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Automatic Web accessibility evaluation process. Case study

Proceso de evaluación automática de accesibilidad Web. Estudio de caso

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Abstract

Web Accessibility, a topic of universal connotation, emerges as an aspect that cannot be postponed due to the digitalization increased by the social, preventive and compulsory isolation caused by the COVID-19 pandemic. Web Accessibility can be approached from different angles, be they engineering-technological aspects or social and professional issues. The article presents a process focused on automatic validation. The study is performed on the home pages of a sample of 13 sites built to solve specific problematic situations. The analysis of the results determined that the limitation to understand is the most frequent factor, followed by the limitation of the upper limbs, total limitation to see, severe limitation to see and limitations derived from age. The findings indicate the need to advance in these studies, aimed at raising awareness and reducing the barriers to access to information in order to ensure an inclusive knowledge society.

Keyword: web accessibility, process, automatic validation, access to information

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Resumen

La Accesibilidad Web, tema de connotación universal, emerge como un aspecto impostergable debido a la digitalización incrementada por el aislamiento social, preventivo y obligatorio causada por la pandemia de COVID-19. La Accesibilidad Web puede abordarse desde distintas aristas, sean aspectos ingenieriles-tecnológicos o cuestiones sociales y profesionales. El artículo presenta un proceso centrado en la validación automática. El estudio se realiza a las páginas iniciales de una muestra de 13 sitios construidos para resolver situaciones problemáticas específicas. El análisis de los resultados determinó que la limitación para comprender es el factor más frecuente, seguido por la limitación de los miembros superiores, la limitación total para ver, la limitación grave para ver y las limitaciones derivadas de la edad. Los hallazgos dan cuenta la necesidad de avanzar en estos estudios, tendientes a concientizar y disminuir las barreras de acceso a la información para asegurar una sociedad del conocimiento inclusiva.

Palabras clave Accesibilidad web, proceso, validación automática, acceso a la información

Introduction

The substantive activities of the University concern research, teaching, extension, transfer and training of human resources and the different interrelationships that derive from them. There is a diversity of theoretical-methodological strategies to achieve the goals of the various institutional projects. It is Social Responsibility of the University actors to contribute to the consolidation of the Information society (Larrán and Andrades Peña 2015; Hernández Arteaga, Alvarado Pérez and Luna 2015; Toca Torres 2017; Mariño, Alfonzo and Godoy 2021). Thus, involving future professionals from the undergraduate level is considered relevant for the software industry.

The article evaluates websites built to improve Web Accessibility (WA) and thus contribute to positive and relevant user experiences in the context of inclusive societies. From the perspective of Software Engineering (SI) it is remarkable to determine the quality of software products in the development process, being the WA a measure applicable from early stages of development and treated as a non-functional requirement (Mariño et al. 2012; Hernández Arteaga, Alvarado Pérez and Luna 2015).

The User Experience (UX) ensures the appropriation by the recipients of a development. Therefore, considering the UX as a quality assurance strategy contributes to the digital transformation of the 21st century by facing the inclusion in this new and avoiding restrictions on access to information. In Mariño, Alfonzo and Godoy (2021), AW is proposed to ensure positive user experiences. The SWEBOK (Software Engineering Body of Knowledge) guide presents 15 knowledge areas (Bourque and Fairley 2014b). These are identified as software requirements, software design, software design, software construction, software testing, software maintenance, software configuration

management, software engineering management, software engineering process, software engineering models and methods, software quality, software engineering professional practice, software engineering economics, computer science fundamentals, mathematical fundamentals, engineering fundamentals.

The SWEBOK guide is considered a guide to the discipline. Among some of its features are mentioned (Bourque and Fairley 2014a):

- Characterize the contents of Software Engineering.
- To provide access to the body of knowledge in Software Engineering through the thematic areas.
- Promote a consistent vision of Software Engineering worldwide.
- Clarify the position of Software Engineering with respect to other disciplines, such as Computer Science or Mathematics.
- Provide a basis for curriculum development and the creation of certification materials.

It should be clarified that study initiatives such as the one described above are in line with those discussed in other contexts (Barrios, Marín and Torrente 2017; Casasola Balsells et al. 2019; Amatriain et al. 2018; Lafuente, Ballesteros and Filippi 2018; Lafuente et al. 2020). Universal access to the web is a challenge where most activities are mediated by Internet services.

Web Accessibility (WA) is an aspect of software quality. In particular, it refers to universal access to the Web, regardless of the type of hardware, software, network infrastructure, language, culture, geographical location and capabilities of users. It aims to achieve equal and equitable access (Luján Mora, 2022; W3C, 2022; Mariño, Alfonzo and Godoy 2020a).

