Evaluation of the accessibility of the home pages of the web portals of Ecuadorian higher education institutions ranked in Webometrics

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Abstract—The Web is essential for education and e-learning. This situation has been boosted by migration to distance education due to the SARS-CoV-2. However, students with disabilities have been seriously affected because online teaching is very often not accessible. For this reason, this research aims to evaluate the accessibility of the home pages of the web portals of the Ecuadorian higher education institutions ranked in the Webometrics with the Web Content Accessibility Guidelines (WCAG) 2.1 of the World Wide Web Consortium. The results obtained determined that the 65 home pages analyzed of the web portals have accessibility errors. Therefore, we concluded that we should adopt the WCAG in the websites to comply with the Ecuadorian technical regulation RTE INEN 288 "Accessibility for web content."

Keywords—evaluation, universities, WCAG, websites, web accessibility

I. INTRODUCTION

The global lockdown performed to stop the spread of SARS-CoV-2 has led to the closure of educational institutions in most countries as one of the first measures. According to the report published by the United Nations [1], "the COVID-19 pandemic has created the largest disruption of education systems in history, affecting nearly 1.6 billion learners in more than 190 countries and all continents. Closures of schools and other learning spaces have impacted 94 percent of the world's student population, up to 99 percent in low and lower-middle-income countries." Technology has always been necessary for high-level education, regardless of the pandemic. However, the pandemic has exposed weak points in educational planning which will be more accurate to discuss. In addition,

the pandemic has tested whether educational institutions are prepared to deal with online and distance education. Online education involves innovating pedagogically with technology for simulation-based teaching (online lectures, video cases, virtual simulators, webcasting, online chat rooms, and so on) [2].

The SARS-CoV-2 pandemic is a massive challenge for education systems [3]. Although distance education is offered to many students, children, and youth, those living in remote and extremely poor regions cannot have the same learning opportunities without a computer and access to quality Internet [4]. Likewise, students with disabilities have been affected because online teaching is very often not accessible.

Tim Berners-Lee, Director of the World Wide Web Consortium (W3C) and inventor of the World Wide Web [5], states that "the power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect" [6]. In addition, the W3C states [7] that "accessibility is essential for developers and organizations that want to create high-quality websites and web tools, and not exclude people from using their products and services." Today the W3C community is the leading source of information on universal web accessibility. It has published the Web Content Accessibility Guidelines (WCAG) for the design and development of accessible websites [8]. These guidelines have been updated over time with the publication of the first version WCAG 1.0 in 1999 [9], WCAG 2.0 in 2008 [10], WCAG 2.1 in 2018 [11], the draft of WCAG 2.2 in 2020 [12] and the first public working draft of WCAG 3.0 in 2021 [13]. Also, in many countries, WCAG has been adopted in laws and policies for compliance of web accessibility [14].

The new versions of WCAG build on previous versions to provide backward compatibility; for example, WCAG 2.1

includes all the principles, guidelines, and success criteria of WCAG 2.0, including one new guideline and 17 new success criteria [11]. If a website complies with the recommendations of WCAG 2.1, it also complies with WCAG 2.0.

Like other countries [14], Ecuador has adopted the ISO/IEC40500:2012 standard, which is precisely the same as WCAG 2.0 [15]. To monitor mandatory compliance with the standard, the Ecuadorian technical regulation RTE INEN 288 "Accessibility for web content" was created and came into force on August 8, 2016 [16]. In its first transitory provision it establishes that, by August 8, 2018, all Ecuadorian websites that provide public service must be accessible according to WCAG 2.0 with a conformance level A and, in its second transitory provision, that by August 8, 2020, they must be accessible according to WCAG 2.0 with a conformance level AA.

The World Health Organization (WHO), in its 2011 World Disability Report, estimates that "more than a billion people are estimated to live with some form of disability, or about 15 % of the world's population (based on 2010 global population estimates). This estimate is higher than previous World Health Organization estimates, which date from the 1970s and suggested around 10 %" [17, pp. 7]. Therefore, the number of people with disabilities in the world is increasing. According to data published by the National Council on Disabilities in 2018 [18], 5.917 students with disabilities enrolled in Universities and Polytechnic Schools in Ecuador.

Taking into consideration the implications of COVID-19 in education, the WCAG recommendations, the adoption in Ecuador of NTE INEN-ISO/IEC 40500 [19], and students with disabilities enrolled in Universities and Polytechnic Schools in Ecuador, the objective of this research is to evaluate the accessibility of the home pages of the web portals of Ecuadorian higher education institutions (HEI) ranked in the Webometrics[1]. The evaluation is carried out using the automatic evaluation tools AccessMonitor[2], AChecker[3], TAW[4], and WAVE[5].

