept of Open Educational Resources (OER) describes any educational content available for free in digital format and stored in repositories accessible through a website. This broad concept includes resources with distinct granularity and specific formats, e.g., syllabus, course materials, textbooks, streaming videos, multimedia applications, podcasts, tests, assessments, and so forth.

In the last decade the OER initiatives have grown steadily either in the number of universities and educational institutions that have joined this initiative, as well as in the number of educational resources available on the OER websites [1, 2].

However, quite a few OER websites are not suitable by people with disabilities because these sites do not consider Web accessibility principles in their design. These websites cannot ensure a quality user experience.

User experience (UX) is a focal point for web design. It focuses on how the users will achieve their target goals when interacting within a website. UX refers to the quality of interaction and response in terms of effectiveness and efficiency and also user satisfaction when accomplish a task on website [3].

In order to offer a positive UX, the OER websites should fulfill some standards and relevant guidelines for accessibility and usability.

We evaluate the UX of some important OER websites to verify their suitability for usage of users with disabilities. The evaluation is centered in Web accessibility and Web usability.

II. Research Objectives

A. General Objective

Evaluate the UX in some OER websites in order to verify their readiness and suitability to serve users with disabilities.

B. Specific Objectives

- Recognize the implications of Web accessibility and Web usability in the UX.
- Define evaluation methods for Web accessibility and Web usability.
- Review the results and their impact in UX focusing in disabled users.

III. Problem

In spite of the growing trend in the usage and producing of OER, and the advantages derived of their usage in both formal and informal education, the design of their websites fails in consider accessibility and usability principles; therefore, these websites do not enable the equal participation of users with disabilities.

At this respect, a previous investigation about accessibility conditions in OER websites and resources themselves [4] gives as results that OER websites have accessibility issues, i.e., the websites present access barriers for people with disabilities.

Complementarily, the websites were reviewed for accessibility issues through a heuristic approach [5].

The results of both studies confirm that there are still many accessibility issues that have to be solved. The lack of accessibility in OER websites results in discrimination against people with disabilities. They do not have the opportunity to access —under equitable conditions— to educational resources and therefore they cannot improve their education and job training.

Besides, in relation to UX, persons with disabilities require more effort to use the web and consequently a positive UX is critical for them to take advantage of OER.

Rosa Navarrete is a Professor of the Department of Informatics and Computer Sciences of National Polytechnic School of Ecuador. (email: rosa.navarrete@epn.edu.ec).
Sergio Luján Mora is an Associate professor at the Department of Software and Computing Systems at the University of Alicante (Spain). (email: sergio.lujan@ua.es).

IV. METHODOLOGY

The methodology is based on the evaluation of Web accessibility and Web usability as the foundations of the UX on the websites.

The evaluation of Web accessibility is conducted with automatic tools to verify the compliance with Web Content Accessibility Guidelines 2.0 (WCAG 2.0) [6] .

On the other hand, the evaluation of Web usability is based on a heuristic approach to evaluate a subset of the standard Ergonomics of human-system interaction -- Part 151: Guidance on World Wide Web user interfaces guidelines, ISO 9241-151:2008 [7].

Finally, we consider the impact of each parameter for a quality UX.

V. THEORETICAL FRAMEWORK

A. *Open Educational Resources*

The term Open Educational Resources (OER) was coined by UNESCO in 2002 [8] to establish a single name for the terms "open courseware", "open learning resources" and "open teaching / learning resources".

The evolution of OER has led to some definitions, however, the most widespread is from William and Flora Hewlett Foundation [9], "OER are teaching resources - learning and research that reside in the public domain or they have been released under an intellectual property license that permits their free use or repurposing [...]".

The harnessing of OER has been encouraged from organizations and governments in worldwide.

The UNESCO's OER World Congress in 2012 [10] aimed to foster awareness and to promote the development of specific policies for the production and use of OER within wider strategies for advancing education.

In the same year, the European Commission through the "Communication on Rethinking Education" [11] motivates the expansion of OER use in all learning contexts.

Besides, in 2014, the U.S. Government in the "Second Open Government National Action Plan" [12] raises the commitment of U.S. Government with use of OER to support learning in formal and non-formal learning environments.

The OER producers are mainly universities, academic and research institutions, governmental initiatives, and educational communities. The resources have distinct level of granularity, e.g., full courses of academic programs, course material, textbooks, streaming videos, assessments, tests, software or any other learning materials.

Nowadays, the use and production of OER has become a growing trend. Many universities around the world are joining to this initiative through Opencourseware websites, and the number of resources in OER repositories are increasing in sustained way [13]. Besides, the use of OER in higher education has obtained promising results [14], although the quality issues of resources are still pending, e.g., the thoroughness and timeliness of resource , their pedagogical pertinence and didactical utility, and even their accessibility for all users with and without disabilities.

Categories of OER

We adopt two criteria to categorize OER: the type of resources [14], and the type of repository.

According to the type of resources:

- *Open Courseware (OCW)*
  Universities release full courses of their academic programs including syllabus, learning materials and evaluation tools; some examples: Oli Carnegie Mellon (http://oli.cmu.edu), MIT OCW (http://ocw.mit.edu), Standford OCW (http://online.stanford.edu/courses). Also, OCW can be associations of very large number of universities, such as Open Education Consortium (http://www.oeconsortium.org/) —groups more than 200 universities and 30,000 courses—, and OCW Universia (http://ocw.universia.net/en/) —more than 150 universities including some of Latin American.
- *Content Creation Initiatives*
  Websites for collaborative creation of educational resources. For example, Curriki (www.curriki.org/).
- *Subject-Specific OCW OER*
  Websites with specialized resources for a specific area. For example, Health Education Assets Library from Utah University (http://library.med.utah.edu/index.php).
- *OER Repositories and websites*
  I. Websites that offer OER in distinct granularities from many providers. Some outstanding websites are: MERLOT II (http://www.merlot.org/), it is a program of California State University, and OER Commons (http://www.oercommons.org/).

According to the type of repositories:

OER repositories store both resources and their metadata. Through OER websites the resources are retrieved by user from the repositories. In relation to type of repository, we can distinguish three cases of OER websites [15, 16]:

- OER websites that have resources and metadata stored in local repository.
- OER website that provide access to resources and heterogeneous metadata stored in external repositories.
- OER websites that provide access to local repository as well as to external repositories. These repositories belong to hybrid OER websites.

