JCTA Journal of Computing Theories and Applications ISSN:3024-9104

Research Article

Evaluation of University Websites in Nigeria using the Web Content Accessibility Guidelines

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Abstract: Providing accessible open educational resources (OER) is essential for users with impairments to access university resources. To achieve this, web content accessibility guidelines (WCAG) have been developed. In this study, we used the AChecker web accessibility evaluation tool to assess the content of 42 federal university websites in Nigeria and recorded their conformance level to the WCAG. The findings show that at Level A (Minimal Compliance), there were 855 known problems, 55 likely problems, and 7536 potential problems. At Level AA (Acceptable Compliance), 2516 known problems, 58 likely problems, and 15537 potential problems were identified. At Level AAA (Optimal Compliance), 2679 known problems were found, while there were no likely problems, and 16772 potential problems. The results indicated that most websites did not conform to the accessibility guidelines, highlighting the need for educational institutions to comply with WCAG2.1 content standard. The study recommends introducing accessibility training courses in web design and development to ensure effective OER creation for people with diverse abilities. Furthermore, enforcing the implementation of these guidelines by flagging down non-compliant educational websites was suggested. There is a problem of lack of accessibility in federal university websites in Nigeria, leading to unequal access to web content for users with varying abilities. The study aimed to identify aspects of the websites where accessibility needs to be improved and promote diversity and inclusiveness for users with different abilities to have equal access to web content.

Keywords: AChecker; Conformance; Human-computer interaction; WCAG 2.1 standards; Web content accessibility guidelines.

Received: October, 20th 2023
Revised: November, 28th 2023
Accepted: November, 30th 2023
Published: December, 11th 2023

1. Introduction

University websites serve as an interface connecting universities with a diverse audience, facilitating the sharing of essential information with the public. These academic websites serve several key functions, including providing prospective students with insights into the institution, details on available courses, course syllabus, admission requirements, research groups and publications, career counseling services, disability support services, library resources, financial aid opportunities, employment updates, institutional policies, and news updates, among others[1]. The advent of the Internet technology and its recent growth had created the need for people of different abilities to access educational content online. This development in the educational sector had been met with diverse challenges ranging from technical expertise to regular usage. While several educational support services like hostel accommodation registration, school fees payment, checking of examination timetables and results, and many more have now been handled online, the need to encourage inclusiveness and diversity arises. The educational website should be able to serve both staffs and students with different impairments; likewise, it should efficiently serve the general public who visits. It is pertinent to state that the website's efficiency is crucial for every category of its user to accomplish their tasks. The accessibility and usability of educational websites are critical factors that determine their efficiency. Website accessibility remains a widespread issue not only in Nigeria but also

in various regions and sectors across the globe. Common problems include the lack of adherence to WCAG standards, missing text alternatives for non-text items, unclear page names, broken links, unassigned document primary language, contrast violations, and imprecise labels. These issues consistently hinder the accessibility of websites for individuals with disabilities and pose challenges to users in general. These issues consistently hinder the accessibility of websites for individuals with disabilities and pose challenges to users in general. The W3C Website Accessibility Initiative (WAI) described web accessibility as everyone's ability, including people with disabilities, to effectively use websites, tools, or technologies with ease[2]. All disabilities that restrict access to the web are included in web accessibility, such as auditory, cognitive, neurological, physical, speech, and visual impairments. It has also been observed that web accessibility has benefited persons who do not have any disabilities[2]. As part of the solutions to making the web equally accessible to everyone, irrespective of their individual abilities, the W3C WAI developed international standards for web accessibility. One of these standards that would be used in this study is the Web Content Accessibility Guidelines (WCAG).

The WCAG contains rules that have to be met before it can be said that a website complies with the accessibility standards. Over time, there have been improvements to the versions of the WCAG from 1.0 to 2.x (2.0, 2.1, and 2.2), with each new version building up on the previous one for improvement. The current functional version is the WCAG 2.1 [2]. It encompasses a wide range of recommendations for improving the accessibility of web content[3]. It is based on four main guiding principles known as POUR, which stands for perceivable, operable, understandable, and robust. In practice, it was built around a set of 4 guidelines with 29 success criteria addressing the perceivable principle, five guidelines with 29 success criteria addressing the operable principle, three guidelines with 17 success criteria addressing the understandable principle, and 1 guideline with three success criteria addressing the robust principle. This is shown in Table 1 alongside the different conformance levels they address.