This paper is divided into the following sections. Section II defines the background of the main concepts needed to understand WCAG, web accessibility evaluation tools, and the Website Accessibility Conformance Evaluation Methodology (WCAG-EM). Section III presents the results of the evaluation. Section IV describes the discussion of this study. Section V presents the conclusions and future work.

II. BACKGROUND

In this section introduces the concepts necessary to understand web accessibility, web accessibility evaluation tools, and the WCAG-EM methodology.

A. Web Content Accessibility Guidelines (WCAG) 2.1

WCAG 2.1 [11] has 4 principles, 13 guidelines, and 78 success criteria. The success criteria have three levels of conformance A, AA, and AAA. In addition, there exist sufficient techniques, advisory techniques, and failures per success criteria. Figure 1 summarizes WCAG 2.1 with the principles, guidelines, success criteria, and conformance levels.
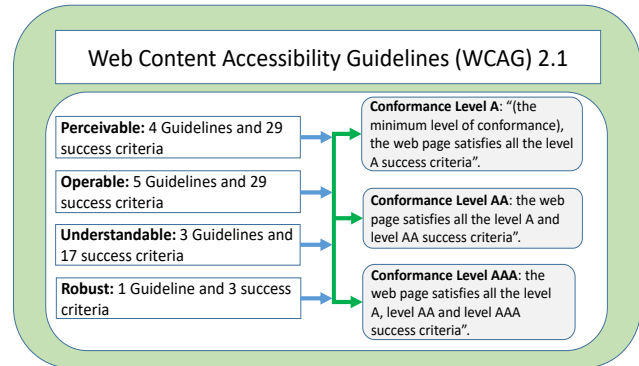

Fig. 1. Principles, guidelines, success criteria, and conformance levels of WCAG 2.1.

B. Web accessibility evaluation tools

The WCAG has been implemented in programs or online services that allow checking web accessibility [20]. These tools can be classified into specific and general [21]. Specific tools evaluate the accessibility of one or more success criteria such as contrast, HTML code, CSS, JavaScript, etc. The available tools consider the WCAG in its principles, guidelines, success criteria with conformance levels A, AA, and AAA. In addition, these tools allow manual evaluations, with experts and end-users in combination with specific web accessibility tools [22]. WebAIM states that "no automated evaluation tool can tell you if your site is accessible, or even compliant. Human testing is always necessary because accessibility is about the human experience" [23]. Therefore, web accessibility evaluation tools do not replace the evaluation performed by a web accessibility expert and should be used as a first step, but not the only one.

C. Website Accessibility Conformance Evaluation Methodology

The WCAG-EM methodology [24], was developed by the W3C/WAI to evaluate websites with WCAG 2.0. However, this methodology is also used to assess WCAG 2.1 because it fully including version 2.0. This methodology guides evaluators in using best practices to prevent common errors and obtain more efficient results. This methodology consists of five steps: 1) Define the evaluation scope; 2) Explore the target website; 3) Select a representative sample; 4) Audit the selected sample, and 5) Report the findings. The interrelationship of the steps can be seen in Figure 2.
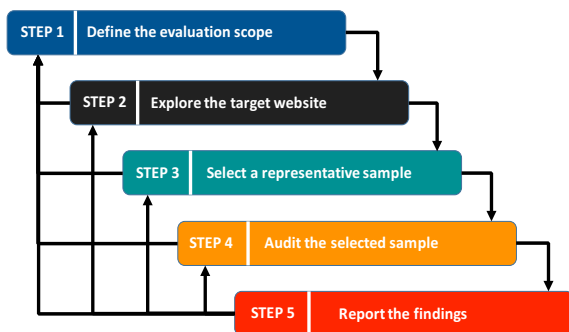
Fig. 2. Evaluation Procedure: WCAG-EM 1.0 [24].

III. RELATED WORK

Related works were searched in the scientific databases Scopus and Web of Science. The search string used was ("web accessibility" AND universit* AND Ecuador). After applying the search string, we found 13 articles in Web of Science and 3 in Scopus. However, of the 16 articles found, only three refer to university websites in Ecuador, which are described below:

1) In 2017 [25], the accessibility of 44 universities in Ecuador located in categories A, B, and C were evaluated. The evaluation was carried out with the automatic tool Examinator. The authors determined that the 44 university websites in Ecuador have an average score of 5 out of 10. Therefore, they concluded that the websites are not accessible.