B. *Disabilities and the Web*

According to the World Health Organization [17], disability is part of human condition and is related to problems that affect an impairment in body structure or function, difficulties associated to such limitations for actions accomplishing or tasks, and also participation restrictions due to environmental or societal situations.

Regarding the web, disability focuses on deficiencies, limitations, and restrictions inherent to people that hinder their interaction and use of the web in terms of fairness to non-disabled people [18]. Disabilities that affect web interaction can be:

- *Motor disabilities*: mobility restrictions in upper limbs

(arms, hands, fingers), motion control problems (involuntary movement of the hands), dexterity problems.

- *Sensory disabilities*: blindness, color blindness, severe visual impairment, photosensitivity; hearing loss, deafness.
- *Cognitive disabilities*: problems related to the intellect, such as: Asperger syndrome, Down syndrome, Alzheimer's disease, autism, speech disorders (stuttering), literacy disorders (dyslexia).

Additionally, elderly people have disabilities related to the deterioration of motor, sensory and cognitive functions.

According to the World Report on Disability [19], one billion people, which is about 15% of the world's population, live with some form of disability and hence with limited access to fundamental rights: health, education, employment, transportation and information, under conditions of poverty and vulnerability. Further, according to the United Nations' report on the aging population [20], the percentage of people over 60 continues to grow. In 2013, it accounted for 11.7% of the population (841 million) and is expected to 2050 is 21.1% (2 billion).

Tim Berners-Lee [21] emphasizes the inclusive character of web stating, "as we move towards a highly connected world, it is critical that the Web be usable by anyone, regardless of individual capabilities and disabilities." Moreover, the Convention on the Rights of Persons with Disabilities [22] promotes equal enjoyment of all human rights for people with disabilities, including education as a fundamental right. To achieve this goal, the opportunities offered by OER usage should be extended to people with disabilities.

C. User experience

User experience (UX) encompasses all aspects of the user interaction with the website, emphasizing in user needs in relation to website purpose [23]. UX goes beyond effectiveness, efficiency, and conventional interpretations of satisfaction in tasks achievement [24].

The evaluation of UX also has approaches that include some qualitative aspects. For example, Hassenzahl & Tractinsky (2006) [25] propose a holistic view of UX that includes balance with other aspects such as the feeling of control, the appreciation of the pleasant look of the website, users' subjective perception of their interaction with the website, and positive aspects such as happiness or engagement.

Hence, in case of OER websites, the primary goal is that users can find the resources according to their requirements. To gain a positive user experience, in case of users with disabilities, the website must include accessibility considerations in its design and also best practices of usability to uphold the quality in UX.

For this research we review the considerations of UX in some OER websites to verify their suitability for users with disabilities. The evaluation is centered in Web accessibility and Web usability.

1) Web accessibility

The goal of web accessibility is to ensure that people with disabilities can use the web in equal conditions than others.

OER websites need to be accessible in order to provide equal access to educational opportunities to people with disabilities.

The Web Accessibility Initiative of the World Wide Web Consortium (W3C), has released standards that establish the principles for Web accessibility. Currently, WCAG 2.0 [6] is the standard most broadly accepted [26]. This is a technical standard of 2008, approved as an "ISO/IEC 40500 International accessibility standard" in October 2012.

WCAG 2.0 has 12 guidelines organized under four principles: Perceivable (users must be able to perceive the information being presented), Operable (users must be able to operate the interface), Understandable (users must be able to understand the information as well as the operation of the user interface), and Robust (users must be able to access the content as technologies advance).

For each guideline, there are a set of testable success criteria that are technology neutral. Conformance to the WCAG 2.0 is defined on ordinal levels (A, AA, and AAA) from obligatory, recommended and desirable.

Evaluation procedure

The accessibility in home page of website is a meaningful indicator about accessibility on the entire website; if users with disabilities encounter access barriers in the home page, they cannot use the website. So, in this research, the accessibility evaluation is applied on the home page of the website.

Accessibility evaluation is a time consuming activity but can rely on the use of automated tools for preliminary assessments. The evaluation results obtained with automatic tools should be reviewed by a human expert in order to improve the assessment accuracy.

It is necessary to bear in mind that the use of automatic tools for accessibility assessment is not entirely precise and it is limited to the verification of testable characteristics of web page according to accessibility guidelines. Besides, according to results of a recent study in six automated tools [18], these tools present differences in their coverage, completeness and correctness, with regard to conformance review of WCAG 2.0. So, this study recommends the use of some automatic tools to increase the reliability of the analysis.

In this research we use four automatic tools to complement the evaluation results of each one. These automatic tools are:

- *AChecker* [27]. It is a free online tool that produces a report of all accessibility problems according to guidelines (WCAG 1.0, WCAG 2.0, and Section 508). It reports accessibility problems categorized in: known problems (accessibility problems identified with certainty), likely problems (probable accessibility problems that require a human judgment to make a decision) and potential problems (accessibility problems that cannot be identified because it requires a human decision).
- *eXaminator* [28]. It is an online free service to evaluate Web accessibility based on WCAG 2.0. This tool assigns

a score between 1 and 10 as a referential indicator of the level of accessibility of the web page, for each of these impairments: Blindness, serious visual impairments, limited mobility of upper limbs, comprehension problem and old-age disabilities. The final score is the average of partial evaluations.

- *TAW* [29]. It is an automated tool for evaluating web accessibility on the compliance of WCAG 1.0 and WCAG 2.0. It outputs a report containing the results of the analysis classified by priority level (A, AA, AAA).
- *WAVE* 5.0 [30]. It is an online automatic tool to evaluate the accessibility of a web content, helping web developers to make their web content more accessible. WAVE cannot state if the web content is truly accessible, but can give an alert about accessibility issues. Always it is necessary the human intervention to determine true accessibility. WAVE includes many checks for compliance issues found in the Section 508 and WCAG 2.0 guidelines.

Another quality criteria is the use of standard, interoperable markup and stylesheets; hence, we validate HTML [31] and CSS [32] using W3C Validation Service. The conformance with these standards improves the quality of web pages so they can be handled with different platforms and user-agents.

Finally, using WAVE tool we detect the use of HTML5 and ARIA, both new important standards released by W3C. HTML5 [33] makes creating accessible sites easier due to include new HTML semantic elements like <header>, <footer>, <nav>, <section>, <aside>, etc. allowing screen readers to easily access content. The Accessible Rich Internet Applications specification [34], ARIA, allows web developers to add accessibility information to HTML5, especially for dynamic content and advanced user interface develop with Ajax, JavaScript and related technologies.