The WCAG has 13 guidelines with 78 success criteria addressing different accessibility and usability issues. These exist to meet the varying needs of web audiences/users. In Nigeria, there is a need to test the conformity of educational sites to these guidelines and provide certain recommendations to cater to the needs of everyone who engages with educational websites. Nigeria has 51 federal universities, 59 state universities, and 111 private universities as of December 2022. This study evaluates 42 of the federal universities whose websites were active at the time of the research. Therefore, the study aims to evaluate the accessibility of the federal university websites to ascertain if they meet the WCAG standards. The study would identify common accessibility challenges amongst the websites and recommend solutions.

Table 1. Description of the POUR Principles and the Guidelines of the WCAG2.1.

Category	Guideline	Success Criteria	Conformance Level
Perceivable The user can identify content and interface elements by means of the senses. For many users, this means perceiving a system primarily visually, while for others, perceivability may be a matter of sound or touch.	1.1 – Text Alternatives Provide text alternatives for any non-text content to change it into other forms people need, such as large print, braille, speech, symbols, or simpler language.	1.1.1 Non-text Content	A
	1.2 – Time-based Media Provide alternatives for time-based media.	1.2.1 Audio-only and Video-only (Prerecorded) 1.2.2 Captions (Prerecorded) 1.2.3 Audio Description or Media Alternative (Prerecorded)	A
		1.2.4 Captions (Live) 1.2.5 Audio Description (Prerecorded)	AA
		1.2.6 Sign Language (Prerecorded) 1.2.7 Extended Audio Description (Prerecorded) 1.2.8 Media Alternative (Prerecorded)	AAA

Category	Guideline	Success Criteria	Conformance Level
		1.2.9 Audio-only (Live)	
	1.3 – Adaptable Create content that can be presented differently (for example, a simpler layout) without losing information or structure.	1.3.1 Info and Relationships 1.3.2 Meaningful Sequence 1.3.3 Sensory Characteristics	A
		1.3.4 Orientation 1.3.5 Identify Input Purpose	AA
		1.3.6 Identify Purpose	AAA
	1.4 – Distinguishable Make it easier for users to see and hear content, including separating foreground from background	1.4.1 Use of Color 1.4.2 Audio Control	A
		1.4.3 Contrast (Minimum) 1.4.4 Resize text 1.4.5 Images of Text	AA
		1.4.6 Contrast (Enhanced) 1.4.7 Low or No Background Audio 1.4.8 Visual Presentation 1.4.9 Images of Text (No Exception)	AAA
		1.4.10 Reflow 1.4.11 Non-text Contrast 1.4.12 Text Spacing 1.4.13 Content on Hover or Focus	AA
Operable Users can use controls, buttons, navigation, and other interactive elements successfully. For many users, this means using assistive technology like voice recognition, keyboards, screen readers etc.	2.1 – Keyboard Accessible Make all functionality available from a keyboard.	2.1.1 Keyboard 2.1.2 No Keyboard Trap	A
		2.1.3 Keyboard (No Exception)	AAA
		2.1.4 Character Key Shortcuts	AA
	2.2 – Enough Time Provide users enough time to read and use content.	2.2.1 Timing Adjustable 2.2.2 Pause, Stop, Hide	A
		2.2.3 No Timing 2.2.4 Interruptions 2.2.5 Re-authenticating 2.2.6 Timeouts	AAA
	2.3 – Seizures and Physical Reactions Do not design content in a way that is known to cause seizures or physical reactions.	2.3.1 Three Flashes or Below Threshold	A
		2.3.2 Three Flashes	AAA
		2.3.3 Animation from Interactions	AAA
	2.4 – Navigable Provide ways to help users navigate, find content, and determine where they are	2.4.1 Bypass Blocks 2.4.2 Page Titled 2.4.3 Focus Order 2.4.4 Link Purpose (In Context)	A
		2.4.5 Multiple Ways 2.4.6 Headings and Labels 2.4.7 Focus Visible	AA
		2.4.8 Location 2.4.9 Link Purpose (Link Only) 2.4.10 Section Headings	AAA
	2. 5 – Input Modalities Make it easier for users to operate functionality through various inputs beyond keyboard	2.5.1 Pointer Gestures 2.5.2 Pointer Cancellation 2.5.3 Label in Name 2.5.4 Motion Actuation	A
		2.5.5 Target Size	AAA