2) In 2019 [26], the accessibility of the websites of 6 public universities in Ecuador located in category A was evaluated using the WCAG-EM methodology. The evaluation was carried out using the NTE INEN-ISO/IEC 40500 standard in force in Ecuador. The results determined that the six websites of the universities analyzed in Ecuador do not comply with the current standard. Therefore, they concluded that the websites are not accessible.

3) In 2019 [27], a paper evaluated the accessibility of the websites of 55 universities and polytechnic schools in Ecuador. The researchers assessed with the automatic tools Examinator, AccessMonitor, TAW, and TENON. In the results, the authors determined that university websites in Ecuador have accessibility problems. Therefore, they concluded that the websites are not accessible.

Unlike the previous ones, our article's contribution is the evaluation of the accessibility of university websites after compliance with the first transitory of the Ecuadorian technical regulation RTE INEN 288 (Conformance level AA - 08/08/2020). In addition, to evaluate if the websites are accessible in times of pandemic since the classes in the universities of Ecuador are mostly taught virtually.

IV. MATERIALS AND METHODS

The websites of the 65 Ecuadorian HEIs were evaluated using WCAG 2.1 and the conformance levels A, AA, and AAA. It should be noted that when evaluating with WCAG 2.1, version 2.0 is also being evaluated. This was done to check if the Ecuadorian HEIs comply with the latest version of the standard. The evaluation is carried out with automatic evaluation tools. The data from this research are available in our IEEE DataPort[6].

A. Define the evaluation scope

The websites subject of this evaluation are the web portals of the Ecuadorian HEI ranked in the Webometrics. The assessment of HEIs is performed using WCAG 2.1 and conformance levels A, AA, and AAA. Many online tools allow us to perform accessibility evaluation of a web page. However, a single tool is not enough because, in some cases, one tool will detect errors on a web page and the other will not, as each tool has a different way of seeing errors [28]. The web accessibility evaluation tools used for the evaluation are AccessMonitor, AChecker, TAW, and WAVE.

B. Explore the target website

The list of relevant pages selected in this research was the home page of each website, taking into account that users can access the rest of the content of the web portals from this page. In the home pages of the universities, polytechnic schools, and institutes of Ecuador, the forms, images, alternative text, links, among others, were evaluated.

C. Select a representative sample

A total of 60 universities, four polytechnic schools, and one institute were found. The home pages of each web portal of the 65 selected Ecuadorian HEIs were evaluated using automatic tools.

D. Audit the selected sample

The home pages of the web portals of Ecuadorian HEIs are evaluated with automatic online evaluation tools to validate the accessibility of the websites. The evaluation results of the AccessMonitor, AChecker, TAW, and WAVE tools considered in this research are described below:

- AccessMonitor. The detailed report presents the results of acceptable, to view manually, and non acceptable accessibility problems. However, only the non-acceptable accessibility problems are used in this research.
- AChecker. The detailed report presents the results of known, concurrent, and potential accessibility problems. All results obtained are used in this research.
- TAW. The detailed report presents the results of accessibility errors, warnings, and unverified items requiring manual review. However, only accessibility errors are used in this research.
- WAVE. The detailed report presents accessibility errors, contrast errors, alerts, features, structural elements, and

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ARIA. However, only accessibility errors and contrast errors are used in this research.

Table I presents a comparative analysis of the evaluation results. The results are the grouping of the frequency of web accessibility problems found with the evaluation tools. The calculation of the Average errors / page is done by dividing the TOTAL / 65 Ecuadorian HIEs analyzed.

TABLE I
COMPARATIVE ANALYSIS OF THE FREQUENCY OF ACCESSIBILITY
PROBLEMS BY SUCCESS CRITERIA AND CONFORMANCE LEVELS.

N°	SC	CL	AM	Achecker	TAW	WAVE
1	1.1.1	A	35	103	53	121
2	1.2.1	A	6			
3	1.3.1	A	60	91	55	51
4	1.3.2	A	3			
5	1.3.3	A		48		
6	1.4.1	A		51		
7	1.4.3	AA	57	28		59
8	1.4.4	AA	8	47		
9	1.4.5	AA		50		
10	1.4.6	AAA		1		
11	1.4.8	AAA	29			
12	2.1.1	A	15	52		3
13	2.1.3	AAA	8		8	
14	2.2.2	A		1	1	
15	2.3.1	A		51		
16	2.4.1	A	53	50		15
17	2.4.2	A	13	54		
18	2.4.4	A	57	77	55	113
19	2.4.5	AA		51	1	
20	2.4.6	AA	4	83		46
21	2.4.7	AA	7			
22	2.4.9	AAA	57		54	
23	2.4.10	AAA	26		56	
24	3.1.1	A	4	5	13	7
25	3.1.2	AA		4		
26	3.2.1	A	7	5		
27	3.2.2	A	24	7	18	
28	3.2.3	AA		51		
29	3.2.4	AA		54		
30	3.3.1	A		37		
31	3.3.2	A	6	65	35	31
32	3.3.3	AA		38		
33	3.3.4	AA		36		
34	4.1.1	A	57	30	52	
35	4.1.2	A	54		42	8
TOTAL			**590**	**1170**	**443**	**454**
Average errors / page			**9,08**	**18,00**	**6,82**	**6,98**