2) Web usability

The standard ISO 9241-11: Guidance on Usability (1998) define usability as "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." [35].

Web usability focuses in successful achievement of particular tasks in particular contexts of use. Some usability design issues in website discourage its use. For example, if a website is complex for navigation or the main menu in home page fails to clearly state what the website offers and what users can do on the site; if users get lost on a website; or, in case of OER websites, if users cannot find the resources. Web usability contributes to better experiences of people with disabilities and without disabilities in web navigation [36].

The website should have some characteristics to be usable [37]:

- *Learnability.* The measure of time and effort required by novice users to learn how to navigate in the website and find what they are looking for. Also, the helpfulness of on-line help, tutorials, and hints.
- *Intuitiveness*. Intuitive web design means that when a user sees the interface, they know exactly what to do in the website. If users use a screen reader the reading of interface should be intuitive.
- *Memorability*. The quality of the website of being easy to remember with respect to its use after a time-lapse between visits of users.
- *Affordance* [27]. The quality of interactive elements in website — buttons, links, and input text boxes— that define its possible uses or make clear how it should be used.
- *Efficiency and preciseness*. The users can find and retrieve the content, according to their requirements, in an efficient way.

Evaluation procedure

Web usability evaluation aims to recognize explicit usability problems in website [38]. In this research we use an empirical approach for usability evaluation, considering a set of 185 guidelines extracted from international standard, ISO 9241-151:2008 [7] that provides guidance on the human-centered design of web user interfaces. The guidelines for usability evaluation are appropriate to websites similar to OER websites. The guidelines are grouped in 9 aspects. Some of the guidelines [7] are presented as an example of the scope of each aspect.

Home page

The guidelines review mainly these characteristics:

- The content on home page is clearly focused on users' key tasks.
- The links on the home page are meaningful.
- The major options are represented in the navigation choices and are ordered in the most logical or task-oriented manner.
- The design of the home page will encourage people to explore the site.

Task Orientation

The guidelines review mainly these characteristics:

- The information is presented in a simple, natural and logical order.
- The site structure is simple, with a clear conceptual model and no unnecessary levels.
- The number of screens required per task has been minimized.
- The users can complete common tasks quickly with minimal scrolling and clicking.
- The most important and frequently used topics, features and functions are close to the center of the page.
- The use of metaphors is easily understandable by the typical user.
- A typical first-time user can do the most common tasks without assistance.
- When users return to the site, they will remember how to carry out the key tasks.
- The functionality of command and action items represented as buttons is obvious.
- The user can sort and filter the information resources.

Navigation & Information Architecture

The guidelines review mainly these characteristics, with respect to navigation:

- The navigation is predictable, convenient and obvious; users can move between related pages and sections through global and local navigation.
- It is easy to return to the home page.
- The information that users are most likely to need is easy to reach from most pages.
- Navigation choices are ordered in the most logical or task-oriented manner.
- The navigation system is broad and shallow (many items on a menu) rather than deep (many menu levels),
- The major sections of the site are available from every page (persistent navigation) and there are no dead ends.
- Navigation tabs are located at the top of the page.
- There is a site map that provides an overview of the site's content.
- There is navigational feedback (e.g. showing where you are in the site).

Regarding to Information Architecture, the guidelines review these characteristics:

- The category labels accurately describe the information in the category.
- The categorization of content is visible and useful to users.
- The content organizations allows the grouping by different criteria.
- The terminology and conventions is consistent with general web usage, including "trigger words" that users will look for to achieve their goal.
- The users can sort and filter catalog of resources,
- The site allows the user to control the pace and sequence of the interaction.

Forms & Data Entry

The guidelines review mainly these characteristics:

- The fields on forms contain default values when appropriate and show the structure of the data and the field length.
- There is a clear distinction between “required” and “optional” fields on forms.
- The fields in forms contain hints, examples or model answers to demonstrate the expected input.
- The pull-down menus, radio buttons and check boxes are used in preference to text entry fields on forms.
- The users can complete simple tasks by entering just essential information.
- The forms allow users to navigate with keyboard.
- The labels are close to the data entry fields.

Trust and Credibility

The guidelines review mainly these characteristics:

- The content is up-to-date, authoritative and trustworthy.
- Each page is clearly branded so that the user knows he is still in the same site.
- The site is free of typographic errors and spelling mistakes.

Writing & Content Quality

The guidelines review mainly these characteristics:

- The text is concise, links and link titles are descriptive and predictive.
- The information is organized hierarchically, from the general to the specific, and the organization is clear and logical.
- Each page is clearly labeled with a descriptive and useful title that makes sense to users.
- The link names match the title of destination pages, so users will know when they have reached the intended page.
- The headings and subheadings are short, straightforward and descriptive.

Page layout & Visual Design

The guidelines review mainly these characteristics:

- The most frequently used topics, features and functions are placed on a highlighted position on page, on all pages.
- The site does not need scrolling horizontally.
- The relations between controls and their actions is obvious.
- Each page has a consistent layout, if fonts are readable,
- The site is pleasant to look at.
- The labels and icons are meaningful and intuitive.
- The colors and contrast is adequate.
- The icons are visually and conceptually distinct yet still harmonious.

Search

The guidelines review mainly these characteristics:

- The search interface is located where users will expect to find it (top right of page).
- The search box and its controls are clearly labelled,
- The search results page shows the user what was searched for, search results are clear, useful and ranked by distinct parameters.
- The search results page makes it clear how many results were retrieved, and the number of results per page can be configured by the user.
- The empty queries do not produce errors.
- The website includes “advanced search” to help users refine their searches.
- The website supports searching and browsing.
- The search results page displays useful meta-information, such as the format of the resource, its provenance, the size of the resource, the date that the document was created.

Help, Feedback & Error Tolerance

The guidelines are focused mainly in these characteristics:

- The help is useful for users and the website provides context sensitive help.
- The website provides feedback.

- The options in a dialog box are obvious.
- The page load quickly.
- There is line space of at least 2 pixels between clickable items.
- The website uses appropriate selection methods (e.g. pull-down menus) as an alternative to typing.

Score assignment

The evaluation based on this set of guidelines, allows inspection and respective valuation of each guideline. In order to get a score for usability, the guidelines are qualified with these weights:

- -1, it does not comply with the guideline.
- 1, it complies with the guideline.
- 0, it needs improve compliance.