Category	Guideline	Success Criteria	Conformance Level
		2.5.6 Concurrent Input Mechanisms	
Understandable Users should be able to comprehend the content, and learn and remember how to use your OER site. Your OER should be consistent in its presentation and format, predictable in its design and usage patterns, and appropriate in its voice and tone to the audience.	3.1 – Readable Make text content readable and understandable.	3.1.1 Language of Page	A
		3.1.2 Language of Parts	AA
		3.1.3 Unusual Words 3.1.4 Abbreviations 3.1.5 Reading Level 3.1.6 Pronunciation	AAA
	3.2 – Predictable Make Web pages appear and operate in predictable ways	3.2.1 On Focus	A
		3.2.2 On Input 3.2.3 Consistent Navigation 3.2.4 Consistent Identification	AA
		3.2.5 Change on Request	AAA
	3.3 – Input Assistance Help users avoid and correct mistakes.	3.3.1 Error Identification 3.3.2 Labels or Instructions	A
		3.3.3 Error Suggestion 3.3.4 Error Prevention (Legal, Financial, Data)	AA
		3.3.5 Help 3.3.6 Error Prevention (All)	AAA
Robust Content must be robust enough to be interpreted reliably by various users, allowing them to choose the technology they use to interact with websites, online documents, multimedia, and other information formats.	4.1 – Compatible Maximize compatibility with current and future user agents, including assistive technologies	4.1.1 Parsing	A
		4.1.2 Name, Role, Value 4.1.3 Status Messages	AA

Table 1 source adapted from https://guides.cuny.edu/accessibility and https://www.w3.org/TR/WCAG21/

2. Literature Review

Yerlikaya and Durdu [4] assessed the accessibility of the websites of twenty (20) randomly selected Turkish public universities based on their university ranking by academic performance using the SortSite testing tool for the automatic assessment. The findings suggest that none of the twenty websites fully adhere to the WCAG 2.0 standards. Some of the most common problems on the websites are lacking text alternatives for non-text items, missing helpful and clear page names, unclear links, unassigned document primary language, contrast violations, or imprecise labels. To ensure that everyone has an equal opportunity to use the websites, they advise web developers to consider accessibility and act practically. In the same vein, [5] reviewed the websites of the best universities in Turkey, Kyrgyzstan, Kazakhstan, and Azerbaijan for accessibility in their research. The accessibility checks were carried out using the AChecker tool. The research found that Turkish university websites are more widely used and that the developers are more concerned with website performance than their counterparts in Azerbaijan, Kyrgyzstan, and Kazakhstan. The university websites performed better in this study when compared to a similar study the researchers conducted with government websites in the same countries despite having the same widespread issues as in previous studies. The research also found that most university websites did not comply with the WCAG 2.0 accessibility guidelines. Only two (2) Kyrgyz and two (2) Kazakh university websites earned level A compliance, and only three (3) received level AAA compliance, one (1) Kyrgyz and two (2) Kazakh. The researcher recommended that the organizations that took part in the evaluation should put more effort into making their websites more user-friendly. Another work involving the Turkish web was done by [6]. He evaluates the accessibility, usability, quality performance, and readability of all Turkish state and private university websites. He reported that only 14 websites out of 179 met the WCAG 2.0 accessibility criteria, achieving conformance Level A through the use of the AChecker.