Its relevance is supported by the numerous initiatives of recognized organizations such as W3C (2022), ISO (2022), the Sidar Foundation (2016) and CIDAT (2022).
In addition, many countries have defined and enacted the corresponding regulations, including the United States, Portugal, Spain, Brazil, Chile, Peru, among others (Luján Mora 2021). In Argentina, Law 26.653 (InfoLEG 2010, p. 1), on Accessibility of Public Information on Web Pages, was enacted in November 2010. The text of the Law in its Article 1 states:

"The national State, including the three powers that constitute it, its decentralized or autarchic agencies, non-state public entities, State companies and private companies holding concessions for public services, companies providing or contracting goods and services, must respect in the design of their web pages the standards and requirements on accessibility of information that facilitate access to its contents, to all persons with disabilities in order to ensure real equality of opportunities and treatment, thus avoiding any kind of discrimination".

Decree No. 656/2019 and Provision No. 6/2019, provide new guidelines for compliance with this Law (Marval O'Farrell Mairal 2019). The study and approach to AW is addressed in other universities as mentioned in Amatriain et al. (2018), Lafuente et al. (2019), Soto (2021), Balmaceda Castro et al. (2021), Díaz et al. (2021), Herrera et al. (2021), among others. In most studies, evaluations and analyses focus on the WCAG 2.0 standard (WCAG, 2008) defined by the W3C.

The aforementioned standard proposes four principles for evaluating AW, identified as: Perceptible, Operable, Understandable and Robust. Each principle is grouped into guidelines and these in turn contain the success criteria to verify. Tools and accessibility experts check compliance with the success criteria in order to determine the level of accessibility of a web page or site.

The WCAG (2008) defines the corresponding priority level for each criterion or verification point included in the four principles. Thus, it is specified for the verification points that concern: i) Priority 1: those to be met to ensure access to the information on a Web site; ii) Priority 2: those to be met to avoid making it very difficult for certain groups of users to access the information; iii) Priority 3: those to be met to prevent certain users from experiencing certain problems in accessing the information.

With respect to the three levels of conformance associated with the priorities, W3C (2022) determines that: i) if all Priority 1 checkpoints are satisfied, Conformance Level "A" is achieved; ii) if all Priority 1 and 2 checkpoints are satisfied, Conformance Level "AA" is achieved; and iii) if all Priority 1, 2 and 3 checkpoints are satisfied, Conformance Level "AAA" is achieved.

Materials and methods

A process was designed to evaluate the AW, integrating theoretical and empirical aspects. Phase 1. Documentary research, recovering theoretical aspects related to legislation, standards and some AW evaluation experiences. Phase 2. Definition of the process, based on theoretical aspects, oriented to the measurement of AW using automatic validators. Validation of the process, defining the case study. It is described in section 3.2. It consisted of a descriptive study of the accessibility of 13 selected websites, opting for the use of an automatic validator.

Results

For the team of teacher-researchers, it is essential to address theoretical, methodological and practical aspects based on experience. This makes it possible to define and apply criteria oriented to unrestricted access to information available on the web, and to contribute with positive experiences for users with a view to improving their quality of life, particularly by focusing on access to contents.

In reference to the theoretical underpinning of this study, some issues of Software Engineering and its relationship with AW are mentioned, as shown in Figure 2.

- Delimitation of knowledge areas of the Swebok guide integrated in the proposal. Of the SI knowledge areas, the following were chosen: Software Requirements (SR) and Software Evaluation (SE). RS was selected to ensure that AW is included as a non-functional requirement. As a non-functional requirement and the ES focused on the evaluation of the AW as an aspect of software quality, in particular to verify compliance with the chosen standard. The knowledge area Software Requirements, deals with the elicitation, analysis, specification and validation of software requirements, as well as the management of requirements throughout the software product life cycle. Requirements express the needs and constraints imposed on a software product that contribute to the solution of some real-world problem (Bourque and Fairley 2014b). Software Evaluation consists of the verification that a program provides the expected behaviors on a finite set of test cases, appropriately selected from the execution domain (Bourque and Fairley 2014b). In this study, they target test cases with respect to compliance with WCAG 2.0 guidelines.
- Identification and analysis of quality standards related to AW: WCAG (2008), UNE (2012), Mobile Accessibility (2015), WCAG (2018), opting for WCAG 2.0 to determine AW levels in different software products and thus suggest and/or apply improvements.
- Determination of AW models, methods and procedures. The literature establishes various ways of proceeding in the evaluation of AW, it is required to define the scope of each of these resources, similarities and differences; and the feasibility of adapting to the context, according to guidelines and criteria described in Ilunion (2015) and defined in the WCAG (2008).

