ARTÍCULO ORIGINAL

Analysis of web accessibility to Colombian universities under the guidelines proposed by WCAG 2.1

Análisis de accesibilidad web a universidades colombianas bajo las pautas propuestas por la WCAG 2.1

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SUMMARY

This article reports the results of a study that aimed to analyze the level of accessibility of the websites of Colombian universities under the accessibility guidelines for web content, WCAG 2.1. The web portals of 11 universities categorized in the Q1 and Q2 quartiles of the U-sapiens 2020-1 Ranking were analyzed. The results show that no university met all the success criteria, and the most accessible only reached 71.79 % of them. No relationship was found between the accessibility of web pages and the ranking of universities in the U-Sapiens 2020-1 ranking. This indicates that the websites of the universities studied are not fully accessible. Although there are regulations that promote web inclusion for all people, regardless of their disability status, it is necessary to promote educational campaigns that teach and motivate designers, digital content creators, and programmers to consider when developing websites.

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RESUMEN

En este artículo se reportan los resultados de un estudio que tuvo por objeto analizar el nivel de accesibilidad de los sitios web de las universidades colombianas, bajo las pautas de accesibilidad para el contenido web, WCAG 2.1. Se analizaron los portales web de 11 universidades categorizadas en los cuartiles Q1 y Q2, del Ranking U-sapiens 2020-1. Los resultados muestran que ninguna universidad cumplió con todos los criterios de éxito, y la más accesible tan solo alcanzó el 71,79 % de los mismos. Tampoco se encontró relación entre la accesibilidad de las páginas web y la clasificación de las universidades en el ránking U-Sapiens 2020-1. Lo anterior indica que los sitios web de las universidades estudiadas no son del todo accesibles. Esto se debe a que, aunque en la actualidad existen normativas que promueven la inclusión web para todas las personas, sin importar su condición de discapacidad, es necesario promover campañas pedagógicas, que enseñen y motiven a: diseñadores, creadores de contenido digital y programadores, a tenerlas en cuenta al momento de desarrollar los sitios web.

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INTRODUCTION

In Colombia, education is a right of the person and public service, which provides access to knowledge, science, technique, and other goods and values of culture (1). In this sense, educational institutions at all levels have established various study plans and modalities of access to the educational service, with the face-to-face modality being the one with the most outstanding coverage and acceptance (2). However, the appearance of SARS-CoV-2 or COVID-19 has generated inconveniences in providing educational services, significantly altering the face-to-face programs offered by universities (3,4).

Among the difficulties caused by COVID-19 is the migration from face-to-face to virtuality, which has led Higher Education Institutions (HEIs) to strengthen their technological platforms (5). This is to provide: officials, teachers, and students the possibility of performing their tasks optimally through virtuality (6,7).

The HEIs usually improve infrastructure aspects related to Information and Communication Technologies (ICT), such as greater bandwidth for connectivity, cloud storage services, hardware with greater processing capacity, and digital tools for content management (8, 9). However, acquiring or using computer tools does not guarantee success in providing an excellent educational service if they do not allow access (10,11).

In the case of web pages, accessibility is understood as the ease of accessing information, regardless of users' personal, social, or infrastructure characteristics (12,13). The World Wide Web Consortium (W3C) has established the Web Content Accessibility Guidelines, WCAG (14), at an international level. In the WCAG, version 2.1, 78 success criteria are established, which every website must meet to be considered accessible. In this sense, there are 3 levels of conformity (A, AA, and AAA); 4 principles: perceivable, operable, understandable, and robust; and 13 guidelines, which provide the primary goals to be considered by developers so that content is accessible to users with different disabilities (15).

The objective of this study was to validate, under the guidelines proposed by WCAG 2.1, the level of accessibility of the websites of the 11 best-positioned Colombian universities in the U-Sapiens 2020-1 Ranking. The following section presents the methodology used to carry out this research. Then, the levels of accessibility of the evaluated universities are exposed based on the four principles established in the WCAG. Subsequently, the shortcomings are described, and some recommendations are provided to address them.

METHODS

In this study, 11 websites of Colombian universities, both public and private, were analyzed, 3 of them positioned in the Q1 quartile and 8 in the Q2 quartile of the Ranking U-Sapiens 2020-1 (16). It should be noted that the U-Sapiens Ranking classifies the best Colombian universities according to research indicators, such as indexed journals, postgraduate programs (masters and doctorates), and research groups categorized by Minciencias (17).