Agangiba, Nketiah, and Agangiba,[7] highlighted in their study how the use of internet-based sources had improved surprisingly among Higher Education Institutions (HEIs) globally. Although, a few students can be excluded from its benefits because they cannot use general modes to access these websites for students with disabilities and the visually impaired. In this research the authors compared based on the WCAG, the accessibility of a few HEIs' websites in Ghana with the use of the diagnostic automated device. The findings show that most HEIs websites failed to follow the perceivable and operable standards of WCAG. The study recommends growing focus, schooling web builders and users, and growing contextualized web accessibility suggestions as some suggested steps to ensure the mixing of visually impaired college students into the digital society. Another work in the global scene was done by [8]. They performed accessibility, usage performance, and security analysis of prospective student web pages of 330 universities from three continents, namely Europe, North America, and Oceania. For this purpose, university websites were selected based on the Webometrics ranking. The TAW tool was used for the web accessibility analysis in this study. At A-level conformance, accessibility errors were the most common. The results showed that more than 85% of the websites had issues with missing text alternatives, broken links, and broken parsing. A few websites also failed to adhere to page names, and only 75% of the websites had understandable languages on their web pages. The findings demonstrated that websites at North American colleges gave greater consideration to usability and accessibility on web pages for potential students, followed by websites from Oceania and Europe. The authors provide and discuss advice for website administrators and developers on how to address security, usability, and accessibility issues while evenly disseminating information to all stakeholders. Likewise, [9] perform an accessibility analysis of top educational institutions of different countries using WCAG 2.0. The evaluation tools used were the HERA, Test de accessibilidad Web (TAW), and Firefox Accessibility Evaluation Toolbar for manual evaluation. University websites in the United Kingdom, Russia, China, Germany, and India were analyzed. It was reported at the end that most of these institution websites comply with less than 50% of the guidelines. The authors provided recommendations on areas that needed to be improved on the different websites.

In Africa, [10] compared the accessibility of all South African university websites, not simply the most popular ones, as in the earlier analysis of [4]. Similarly, in this study, an accessibility audit of all 26 South African university websites' homepages using the AChecker and TAW tool revealed that none of the websites met all of the WCAG 2.0 accessibility requirements. On average, the websites broke eight (8) requirements, several of which were fundamental Level A standards that all websites ought to adhere to. In addition, each website had broken links, and four of them failed Google's mobile-friendliness tests. The authors advised South African colleges to invest the necessary time and money to make their web pages more accessible. In Nigeria, [11] did a study on evaluating Nigerian university websites using the Alexa Internet Tool Webometric approaches. The top 20 Nigerian university websites were evaluated. Each university's website was searched in the Alexa databank, and pertinent data such as links, pages viewed, speed, bounce percentage, time on site, search percentage, traffic rank, and proportion of Nigerian/foreign users were gathered, tallied, and analyzed using a Microsoft Excel worksheet. According to the findings, one of the universities has the most links, another has the most average pages read by people daily, another has the greatest traffic rating in Nigeria, and another has the highest traffic rank globally. A similar work was done by [12] to analyze the websites of nine federal universities in Nigeria. This analysis involved observing and comparing the ranking metrics utilized in Search Engine Optimization tools. The results showed that the majority of the universities have insufficient high-quality research output available online for webometric ranking. Another researcher [13] investigated the usability of academic websites using automated tools. The study aimed to determine the usability level of federal universities in Nigeria through accessibility evaluation. The automated tools AChecker, HERA, and WARE are used to inspect the conformity of websites with WCAG 1.0 and 2.0 by reporting violations in the form of errors and problems. The results show that all websites were not fully compliant with WCAG due to several accessibility issues.

Deedam [1] evaluated the accessibility and usability of state-owned university websites in Nigeria. They used the SortSite Automated Tool to assess the conformance of 10 randomly selected websites to Web Content Accessibility Guidelines (WCAG) 2.0 and US Federal (Usability.gov) guidelines to determine whether these websites meet the criteria for accessibility

and usability for a wide range of users. The result showed that the websites did not conform to the implementation of WCAG 2.0.

Ismail & Kuppusamy [14] evaluated the usability and accessibility of university websites in different regions of Africa, including Unisia (North Africa), South Africa (Southern Africa), Kenya (East Africa), and Nigeria (West Africa), using automated tools such as WAVE, TAW, Achecker, and a Contrast Colour Checker. The study was evaluated, and the result showed that the University of Nigeria, Nsukka (UNN), located in Nigeria, had the best-performing website with the fewest errors. Carthage University in Tunisia was identified as the best in North Africa, while the University of Nairobi excelled in East Africa. In South Africa, none of the evaluated universities stood out and did not fully meet WCAG 2.0 guidelines.

Ahmi and Mohamad [15] evaluated the web accessibility of 20 such universities using AChecker and WAVE tools, showing a low level of compliance with web accessibility standards failing to meet WCAG 2.0 Level A requirements. The results showed widespread non-compliance, with most websites failing to meet even basic Level A requirements. Common issues included missing text alternatives for non-text content, keyboard accessibility, color contrast, empty links, and empty headings. WAVE analysis gave errors like empty links, missing image alternative text, and empty headings.