The following activities are proposed:

- Selection of the Evidence-Based Software Engineering or ISBE method (Mariño and Alfonzo 2019). It consisted of the following stages: i) Definition; ii) Experimental design; iii) Conduct and analysis; iv) Interpretation of the results, v) Preparation of the report.
- Experimentation. In the analysis of the AW, based on a descriptive quantitative approach.
- Description of the research variables related to the object of study. The international standard WCAG (2008) was chosen for the evaluation of the AW.
- Selection of data collection tools, i.e., those to automatically evaluate AW. Some of these include TAW, Hera, Examinator.
- Definition of limitations. The experimental study is restricted to the use of an automatic validator that checks the accessibility of the HTML code of the chosen page. Several validators can be applied to obtain other results and thus facilitate the triangulation of information.
- Execution of automatic AW tests applied to the sample web pages and collection of empirical data.
- Estimation of metrics. The PIC metric (1) is defined, which determines the percentage of non-compliance per criterion in the sites analyzed. That is, it

determines the criteria incorrectly applied and detected by the selected data collection tool.

$$PIC = \frac{CSIC}{CSA} * 100 \quad (1)$$

CSIC = Number of sites that do not comply with the analyzed criterion.

CSA = Number of sites analyzed

- Analysis of results. The findings are synthesized quantitatively by applying the PIC metric. In addition, the information collected for each element of the sample can be used to support the maintenance of that website.

To validate the proposed process, 13 (thirteen) websites developed for various organizations, public and private in the period 2016-2020 were selected. These artifacts were built using various web development tools. As discussed in Mariño and Alfonzo (2019), for privacy reasons the name and email address of the evaluated sites are omitted. Their construction was characterized by: i) orientation towards the resolution of a problem posed by a need for information processing and its dissemination through the web; ii) use of development environments and freely distributed languages in the generation of the code; iii) execution of verification tests; iv) assurance regarding the functioning of the product by its recipients.

In order to obtain empirical evidence, the principles, the guidelines they group together and the criteria included in the WGAG 2.0 guidelines (WCAG, 2008) were verified.

The automatic data collection validator Examinator (2015), available online, was chosen to capture evidence of how accessible each of the sites that made up the sample is. Its choice is based on the fact that it is a web-based tool that facilitates access to the information processed as a result of the analysis. This tool automates the assessment of the WCAG 2.0 (WCAG, 2008), using as a reference the techniques recommended by the Web Content Accessibility Guidelines 2.0 (WCAG, 2008). It awards a score between 1 and 10 according to the errors and successes detected, assigning a grade and provides a detailed report of the tests performed. The tests are based on the techniques recommended by the WCAG (2008) and the results measure the performance of the page with respect to those techniques; and the grade reflects the accessibility of the content (Benavides, 2012) proposes the following scale: Very bad: 1, Bad: 2 or 3, Fair: 4 or 5, Good: 6 or 7, Very good: 8 or 9, Excellent: 10 in order to express value judgments.

The selected sites were evaluated. An analysis focused on their home pages, summarized in Table 1, summarizes that in most of the tests applied, errors in the excellent category - on average 5.23 and bad - representing an average of 3 - were more frequently found in the 13 sites evaluated. In addition, the least frequently detected errors correspond to the very bad and regular categories. The automatic

evaluation tool detects the values according to different types of disabilities such as: total limitation to see, severe limitation to see, limitation of the upper limbs, limitation to understand and limitations derived from age (Benavidez 2012).

In Table 2, the evaluation focuses on determining the various types of disabilities, focusing the study on the initial pages. It is identified that the limitation to understand is the most frequent factor, the second place corresponds to the limitation of the upper limbs, followed by the total limitation to see, the severe limitation to see and finally the limitations derived from age.
Following the scale proposed in Benavidez (2012), given that on average the limitations exceed the value 5 and are less than 7, it is possible to infer that the accessibility of the sites analyzed is good. However, it is necessary to pay attention to the details of the errors detected in the different tests in order to apply AW criteria from the early stages of web development.

Table 1. *Scores assigned to the evaluated sites according to limitations.*

Sites	NumberTotalTests	Excellent	Very good	Good	Regular	Mal	Very Bad
Site 1		5					5
Site 2		5					
Site 3					1		
Site 4		5					1
Site 5							
Site 6							
Site 7							1
Site 8							
Site 9		5					
Site 10							
Site 11					1		1
Site 12					1	1	1
Site 13							1
Average	9,92	5,23	-	-	1,40	3,00	2,13

Since the WCAG (2008) proposes four principles: Perceptible, Operable, Understandable and Robust, which are grouped into guidelines and these in turn contain the success criteria to verify. Table 3, presents the evaluation of the 13 (thirteen) websites considering the PIC metric.