A raw score is a sum of these weights. The total score is calculated as:

$$\text{Score (\%)} = (\text{RS} + \text{Guidelines}) / (2^* \text{ Guidelines})$$

The score obtained comes from a heuristic approach to evaluate usability that aims to understand usability issues in UX. To obtain a real valuation of usability it is necessary to make users' usability tests, in this case, to users with distinct disabilities. However, this preliminary evaluation can be used for managing the issues detected in usability in order to improve these characteristics on the website.

VI. OER WEBSITES FOR EVALUATION

The websites for evaluation are large-scale OER websites. Both, MERLOT and OER Commons are websites for resources coming from distinct providers, while OCW UPM and OLI Carnegie Mellon are OER coursewares.

- *MERLOT II (http://www.merlot.org/).* (MERLOT). It is a program of California State University sustained with the participation of many higher education institutions and international partners. Began in 1997, and nowadays it is one of the largest OER websites. Many materials in MERLOT pass by "peer review" previous their publication in collections of resources.
- *Open CourseWare Universidad Politécnica de Madrid (http://ocw.upm.es/).* (OCW UPM). This website is sponsored by the university and it is member of Open CourseWare initiative. It offers some courses from university degrees of the university, mostly of them in Spanish language.
- *OER Commons (https://www.oercommons.org/).* (OER COMMONS) It is supported by The William and Flora Hewlett Foundation and the Institute for the Study of Knowledge Management in Education. It was created in February 2007, provides access to highest quality content. Some of its content providers are outstanding universities around the world, research institutes, libraries and institutions related to educational field.
- *Open Learning Initiative Carnegie Mellon (http://oli.cmu.edu/).* (OLI). It is a grant-funded group at Carnegie Mellon University, offering whole online courses from university degrees in open mode. It is sustained by foundations like the William and Flora Hewlett Foundation, Bill & Melinda Gates Foundation, National Science Foundation among others.

VII. EVALUATION RESULTS

A. *Accessibility evaluation results.*

All the tests were conducted in same day in order to prevent changes in its content. The accessibility evaluation on home page of the website have been carried on under WCAG 2.0 for AA level.

eXaminator

Table I shows the accessibility evaluation results obtained with eXaminator tool. Each column shows the accessibility score related to distinct impairments: blindness, severe visual impairment, upper-limb impairments, comprehension impairment, and age-old impairment; the final column shows a general accessibility score for the web page.

TABLE I ACCESSIBILITY EVALUATION WITH EXAMINATOR

Website	Blind	Visual	Upper l.	Compr.	Aging	Score
MERLOT	8.0	6.4	8.4	5.8	6.5	**7.0**
OCW UPM	5.2	5	5.8	4.4	5.3	**5.1**
OER COMMONS	6.2	7	6.6	6.7	6.7	**6.6**
OLI	5.7	6.3	6.1	6	6.4	**6.1**

All the websites have low values for accessibility in all disabilities, hence, the impact of these obstacles in UX is total, because if users with disabilities cannot access to website simply they cannot use the website.

By way of example, we can see in Fig. 1, how the errors are detected by eXaminator. It is necessary to bear in mind that eXaminator does not checks all the WCAG 2.0, just the guidelines related to each disability.

The error highlighted as "Use title attribute for the frame and iframe elements" is produced by iframe (inline frame) video.

The title attribute of the frame or iframe element describes the contents of each frame [39]. This provides a label for the frame so users can determine which frame to enter and explore in detail.

The error highlighted as "HTML layout table that does not make sense when linearized" is a wrong use of HTML table to layout contents.

Although WCAG 2.0 does not prohibit the use of layout tables, CSS-based layouts are recommended in order to retain the defined semantic meaning of the HTML table elements and to conform to the coding practice of separating presentation from content [40].

When a layout table is used, it is important that the content makes sense when linearized. Besides, a layout table should include the ARIA attribute role="presentation" to highlight that the table is only used for presentation purposes.

TAW

Table II shows accessibility evaluation results obtained with TAW tool.

The columns represent the number of accessibility errors detected in WCAG 2.0 level AA, for the four principles, Perceptible, Operable, Understandable, and Robust. For each principle the Errors and Warnings are annotated.

TAW only verifies testable elements, so warnings are usually related with issues that need to be judged by human expert, e.g., missing alt text in images when suppose that image is for decorative purpose, the need of hierarchy in text with the use of h1 to h6 labels, and the color contrast in areas that do not affect the page accessibility.

TABLE II ACCESSIBILITY EVALUATION WITH TAW

Website	Perceptible		Operable		Understandable		Robust	
	E	W	E	W	E	W	E	W
MERLOT	2	132	0	65	0	12	14	48
OCW UPM	9	2	1	32	1	12	2	172
OER COMMONS	5	18	17	23	2	18	1	507
OLI	10	35	1	29	2	6	2	714