Karaim and Inal [16]conducted a usability evaluation of the Management of Scholarships website, a Libyan government website, using Nielsen's heuristics. It identified various usability problems related to factors like system status visibility, user control, and error recovery. The evaluators also categorized the severity of these issues, with over 50% being rated as 'major' or 'catastrophic. The study assessed the accessibility of ten Libyan government websites according to the WCAG 2.0 guidelines using two automated tools, AChecker and TAW. The results showed significant accessibility issues, with none of the websites fully conforming to the standards, making it challenging for citizens, especially those with disabilities, to access government services.

Sulemanu, Ternenge, and Kashimana [17]conducted a study on assessing the availability, accessibility, and utilization of electronic information resources for research by students at the Francis Sulemanu Idachaba Library, University of Agriculture, Makurdi, Benue State, Nigeria. With a population of 7,952 registered student library members, a sample of 381 students was selected using a simple random sampling technique. Data was collected using a checklist on availability and a questionnaire on accessibility and utilization, validated and found reliable. The result showed that various electronic resources, such as e-journals, e-newspapers, and online databases, were available and widely accessible to students, facilitating their research endeavors. However, students encountered challenges like poor internet connectivity and inadequate computers in the library, underscoring the need for infrastructure improvements to enhance the overall usability of these resources.

Barricelli, et al. [18] conducted research to assess the accessibility of Italian public universities' websites in accordance with the Stanca Act, a law designed to ensure accessibility for individuals with disabilities. They analyzed 64 university websites, focusing on known problems (KPs) and likely problems (LPs) related to accessibility. The study showed that none of the websites fully complied with the Stanca Act, primarily due to the strict Requirement 1, which deals with the use of HTML5. When excluding the HTML5-related checks, four websites were found to be compliant.

Alajarmeh [19] evaluated accessibility on public health websites from twenty-five (25) countries. The study combined several testing tools to evaluate 24 websites from the countries. This study also found a pattern similar to results from earlier accessibility studies on websites from various sectors. A detailed examination of the found flaws revealed numerous violations of the fundamental accessibility compliance levels (i.e., WCAG 2.0 Level A). More precisely, a few of the most frequent mistakes involved the absence of alternate descriptive text for UI elements like links and photos. Additionally, the majority of websites showed potential problems with assistive technology compatibility. These results imply that many web developers are probably unaware of the specifics of accessibility standards or that these standards and the accompanying legally required legislation are frequently disregarded when creating websites. The researcher advocated for the urgent need for legal enforcement, public awareness, education, and training on the web accessibility needs of various users. The review of the various literature shows that accessibility evaluation has been conducted on websites from different sectors, and the same problems have been reported for more than a decade. This shows a lack of advancement and adoption of accessibility standards by many websites

to meet the needs of diverse users' abilities. The research is important because it shows that many university websites have problems that make them hard to use for people with disabilities. This is a problem that needs to be addressed because these websites are important for students and staff. Despite many past studies pointing out these problems, they still exist. This research is urgent because it's a big step towards fixing these issues. Using up-to-date guidelines can help ensure that everyone, including people with disabilities, can easily access important educational information online. In this study, we analyzed 42 universities, specifically federal university websites in Nigeria, to determine their compliance with WCAG 2.1 standards. This shows an advancement when compared to previous studies that adhered to the WCAG 2.0 accessibility guidelines and also did not evaluate as many as 42 universities in Nigeria.

3. Methodology

The AChecker was chosen for the evaluation tasks in this study. It is a web accessibility tool that evaluates the content of a website to discover and report the accessibility problems it contains. In each of the 42 websites on our evaluation list, we identified the number of known, likely, and potential problems based on the selected guidelines/success criteria. While the known problems are categorical barriers to accessibility in the webpage, which must be addressed by a redesign, the likely and potential problems impede issues that require human verification and validation. Next, we checked the conformance level of each of the websites to the WCAG in terms of how they meet the success criteria for each guideline. This is reported in three (3) levels. The minimal compliance (Level A) forbids any components that would make the website inaccessible or difficult for disabled users. Acceptable compliance (Level AA) makes the website usable and understandable for all users. And the optimal compliance (Level AAA) creates an ideal experience expectation for all users. The acceesible metrics [20] noted that it is not possible to satisfy all Level AAA success criteria for some web content hence we concentrated on identifying the Levels A and AA known problems for the evaluated websites. Figure 1 shows the phases of the of the methodology.