The evaluation of the accessibility levels of the websites of the selected universities was carried out automatically and manually. Although there are digital tools that automate the task, not all of the 78 success criteria proposed by WCAG 2.1 can be assessed in this way (18). In this case, the Google Chrome browser was used, along with the following tools:

WebValidator 2.1: "Análisis de accesibilidad de sitios web bajo pautas WCAG 2.1". The authors of this article developed the tool. Its main objective is to assess the HTML, XHTML, and CSS code of websites, using the Web Scraping technique, to identify whether it meets some criteria of the WCAG 2.1 standard. This tool was also used as a rubric or matrix to report compliance or non-compliance with criteria that require manual assessment, like the way *Audit Tool WCAG 2.1* does (19).

TAW. Test de Accesibilidad Web. In addition to evaluating some accessibility criteria for levels A, AA, and AAA, this tool was also used to validate the accessibility of the codes produced by Javascript.

WAVE: Web Accessibility Evaluation Tool. This tool was used as an extension of the Google Chrome browser to identify accessibility errors on websites related to color contrast, font size, animations and interactions, hyperlinks, and redundant texts.

JAWS: Job Access with Speech. This screen reader was used to evaluate the criteria of keyboard accessibility, text alternatives for non-text content, and identification of labels or instructions.

The procedure followed to verify accessibility began with the analysis of each university's leading web page and 4 subordinate pages through the Web Validator 2.1 tool. The automatic analysis was complemented with TAW, which allowed the evaluation of some additional criteria. Then, the WAVE extension was used, and the missing criteria were evaluated manually with the help of the JAWS for Windows software.

The information collected during July 2020 was analyzed, emphasizing the 4 accessibility principles: perceivable, operable, understandable,

and robust. In the same way, the analysis of the websites was carried out in compliance with the 3 levels of accessibility: A, AA, and AAA proposed by WCAG 2.1.

RESULTS

Perceptibility principle

The results obtained for the principle of perceptibility are reported in Table 1. It shows that the only university that met criterion 1.1.1: "*content without text*," stipulated in the *Text Alternatives* guideline, was the University of Caldas. Regarding the *time-based Media pattern*, Table 1 illustrates that the Universidad de Caldas met the highest number of compliance criteria, 6 out of 9, followed by the Universidad Industrial de Santander, with 5 criteria met.

Likewise, the Universidad Pontificia Bolivariana and the Universidad de Caldas met 4 of the 6 conformity criteria stipulated for the *Adaptable* guideline. Regarding the *Distinguishable* guideline, the Universidad de Caldas met all the established criteria, while the Universidad Javeriana was the institution with the lowest compliance, with only 5 of the 13 criteria.

Table 1

Criteria fulfilled for the principle of perceptibility

Quartile	University	Guidelines for the principle of Perceptibility (29)			
		Text Alternatives (1)	Time Based Media (9)	Adaptable (6)	Distinguishable (13)
Q1	Universidad Nacional de Colombia - Bogotá	0	0	1	9
	Universidad de Antioquia - Medellín	0	0	2	7
	Universidad del Valle - Cali	0	0	1	7
Q2	Universidad de los Andes - Bogotá	0	4	2	10
	Universidad Javeriana - Bogotá	0	4	1	5
	Universidad Nacional de Colombia - Medellín	0	1	3	7
	Universidad Industrial de Santander - Bucaramanga	0	5	1	6
	Universidad del Norte - Barranquilla	0	2	1	8
	Universidad Pontificia Bolivariana – Medellín	0	3	4	11
	Universidad de Caldas – Manizales	1	6	4	13
	Universidad Tecnológica de Pereira	0	2	3	9

Source: Authorship

Operability principle

Data in Table 2 indicate the university's conformity criteria for each of the 5 guidelines established in the principle of operability. Regarding the *Accessible Keyboard* guideline, the results show that the Universidad Tecnológica de Pereira was the only institution that met all the proposed criteria (4), while the Universidad del Norte did not meet any of them.

Regarding the *Enough Time* pattern, the Universidad de Caldas was the institution that met the highest number of criteria (5 out of 6), while the Universidad de Los Andes did not meet any of them.