Abbreviations means: SC=Success criteria, CL=Conformance Level, and AM=AccessMonitor.

The tool that found the highest average number of accessibility issues per website is AChecker. The five success criteria with the biggest accessibility problems are 1.1.1, 2.4.4, 1.3.1, 1.4.3, and 4.1.1.

E. Report the evaluation findings

According to the results obtained, accessibility errors are evident in the 65 home pages of the web portals of the Ecuadorian HEIs analyzed. The report of the results obtained can be seen in Table II.

After the evaluation with the AccessMonitor, AChecker, TAW, and WAVE tools, it was determined that the websites

TABLE II
REPORTING OF ACCESSIBILITY ERRORS FOUND BY PRINCIPLE, SUCCESS
CRITERIA, AND CONFORMANCE LEVELS.

Principles	No.	SC	CL	AE
Perceivable	1	1.1.1	A	78,00
	2	1.2.1	A	6,00
	3	1.3.1	A	64,25
	4	1.3.2	A	3,00
	5	1.3.3	A	48,00
	6	1.4.1	A	51,00
	7	1.4.3	AA	48,00
	8	1.4.4	AA	27,50
	9	1.4.5	AA	50,00
	10	1.4.6	AAA	1,00
	11	1.4.8	AAA	29,00
Operable	12	2.1.1	A	23,33
	13	2.1.3	AAA	8,00
	14	2.2.2	A	1,00
	15	2.3.1	A	51,00
	16	2.4.1	A	39,33
	17	2.4.2	A	33,50
	18	2.4.4	A	75,50
	19	2.4.5	AA	26,00
	20	2.4.6	AA	44,33
	21	2.4.7	AA	7,00
	22	2.4.9	AAA	55,50
	23	2.4.10	AAA	41,00
Understandable	24	3.1.1	A	7,25
	25	3.1.2	AA	4,00
	26	3.2.1	A	6,00
	27	3.2.2	A	16,33
	28	3.2.3	AA	51,00
	29	3.2.4	AA	54,00
	30	3.3.1	A	37,00
	31	3.3.2	A	34,25
	32	3.3.3	AA	38,00
	33	3.3.4	AA	36,00
Robust	34	4.1.1	A	46,33
	35	4.1.2	A	34,67

Abbreviations means: SC=Success criteria, CL=Conformance Level, AE=Average errors.

of Ecuadorian universities present errors in 11 of the 13 guidelines of the WCAG 2.1. Figure 3 shows the average number of errors in the evaluation per guidelines of the WCAG 21.
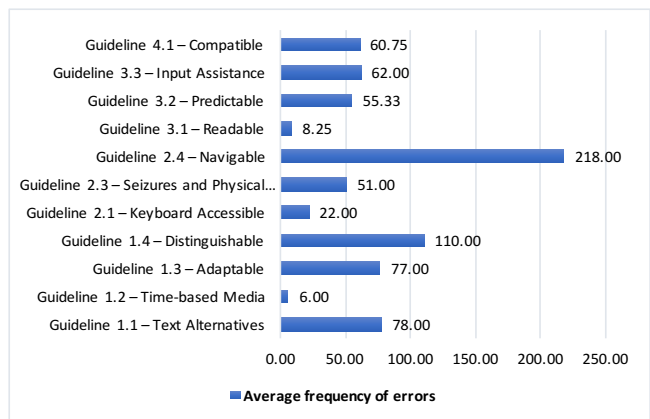

Fig. 3. Average error frequency of Ecuadorian university websites by guideline.

In addition, the results obtained with the automatic evaluation tools show that AChecker has the highest average error frequency of the analyzed data, followed by AcessMonitor, WAVE, and TAW. With the average number of errors found per success criterion, a Pareto diagram was made using the values in the average error column of Table II to graphically present the trend of the percent of errors per success criteria. The results can be seen in Figure 4.