Table 2. *Scores assigned to sites evaluated according to constraints*

Sites	Total limitation to view	Severely limited vision	Limitation of the upper limbs	Limitation in understanding	Age-related limitations
Site 1	5,7	6,1	6,1		6,1
Site 2	4,7	5		4,5	5
Site 3	4,5	5,7	5,8	4,8	5,9
Site 4	6,7	6,1	7,9	6,1	6,4
Site 5	7,1	7,4	5,8	5,5	7,4
Site 6	5,7	6,5	5,8	5,5	6,4
Site 7	7,3	6,9	7,4	6,7	7,3
Site 8	6,7	7,4		7,8	7,4
Site 9	5,1	5,6	4,1	4,1	5,4
Site 10	5,7	6,4	4,8	4,9	6,8
Site 11	6,4	5,8	6,7	5,5	5,8
Site 12	7,5	7,5	7,2	6,1	7,2
Site 13	7,1	7,1	6,1	6,9	7,7
Average	6.17	6.42	5.98	5.72	6.52

Table 3 shows that the Perceptible principle and in particular guideline 1.3.1 Information and relationships presents the highest PIC, followed by guideline 2.4.4 Purpose of links (in context only) reaching 85%. Likewise, guideline 4.1.1 Processing of the Robust principle and guideline 2.4.9 - Purpose of links (only links) of the Operable principle show a lower PIC, representing 8% of non-compliance with the criteria.

The technological projects analyzed are framed within an agreed general objective, to achieve accessible websites implemented in different contexts. However, the specific objectives were delineated and modified in a process of continuous action. The above coincides with what is explained in Barba Martín (2019 p. 126), who states that "realities are changeable and, as such, researchers may modify the objectives and focal points of the research as new knowledge is acquired and/or conditions change".

Table 3. Percentage of non-compliance of the evaluated sites

Principles	Guidelines/Criteria	Level	CSIC	PIC
Perceptible	1.1-Alternative texts			
	1.1.1 - Non-textual content	A		
	1.3-Adaptable			
	1.3.1 - Information and relationships	A		92 %
	1.4-Distinguishable			
	1.4.3 - Contrast (Minimum)	A		23 %

	1.4.4 - Text resizing	A		31 %
Operable	**2.4-Navigable**			
	2.4.2 - Title pages	A		
	2.4.4 - Purpose of links (in context)	A		85 %
	2.4.9 - Purpose of links (links only)	AAA	1	8%
	2.4.10 - Section headings	AAA		
Understandable	**3.1-Eligible**			
	3.1.1 - Page language	A	5	38 %
	3.3-Assisted Data Entry			
	3.3.2 - Labels or instructions	A		31 %
Robust	**4.1-Compatible**			
	4.1.1 - Processing	A	1	8%

In addition, following De Oliveira Figueiredo (2015) and considering the diversity of aspects of the social reality, flexibility was assumed in the different intervention projects, attending to the specific characteristics, in order to meet the expectations of potential users.

In view of the above, analyzing web accessibility and reporting the findings contributes significantly to reducing barriers to access to information in the knowledge society. Thus, an approach to Web Accessibility from the perspective of university social responsibility is exemplified in Mariño, Alfonzo and Godoy (2020b) and Mariño, Alfonzo and Godoy (2021).

Conclusions

Numerous efforts revolve around education among which the right to "inclusive, equitable and quality education, promoting learning opportunities" referred to in the fourth sustainable development goal of the 2030 Agenda of the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021). In particular, Iglesias and Martín (2020) refer to the Salamanca Statement that defines at the international level the so-called inclusive education.

It is worth noting the international efforts, the numerous AW legislation and standards to comply with these initiatives that ensure access to content in an effort to ensure universal inclusion. In this sense, the article proposes an integration of theory and practice, planning, action (through the evaluation of AW), analysis of results, aimed at awareness and transformation for individual and communal well-being, focused on ensuring access to content.

In addition, it reflects the social responsibility of educational institutions and in particular from this work team, from the evaluation of the AW to raise awareness and exemplify the subject with concrete cases from a participatory action research approach.

Therefore, the knowledge acquired and deepened within the framework of the different interventions is capitalized by the human resources trained and in training who are inserted in the Software Industry, thus reflecting the know-how. On the other hand, the R&D&I team systematizes the experiences in a database to address future interventions. The transfer of knowledge, mediated to empirical activities and developed in academic environments, is oriented to achieve the disciplinary training in Web Accessibility as a social, technological and professional aspect in line with the approach of computer science as a bio-psycho-social discipline.

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