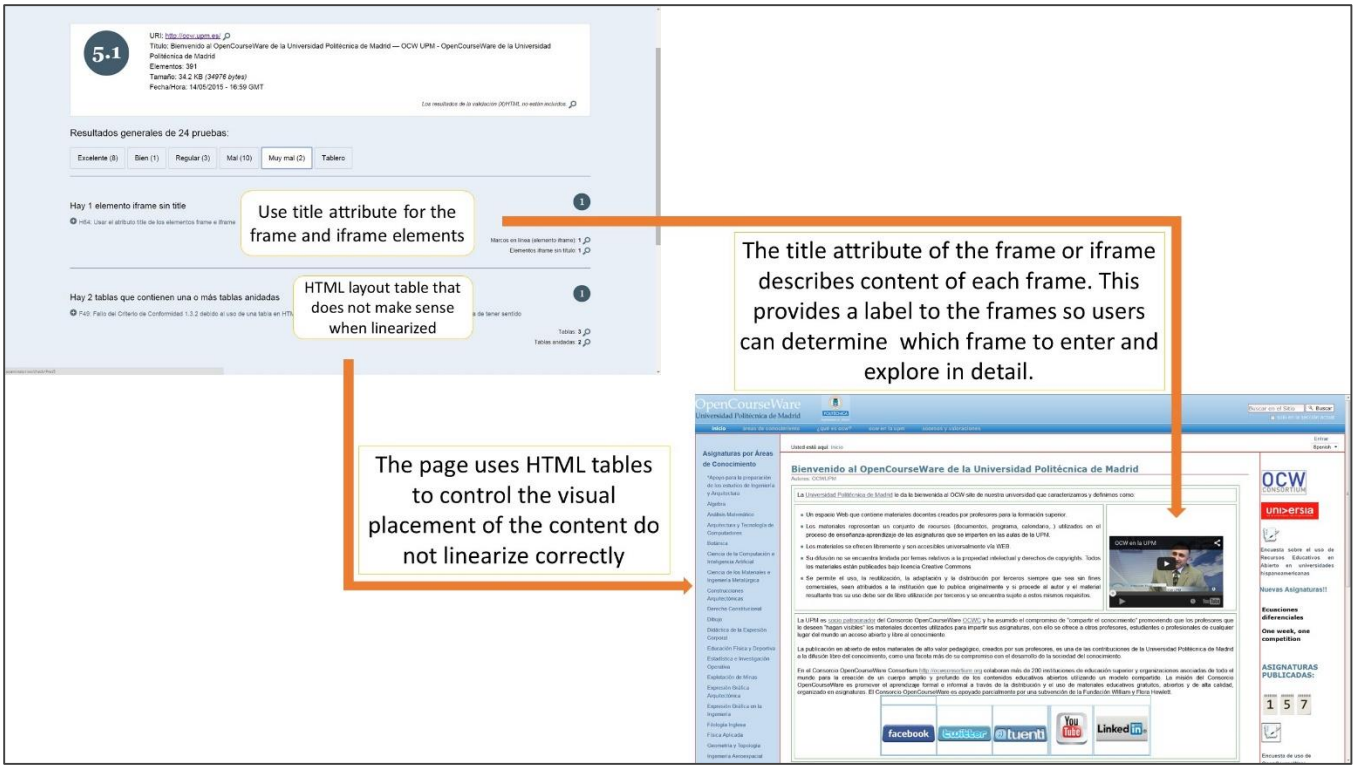

Fig. 1 OCW evaluation with eXaminator tool

Some common problems are related with guidelines such as, “3.2 Make the placement and functionality of content predictable” [6], e.g., beyond moving to the next in tab order; “2.4.4 Provide mechanisms to help users find content, orient themselves within it, and navigate through it”, e.g. each link is associated with text from which its purpose can be determine, “1.3 Ensure that information and structure can be separated from presentation”, “4.1 Support compatibility with current and future user agents (including assistive technologies)”.

The number of errors detected are lower than the number of warnings, it implies that a human expert validation is required to truly define if these warnings can become errors.

AChecker

Table III shows the accessibility evaluation results for AChecker. The columns are the number of Known errors, and Likely errors.

The high value annotated in “Known” errors for OER Commons represents multiple problems of insufficient contrast ratio between link text and background, for a specific region in the page. This condition produces an error notification for the automated tools. However, this is not a real problem, because the region in page where the problem is detected is not relevant.

The “Likely” errors refer to issues that need human verification.

TABLE III ACCESSIBILITY EVALUATION WITH ACHECKER

Website	Known	Likely
MERLOT	0	18
OCW UPM	3	1
OER COMMONS	250	0
OLI	11	2

WAVE

Table IV shows the accessibility evaluation with WAVE tool. The columns represents the number of "Errors", when detect compliance issues against the guideline, number of "Alerts" that refer to compliance issues that need a human verification, and the "Contrast" problems mean a fail in contrast ratio between text and its background so that it can be read by people with low vision. The column "HTML5+ARIA", shows the number of HTML5 labels and ARIA landmarks (a high value represents an extensive use of HTML5 + ARIA).

TABLE IV ACCESSIBILITY EVALUATION WITH WAVE

Website	Errors	Alert	Contrast	HTML5+ARIA
MERLOT	0	4	43	296
OCW UPM	5	20	62	0
OER COMMONS	18	13	21	10
OLI	2	32	51	8

HTML and CSS

A generally recommended practice is to validate the website to ensure that the code on the web page complies with the standards set by W3C. Table V shows the HTML and CSS validation results. The number of errors for HTML validation and for CSS validation is low and should be repaired.

However, in case of OLI, the number of errors and warnings for CSS validation need a deeper review.

Regarding the DOCTYPE —an instruction to the web browser about the HTML version of the page— only OCW UPM has not adopted HTML5.

TABLE V HTML AND CSS VALIDATION

Website	HTML Validation			CSS Validation	
	Errors	Warnings	DOCTYPE	Errors	Warnings
MERLOT	4	1	HTML5	9	60
OCW UPM	4	0	XHTML 1.0	0	5
OER COMMONS	2	7	HTML5	35	7
OLI	4	1	HTML	479	378

B. *Usability evaluation results*

Table VI shows the results of usability evaluation for guidelines in each aspect. The column "Guidelines" shows the number of guidelines for each subject, the column "RS" represents the Raw Score obtained in the evaluation of the guidelines belonging to each subject, "Score" is a percentage that represents the usability level.

The radial chart shows in Fig. 2 allows visualization of usability evaluation results in the websites selected.

TABLE VI USABILITY EVALUATION RESULTS

Subject	Guidelines	MERLOT		OCW UPM		OER COMMONS		OLI	
		RS	Score	RS	Score	RS	Score	RS	Score
Home Page	19	16	92%	-1	47%	17	95%	13	84%
Task Orientation	29	20	84%	2	53%	22	88%	12	71%
Navigation & IA	23	14	80%	-10	28%	18	89%	11	74%
Forms & Data Entry	13	7	77%	0	50%	11	92%	7	77%
Trust & Credibility	11	11	100%	8	86%	11	100%	11	100%
Writing & Content Quality	16	16	100%	12	88%	16	100%	16	100%
Page Layout & Visual Design	37	25	84%	6	58%	25	84%	19	76%
Search	19	9	74%	-1	47%	17	95%	1	53%
Help, Feedback & Error Tolerance	18	14	89%	-4	39%	14	89%	14	89%
Overall score	**185**		**87%**		**55%**		**92%**		**80%**

We can see that websites MERLOT, OER Commons, and OLI have nearly the same scores, but OCW UPM has significantly lower values

The usability evaluation results show a good level of usability —at least 80%— for MERLOT, OER Commons, and OLI Carnegie Mellon. However the value of 55% for OCW UPM is unfortunately a clear sign of low usability and hence of

a poor UX. There are some usability issues with scores highlighted in red color in Table VI that are critical for users with disabilities.