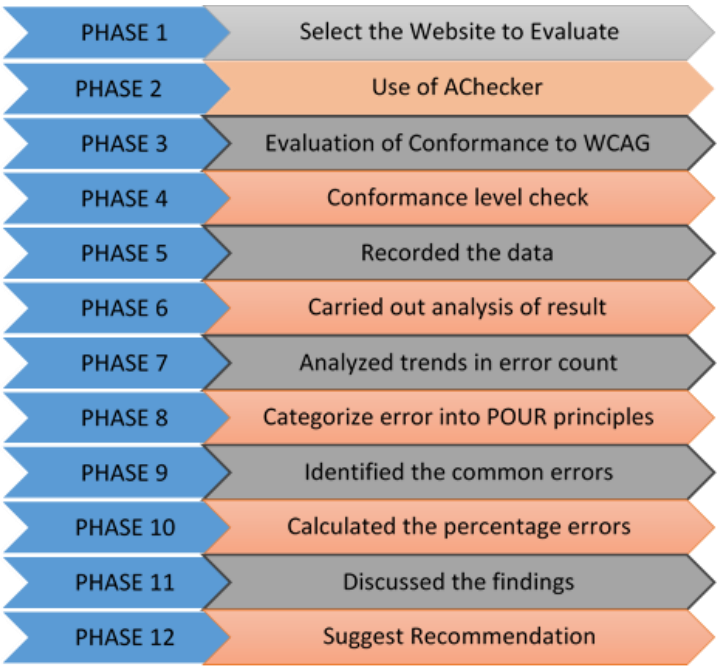

Figure 1. Website Accessibility Conformance Evaluation Methodology (WCAG2.1)

4. Results

The evaluation result for all 42 university websites is shown in Table 2, displaying the known, likely, and potential faults for the WCAG2.1 conformance levels A, AA, and AAA. For privacy reasons, the Universities were coded Univ-01 to Univ-42, while the actual websites are presented in the Appendix in no particular order.

Table 2. Evaluation Results for all WCAG 2.1* Levels: A, AA, and AAA.

University Code	Known Problems			Likely Problems			Potential Problems		
	A	AA	AAA	A	AA	AAA	A	AA	AAA
Univ-01	21	47	47	1	1	96	143	151	159
Univ-02	8	22	27	1	1	219	435	475	491
Univ-03	27	48	48	0	0	188	370	403	409
Univ-04	59	275	278	0	0	154	392	434	443
Univ-05	8	23	23	1	1	69	252	307	312
Univ-06	59	92	92	0	0	205	424	471	477
Univ-07	29	53	53	0	0	264	1249	1289	1296
Univ-08	8	68	68	0	0	411	1138	1155	1163
Univ-09	7	52	52	0	0	77	184	206	212
Univ-10	2	2	2	0	0	0	7	11	16
Univ-11	8	83	83	3	3	251	410	439	445
Univ-12	135	59	60	0	0	284	589	639	644
Univ-13	7	64	64	0	0	124	338	382	387
Univ-14	2	24	24	1	1	186	421	436	441
Univ-15	10	35	35	0	0	168	328	353	359
Univ-16	0	0	0	0	0	0	0	0	0
Univ-17	5	22	22	1	2	80	193	226	231
Univ-18	11	29	30	0	0	102	208	245	251
Univ-19	16	65	65	0	0	303	490	516	531
Univ-20	53	39	41	0	0	236	433	460	467
Univ-21	17	52	59	5	5	154	345	367	379
Univ-22	6	10	10	3	3	175	256	304	311
Univ-23	7	12	12	0	0	93	239	256	262
Univ-24	16	28	59	5	5	171	408	427	432
Univ-25	0	0	0	0	0	0	0	0	0
Univ-26	50	85	86	22	22	420	753	683	761
Univ-27	15	15	15	0	0	133	269	313	320
Univ-28	31	98	98	0	0	204	407	441	447
Univ-29	11	43	43	1	1	163	308	334	340
Univ-30	8	21	21	0	0	225	386	407	430
Univ-31	7	14	14	0	0	59	80	89	94
Univ-32	22	33	33	0	0	209	323	340	348
Univ-33	29	58	58	0	0	213	386	427	432
Univ-34	3	13	13	0	0	151	309	385	390
Univ-35	67	133	133	3	3	149	230	279	292
Univ-36	13	68	68	0	0	667	991	1160	1182
Univ-37	1	454	566	0	0	379	550	573	583
Univ-38	0	0	0	0	0	0	0	0	0
Univ-39	15	125	125	8	8	171	411	445	453
Univ-40	19	45	45	0	0	79	274	304	317
Univ-41	23	64	64	0	2	262	445	459	464
Univ-42	20	43	43	0	0	42	163	181	189
Total	**855**	**2516**	**2679**	**55**	**58**	**7536**	**15537**	**16772**	**17160**
Min	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Max	**135**	**454**	**566**	**22**	**22**	**667**	**1249**	**1289**	**1296**
Average	**20.4**	**59.9**	**68.3**	**1.3**	**1.4**	**179.4**	**379**	**399.3**	**408.6**
Median	**12**	**44**	**46**	**0**	**0**	**169.5**	**345**	**383.5**	**388.5**