Table 2

Criteria met for the principle of operability

Quartile	University	Guidelines for the Principle of Operability (29)				
		Accessible keyboard (4)	Enough time (6)	Seizures and Physical Reactions (3)	Navigable (10)	Entry modalities (6)
Q1	Universidad Nacional de Colombia - Bogotá	2	1	1	4	1
	Universidad de Antioquia - Medellín	2	3	0	3	3
	Universidad del Valle - Cali	1	2	0	4	3
Q2	Universidad de los Andes - Bogotá	1	0	0	3	3
	Universidad Javeriana - Bogotá	2	3	1	5	3
	Universidad Nacional de Colombia - Medellín	1	3	1	6	2
	Universidad Industrial de Santander - Bucaramanga	1	3	0	6	2
	Universidad del Norte - Barranquilla	0	3	1	3	2
	Universidad Pontificia Bolivariana – Medellín	1	4	1	7	4
	Universidad de Caldas – Manizales	3	5	1	7	3
	Universidad Tecnológica de Pereira	4	3	0	3	3

Source: Authorship

Regarding the pattern of *Seizures and Physical Reactions*, in Table 2 it can be seen that the universities: Universidad de Antioquia, Universidad del Valle, Universidad de Los Andes, Universidad Industrial de Santander and Universidad Tecnológica de Pereira, do not comply with any of the 3 criteria proposed for this guideline. However, the remaining universities meet criterion 2.3.3, referring to *Animation from interactions*, since movement animations, triggered by user interactions, are disabled on their web pages.

Regarding the *Navigable* guideline, the Universidad Pontificia Bolivariana and the Universidad de Caldas met the most significant criteria, 7 of the 10 proposed. In addition, in the *Entry Modalities* guideline, the Universidad Pontificia Bolivariana was the one that reached the highest number of fulfilled criteria (4 out of 6), while the Universidad Nacional de Colombia, Bogota, only met 1 of the criteria.

Comprehensibility principle

Results of accessibility analysis for the principle of content comprehensibility, which is found on the websites of the evaluated universities, are reported in Table 3. It is

highlighted that, for the *Readable* guideline, most of the universities complied with 3 of the 6 established criteria. However, the Universidad Nacional de Colombia sede Bogotá, only met 2 criteria, while the Universidad del Valle and the Universidad Industrial de Santander met only 1 of the criteria of the readable guideline.

Regarding the *Predictable* guideline, the Universidad de Caldas was the one that met the highest number of criteria (4 out of 5). Likewise, this same university was the one that obtained a more significant number of criteria (4) before the *Entrance Assistance* guideline, where the number of established success criteria is 6.

Table 3

Criteria met for understandable principle

Quartile	University	Guidelines for the Understandable Principle (17)		
		Readable	Predictable	Entrance Assistance
		(6)	(5)	(6)
Q1	Universidad Nacional de Colombia – Bogotá	2	3	0
	Universidad de Antioquia - Medellín	3	2	0
	Universidad del Valle - Cali	1	3	1
Q2	Universidad de los Andes - Bogotá	3	3	1
	Universidad Javeriana - Bogotá	3	2	3
	Universidad Nacional de Colombia - Medellín	3	3	2
	Universidad Industrial de Santander - Bucaramanga	1	2	1
	Universidad del Norte - Barranquilla	3	3	0
	Universidad Pontificia Bolivariana – Medellín	3	3	2
	Universidad de Caldas – Manizales	3	4	4
	Universidad Tecnológica de Pereira	3	3	2

Source: Authorship

Robustness principle

To identify if the web content is compatible enough to be interpreted by various users while being processed by different assistive technology tools, the 3 criteria proposed for the *Compatible* guideline, which make up the principle of robustness, were analyzed.

The results of the accessibility test made it possible to verify that only 2 of the 11 Colombian universities meet at least one criterion of the compatible guideline. The Universidad Tecnológica de Pereira complied with criterion 4.1.2, referring to *name, role*, and *value* given to form labels, box titles, and other HTML and XHTML markers of websites. The Universidad de Caldas, in addition to meeting criterion 4.1.2, met criterion 4.1.1, which evaluates that: the syntax,

labels, attributes, and IDs are well programmed, regardless of the markup language used.

Conformance levels A, AA, and AAA

Identify levels of conformity in which the websites of the universities studied are found; the analysis was carried out for the levels: A, AA, and AAA. The results are reported in Table 4.

Table 4 shows that the Universidad de Caldas was the institution that met the highest number of criteria at all levels of conformity: 56 of 78, equivalent to 71.79 %, thus: 22 criteria at level A, 17 criteria at level AA, and the same for AAA. In contrast, the Universidad del Valle was the one that obtained the lowest level of success criteria met: 23 of 78, equivalent to 29.48 % since it met 9 criteria for level A and 7 criteria for both level AA for level AAA.