This heuristic evaluation assigns equal weight to all guidelines in order to obtain a percentage for usability score. However, it is important to consider the special contribution of certain guidelines to usability, from the perspective of users with disabilities. These guidelines are concerned to: Home Page, Task Orientation, Navigation and IA, Forms and Data Entry, and Search. On the other hand, the guidelines related to Trust and Credibility, Page Layout and Visual Design, Writing and Content Quality are not significantly relevant to users with disabilities when they use the OER websites.

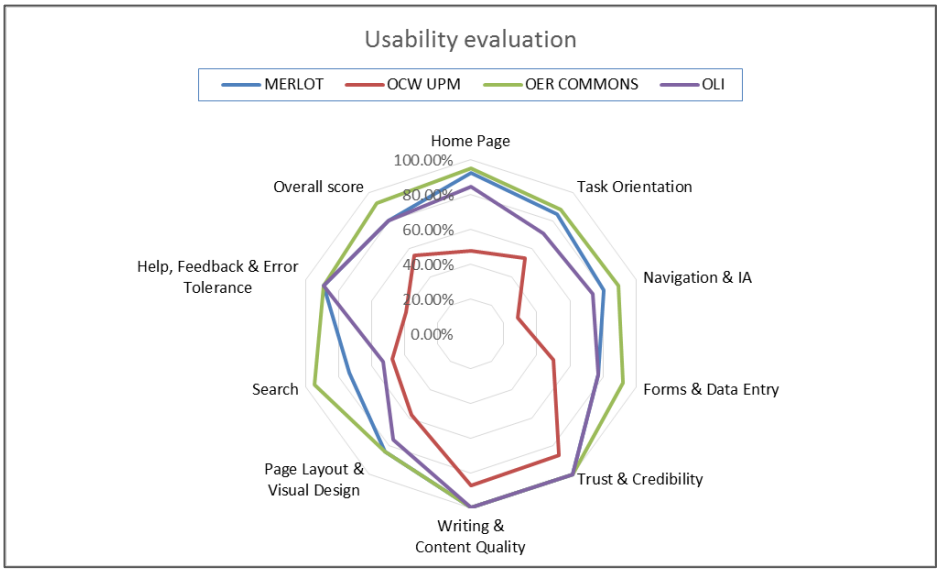

Fig. 2. Radial chart of usability evaluation results

Thereby, in order to appreciate the usability issues, we describe the features of websites with respect to home page interface and structure, content organization, and searching. These aspects are the most representative in UX.

Table VII shows the features inherent to home page interface and content structure i.e., how the information is grouped in home page so that be intelligible and straightforward for users.

TABLE VII HOME PAGE INTERFACE AND STRUCTURE

Website	Home page
MERLOT	The home page interface is based on images and it focuses in user's tasks achievement. Content displayed in home page is minimal but relevant to users.
OCW UPM	This website is in Spanish language. The home page interface is textual. Some information in main content is not relevant to user's tasks achievement.
OER COMMONS	The home page interface is based on text to communicate the main options. Also, there are a carousel of informative images that have alternative text, to allow reading by screen reader software. The content is relevant to user's tasks achievement. The usability and hence UX is increased with the "Learner Options" menu that allows users to adjust viewing preferences, Text and Display, Layout and Navigation, Links and Buttons. This feature is particularly helpful for users with disabilities.
OLI	The home page interface have the main options based on text. There are images but only for decorative purpose. The main options are relevant to users' tasks achievement.

Table VIII shows the content organization, i.e. the way to categorize resources.

All websites analyzed have their own way to categorize resources causing a usability problem, because it is an obstacle to memorability. The users cannot learn how to use these type of websites in a general way, instead, they must to learn how to use each website.

This is an important aspect that not be addressed without a global arrangement about standards for knowledge categorization, and it is a pending issue by now.

TABLE VIII CONTENT ORGANIZATION IN WEBSITES

Website	Content organization
MERLOT	Content organized by multiple parameters (Subject area, Material Types, Mobile Filters, Others filters such as peer review, licenses, accessibility information).
OCW UPM	Content organized by knowledge areas.
OER COMMONS	Content organized by multiple parameters (Subject areas, Grade levels, Material types, Media formats, Conditions of Use).
OLI	A list of courses organized by Open+Free, Future, and Prior Work.

Table IX includes features related to "Basic search" by a keyword in a search box, "Advanced" for refinement of searching based on some simultaneous criteria, and "Browse" for navigate in a grouped list of resources. OER Commons and MERLOT include Advanced Search and Browse of resources. The websites OCW UPM and OLI have limited functionality for Searching.

TABLE IX SEARCHING CHARACTERISTICS IN WEBSITES

Website	Searching

MERLOT	Advanced Search, is enabled through a form for selection of multiple simultaneous conditions: Keywords, Title, Subject Category, and Accessibility information (only if resource has it). Browse, Resources by Category (Arts, Business, Education, Humanities, Science and Technology, Social science), Material Types, Mobile filters and others.
OCW UPM	Advanced Search, is enabled through a form for selection of multiple simultaneous conditions (Title, a list of keywords, description, and type of element). Browse not enabled, instead the option "Knowledge area" shows a list of topics for resources.
OER COMMONS	Advanced Search, is enabled through a form for selection of multiple simultaneous conditions (Subject areas, Grade levels, Conditions of use, Categories, Accessibility). Browse, Resources by category.
OLI	Advanced Search, only for course title. Browse, A list of courses organized by Open+Free, Future, and Prior Work.

By way of example, the Fig. 3 shows some items inspected and evaluated for web usability evaluation. In this case for OER Commons website.

VIII. DISCUSSION AND FUTURE WORK

In this paper, we evaluated the UX from the perspective of users with disabilities in four outstanding OER websites. We considered web accessibility and web usability as the basis for evaluation.

In case of Web accessibility we reviewed level of compliance with WCAG 2.0 by means of using evaluation tools. Although web accessibility evaluation tools can be effective to check level of conformance with accessibility tests, it is necessary to complement with experienced evaluators' judgment. Besides, Web accessibility is only checked for home page of the websites, so the evaluation is a helpful approximation to Web accessibility in the entire website.

As the first outcome we found that web accessibility is still a pending issue in all the websites, with distinct level of severity. Web accessibility is a key condition for UX, because if users with disabilities cannot access to the OER website they cannot use it. In a general way, accessibility barriers degrade the quality of the UX.