V. Discussion

The results showed that 35% of the evaluation of the average error was Perceivable principle, 34% in the Operable principle, 24% in the Understandable principle, and 7% in the Robust principle. The errors were in 19 success criteria with a conformance level A (54%), 11 with a conformance level AA (32%), and 5 with a conformance level AAA (14%).

The guideline with the highest average number of errors is "Guideline 2.4 Navigable", which should "provide ways to help users navigate, find content and determine where they are." Therefore, this accessibility problem makes it difficult for users to navigate and interact with the contents of the websites analyzed.

In the Pareto diagram (Figure 4) we can identify that the alternative text (1.1.1) is the most repeated accessibility problem in the home pages of Ecuadorian HEIs. This diagram can guide the administrators of the websites of Ecuadorian HEIs to define priorities in the solution.

In addition, it is necessary to understand the errors to solve the accessibility problems encountered in the websites of Ecuadorian higher education institutions. The WCAG 2.1 success criteria have the techniques (sufficient and advisory) and failures detailing the issues faced by success criteria, including resolution examples. The results of the WCAG 2.1 success criteria with techniques (sufficient and advisory) and failures.

Also, the web portals of Ecuadorian HEIs should apply the WCAG 2.1 recommendations and check their compliance with automatic evaluation tools, experts, and end-users. Considering the United Nations Convention on the Rights of Persons with Disabilities [29], which defines access to information and communication, including the Web, as a basic human right.

VI. Limitations of the study

The limitation of this study is the evaluation of university websites only with automatic evaluation tools. For more reliable results should perform manual testing with experts and end-users.

VII. Conclusions

The results determined accessibility errors in the 65 home pages of all the Ecuadorian HEIs web portals in the four principles of WCAG 2.1. In addition, the evaluation results decided that 54% of the errors have a conformance level A. Therefore, the web portals of Ecuadorian HEIs do not comply with the first transitory provision of the Ecuadorian technical regulation RTE INEN 288 "Accessibility for web content"

(Conformance level A - 08/08/2018). Also, the results found that 32% of the errors have a conformance level AA. Therefore, the web portals of Ecuadorian HEIs do not comply with the second transitory of the Ecuadorian technical regulation RTE INEN 288 (Conformance level AA - 08/08/2020). To comply with the Ecuadorian technical regulation RTE INEN 288 "Accessibility for web content0", it is necessary to apply the WCAG in the websites. They consider that to meet a conformance level AA; web portals must meet all success criteria with conformance levels A and AA. Failure to comply with the WCAG violates the rights of people with disabilities to access the web on equal terms with others. In addition, our results indicate that the design and development of websites for educational institutions require the adoption of WCAG to comply with legal provisions and facilitate access for people with disabilities.

The use of the web is becoming more and more essential in the life of every human being. It allows us to perform various activities that we humans used to perform face-to-face. Therefore, websites must comply with web content accessibility guidelines to enable universal access.

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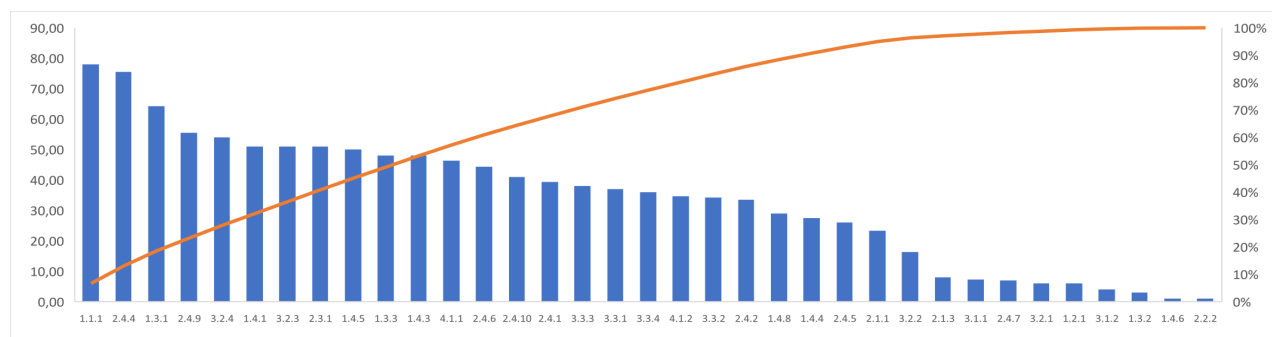
Fig. 4. Pareto diagram of the trend of the average of the most common errors in Ecuadorian HEIs.

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