Table 4

Criteria met by conformance levels

University	Levels		
	A (30)	AA (20)	AAA (28)
Universidad de Caldas – Manizales (Q2)	22	17	17
Universidad Pontificia Bolivariana – Medellín (Q2)	14	16	13
Universidad Tecnológica de Pereira (Q2)	15	12	9
Universidad Javeriana – Bogotá (Q2)	13	9	10
Universidad Nacional de Colombia – Medellín (Q2)	10	12	10
Universidad de los Andes – Bogotá (Q2)	13	10	7
Universidad Industrial de Santander – Bucaramanga (Q2)	10	8	10
Universidad del Norte – Barranquilla (Q2)	6	10	10
Universidad de Antioquia – Medellín (Q1)	9	7	9
Universidad Nacional de Colombia – Bogotá (Q1)	8	9	7
Universidad del Valle – Cali (Q1)	9	7	7

Source: Authorship

DISCUSSION

The web accessibility analysis on the 11 Colombian universities, positioned in the first places of the U-Sapiens 2020-1 Ranking, established that only 2 of them exceeded 50 % of the accessibility level under the WCAG 2.1 guidelines. These institutions were: the Universidad de Caldas, which met 71.79 % (56 criteria), and the Universidad Pontificia Bolivariana, with 55.13 % (43 criteria). Because of the above, it can be said that none of the universities have accessible web pages since the levels of compliance (A, AA, and AAA) are only reached by meeting all the criteria associated with each level (18).

Among the most common errors that prevent websites from meeting accessibility criteria for the perceptible principle is that the images and buttons do not have alternative text, which prevents people with low vision or digital assistance tools from recognizing the presented information. Other errors are the absence of a description of pre-recorded audio and videos, the lack of sign language, the loss of information when accessing web content from technological devices with different screen resolutions, the large spaces between the texts, as well as the little contrast that exists between the background and the text.

Regarding the errors presented in the principle of operability, the inability of users to access web content through keyboard shortcuts is highlighted. Likewise, the excess of animations with interactions, which have some images and banners of news or offers, which disorientates the user's navigation process within the website, is notorious. This situation is common on Colombian university websites, such as Durán-Becerra and Tejedor-Calvo (20).

Regarding the existing errors in the principle of understandability, it was identified that several of the universities analyzed do not use the multilanguage function to present the textual information of the web pages in several languages. Likewise, the input error is presented, in which pop-up windows frequently appear to the user without being notified, and the system does not allow the error to be reported or prevented by the user. This situation violates the principles that guide educational institutions toward the so-called smart campuses, characterized by providing their services in an integrated and accessible way for users (21).

In the principle of understandability, it is highlighted that 5 universities did not comply with criterion 3.3.4, referring to the prevention of errors: legal, financial, and data. The absence of the security certificate, also known as Secure Sockets Layer (SSL), makes browsing unsafe and

unreliable (22). The preceding is worrying since computer crimes related to the impersonation of websites are constantly increasing (23).

In the principle of robustness, the code programming error in Web sites was identified. This issue causes users using the keyboard navigation method to be unable to identify first, second, or third-level titles and paragraphs or image descriptions. This error was one of the most recurrent 10 of the 11 universities and is due to the flexibility in HTML programming since some lexical and syntax elements are omitted. Some cause that, although no problem is visually identified on the website, users who access it through digital assistance tools, such as screen readers, cannot navigate correctly (24).

On the other hand, no relationship was found between accessibility to web pages and the ranking of universities in the U-Sapiens 2020-1 ranking. It is reflected in the fact that the Universidad de Caldas, located in Q2, is the institution that meets the most criteria, while the Universidad del Valle, Q1 in the ranking, is the one with the least accessibility.

Another interesting finding is that the two campuses of the National University of Colombia have different levels of accessibility, the one in Medellin being higher. Despite being the same institution, the administration of each branch's website is carried out independently. Similar results have been reported in other investigations, indicating that web accessibility problems are due to the limited permissions granted by web admins to publish content, together with the predefined templates or themes used to design and manage websites (25).

Failure to meet the minimum success criteria for each level of compliance in terms of web accessibility stipulated by the WCAG for the 11 universities analyzed is common in other pages associated with higher education. Examples of this are Colombian journals in the humanities area indexed in the IBN Publindex (18); some national libraries in Latin America (26); the websites of the Chilean Ministry of Education (27); as well as some higher education institutions in Ecuador (28).

CONCLUSIONS

The results presented above made it possible to verify that the websites of the Colombian universities best located in the U-Sapiens Ranking 2020-1 are not fully accessible. Although there are currently regulations that promote web inclusion for all people, regardless of their disability status, website developers do not consider the accessibility requirements that their designs must meet.

It concludes with the need to propose a pedagogical strategy that teaches and motivates designers, programmers, and creators of digital content, to configure and program websites so that they are accessible to any user and assistive technologies. Likewise, it would be important that in the university accreditation process, the accessibility of websites be considered as part of the quality indicators since most of the interaction that users have is managed through them with the institution.

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