In case of Web usability we used a heuristic approach to verify the compliance of a subset of guidelines of standard ISO 9241-11:1998 that cover the evaluation of whether the website is easy to learn, efficient to use, pleasant, and so forth.

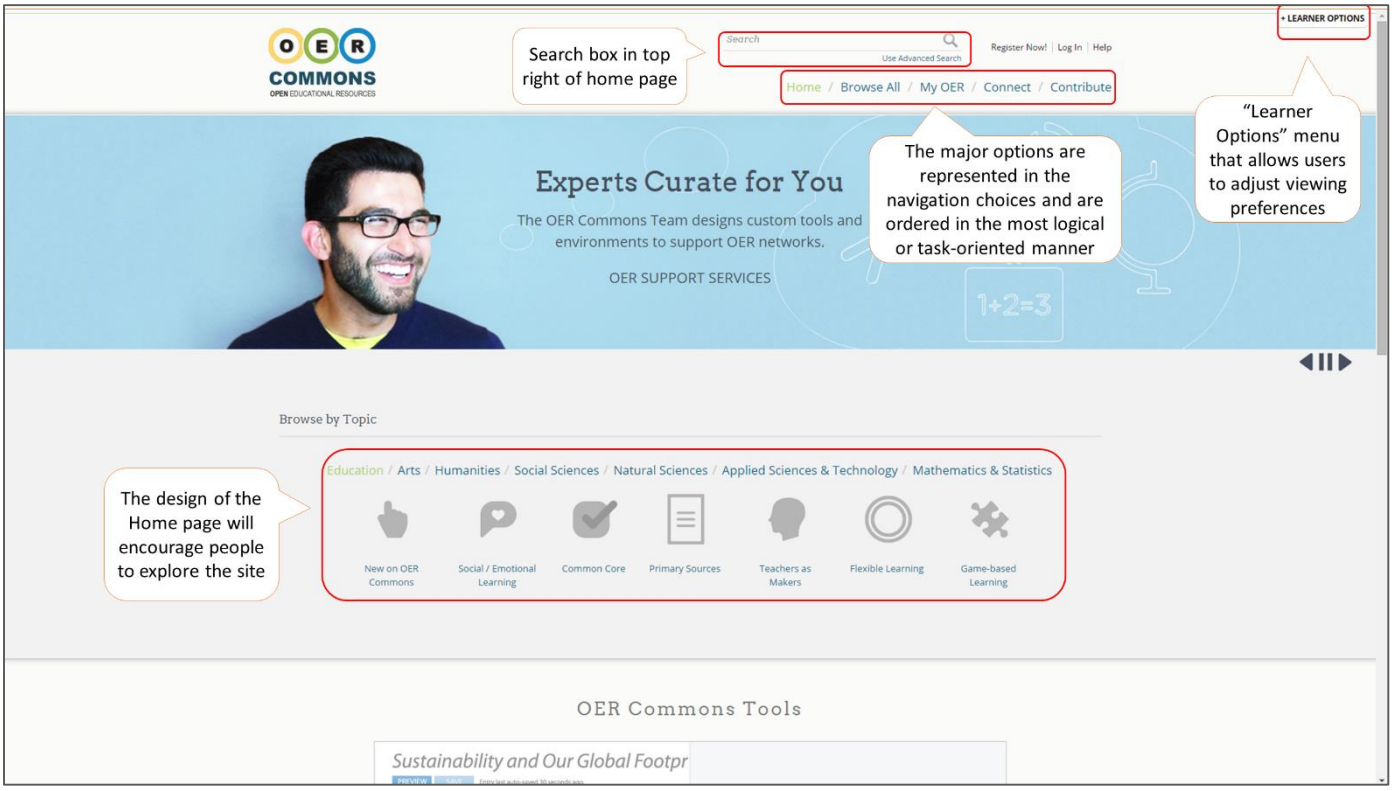

Fig. 3 Usability inspection in OER Commons

The results obtained in this research allow to recognize usability issues in OER website that impact in a negative way in the UX.

Fortunately, we found that at least one of the websites analyzed has incorporated the web usability concept as foundation of its web design. The OER Commons website is task-oriented, easy to follow intuitively and friendly, and it makes possible to explore the categories and subcategories of resources. This represents an advantage to users with disabilities and makes it possible a satisfactory UX. Furthermore, this website includes a "Learner Options" menu that allows users to adjust viewing preferences particularly helpful for users with disabilities. The options to adjust are: Text and Display, Layout and Navigation, Links and Buttons.

From the view of users with disabilities, usability issues are not critical in relation with access to the website, but they are

critical to a successful UX. A website designed according to best usability practices allows more productive experience when users explore the website.

In order to obtain conclusive results about the UX it is convenient that users be involved in a direct way through user testing technique. However, this evaluation provides a first approach to the experience of users with disabilities in OER websites.

These results are helpful to address the troublesome and improve the quality of the UX to users with disabilities and without disabilities.

This research has been focused in UX considering the website, but not the resources; so, in future works we plan complement the study verifying the UX in the educational resources. At respect, some aspects such as the field of knowledge, the educational level, and quality of resources (in terms of content and the inherent pedagogical approach) should be considered.

ACKNOWLEDGMENT

This work has been partially supported by the Prometeo Project by the Secretary of Higher Education, Science Technology and Innovation (SENESCYT) of the Ecuadorian Government.

REFERENCES

[1] R. Farrow, "OER Impact: Collaboration, Evidence, Synthesis," in Proceedings of OpenCourseWare Consortium Global 2014: Open Education for a Multicultural World, Ljubljana, Slovenia, 2014.

[2] X. Ochoa and E. Duval, "Quantitative Analysis of Learning Object Repositories," IEEE Transactions on Learning Technologies, vol. 2, no. 3, pp. 226-238, 2009.

[3] M. Hassenzahl and N. Tractinsky, "User experience - a research agenda," in Behaviour & Information Technology, Taylor & Francis Group, 2006, pp. 91-97.

[4] R. Navarrete and S. Luján-Mora, "Accessibility considerations in Learning Objects and Open Educational Resources," in ICERI2013 Proceedings, Sevilla - Spain, 2013.

[5] R. Navarrete and S. Luján-Mora, "Evaluating accessibility of Open Educational Resource website with an heuristic method," in 9th International Technology, Education and Development Conference, Madrid, Spain, 2015.

[6] W3C, "Web Content Accessiblity Guidelines (WCAG) 2.0," 2012. [Online]. Available: http://www.w3.org/TR/WCAG20/.

[7] ISO, "ISO 9241-151:2008, Ergonomics of human-system interaction -- Part 151: Guidance on World Wide Web user interfaces," 15 05 2008. [Online]. Available: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=37031. [Accessed 05 2 2015].

[8] UNESCO, "Forum on the impact of open courseware for higher education in developing countries," Paris, France, 2002.

[9] D. Atkins, J. Seely Brown and A. L. Hammond , "A review of the Open Educational Resources (OER) Movement: Achivements, Challenges and New Opportunities," February 2007. [Online]. Available: http://www.hewlett.org/uploads/files/ReviewoftheOERMovement.pdf.

[10] UNESCO, "World Open Educational Resources (OER) Congress," 2012.

[11] European Commission, "New Rethinking Education strategy," 11 2012. [Online]. Available: http://europa.eu/rapid/press-release_IP-12-1233_en.htm. [Accessed 03 02 2015].

[12] U.S.Government, "The Open Government Partnership, "Announcing New Open Government Initiatives as part of the Second Open Government National Action Plan for the United States of America," 09 2014. [Online]. Available: https://www.whitehouse.gov/sites/default/files/microsites/ostp/new_nap_commitments_report_092314.pdf. [Accessed 13 02 2015].

[13] N. Butcher, A Basic Guide to Open Educational Resources (OER), Commonwealth of Learning & UNESCO, 2011, pp. 66-85.

[14] E. Allen and J. Seaman, "Opening the Curriculum: Open Educational Resources in U.S. Higher Education," Pearson, 2014.

[15] M.-A. Sicilia, X. Ochoa, G. Stoitsis and J. Klerx, "Learning Objects Analytics for Collections, Repositories & Federations," in Proceedings of the Third International Conference on Learning and Analytics and Knowledge (LAK'13), Leuven, Belgium, 2013.

[16] R. McGreal, "A Typology of Learning Object Repositories," [Online]. Available: http://hdl.handle.net/2149/1078, 2007. [Accessed 8 9 2013].

[17] World Health Organization, "Disabilities," 2015. [Online]. Available: http://www.who.int/topics/disabilities/en/. [Accessed 12 2014].

[18] M. Vigo, J. Brown and V. Conway, "Benchmarking web accessibility evaluation tools: measuring the harm of sole reliance on automated tests," in 10th International Cross-Disciplinary Conference on Web Accessibility, New York, USA,, 2013.

[19] World Health Organization, "World Report on Disability," 2011.

[20] United Nations, Department of Economic and Social Affairs, Population Division, "World Population Ageing 2013," New York, 2013.

[21] W3C, "World Wide Web Consortium (W3C) Launches International Web Accessibility Initiative," 1997. [Online]. Available: http://www.w3.org/Press/WAI-Launch.html.

[22] United Nations, "Conventions on the Rights of Persons with Disabilities and Optional Protocol," 2006. [Online]. Available: http://www.un.org/disabilities/documents/convention/convoptprot-e.pdf. [Accessed 03 10 2014].

[23] J. J. Garret, The elements of User experience - User centered design for the Web, New Riders, 2002.

[24] H. Petrie and N. Bevan, "The evaluation of accessibility, usability and user experience," in The Universal Access Handbook, CRC Press, 2009.

[25] M. Hasssenzahl and N. Tractinsky, "User experience - a research agenda," in Behaviour & Information Technology, vol. 25, Taylor & Francis, 2006.

[26] W3C, "W3C Workshop Report: Referencing and Applying WCAG 2.0 in Different Contexts," 05 2013. [Online]. Available: http://www.w3.org/WAI/ACT/workshop-report. [Accessed 15 02 2015].

[27] AChecker, "Web Accessibility Checker," [Online]. Available: http://achecker.ca/checker/index.php.

[28] eXaminator, "Evaluación de la accesibilidad web," [Online]. Available: http://examinator.ws.

[29] Fundación CTIC, "TAW," [Online]. Available: http://www.tawdis.net/ingles.html?lang=en.

[30] WebAIM, "WAVE," [Online]. Available: http://wave.webaim.org/. [Accessed 04 03 2015].

[31] W3C, "Markup Validation Service," [Online]. Available: http://validator.w3.org/.

[32] W3C, "CSS Validation Service," [Online]. Available: http://jigsaw.w3.org/css-validator/validator.html.en.

[33] W3C, "HTML5," 10 2014. [Online]. Available: http://www.w3.org/TR/html5/. [Accessed 05 03 2015].

[34] W3C-Web Accessibility Initiative, "WAI-ARIA Overview," 06 2014. [Online]. Available: http://www.w3.org/WAI/intro/aria.php. [Accessed 05 03 2015].

[35] ISO, "ISO 9241-11:1998, Ergonomic requirements for office work with visual display terminals (VDTs) — Part 11: Guidance on usability," 1998. [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-1:v1:en. [Accessed 02 03 2015].

[36] W3C, "Web accessibility and Usability working together," [Online]. Available: http://www.w3.org/WAI/intro/usable. [Accessed 5 10 2014].

[37] J. Nielsen, "Nielsen & Norman Group: Usability 101, Introduction to usability," [Online]. Available: http://www.nngroup.com/articles/usability-101-introduction-to-usability/. [Accessed 27 10 2014].

[38] H. Petrie and O. Kheir, "The Relationship Between Accessibility and Usability of Websites," in SIGCHI Conference of Human Factors in Computing Systems, San José California, USA, 2007.

[39] W3C, "Techniques for WCAG 2.0," [Online]. Available: http://www.w3.org/TR/WCAG20-TECHS/H64.html. [Accessed 4 05 2015].

[40] W3C, "Techniques for WCAG 2.0, F49," [Online]. Available: http://www.w3.org/TR/WCAG20-TECHS/F49.html. [Accessed 02 05 2015].

Rosa Navarrete, Doctoral student at the Department of Software and Computing Systems of University of Alicante (Spain). Professor of the Department of Informatics and Computer Sciences of National Polytechnic School of Ecuador.

Sergio Luján Mora, Visiting Teacher at National Polytechnic School. Researcher of Prometeo Project by the Secretary of Higher Education, Science Technology and Innovation (SENESCYT) of Ecuador. Associate professor at the Department of Software and Computing Systems at the University of Alicante (Spain).