* AChecker supports WCAG2.0 as at the time of this report.

As shown in Table 2, out of the 42 university websites evaluated, only three (3) (i.e., Univs-16, 25, and 38) passed the test completely by getting zero errors at all the WCAG 2.1 conformance levels. The remaining websites failed with an average number of known errors of 20.4 at Level A, 59.9 at Level AA, and 68.3 at Level AAA. Figure 2 shows this result. The analysis Table 3 reveals an increase in the number of known errors as the conformance level increases. This implies that it becomes difficult for a website to conform to WCAG2.0 and above guidelines as the conformance level increases. The color-coded likely and potential problems columns are not the focus of this study since they require human verification and validation.

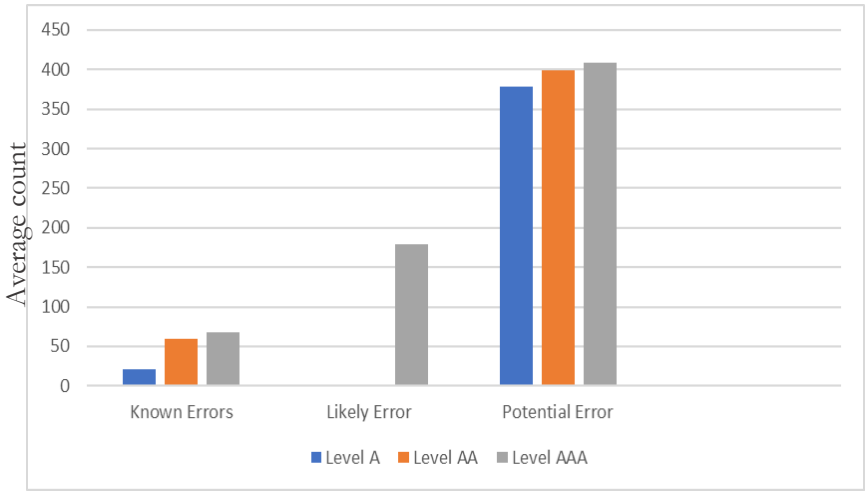

Figure 2. Average Error Results of the Evaluation

Table 3 shows the known errors found at Level A regarding the POUR principles, the failed success criterion, the error's popularity, and the number of affected websites. Amongst the top three most common faults, the category of Perceivable has the highest number of errors. The top five most common errors were: "Anchor contains no text", “Image element missing alternative attribute text”, “Image used as anchor is missing valid Alt text”, “Label text is empty,” and “input element, type of “text” missing an associated label.” The errors encountered are related as they concern missing alternative texts that can assist users in perceiving the website's contents when they use screen readers. For instance, descriptive alternate texts make it easier for users, so it is important for developers of websites not to neglect them when developing a website to reduce accessibility problems and conform to the WCAG2.1 guidelines. This failed success criteria, “Image element missing alternative attribute text” has a high 35.09% error percentage in the result affecting 15 websites. Another high failed success criterion is “Anchor contains no text” in the Operable category, with a 36.73% error percentage affecting 36 websites.

Table 3. A List of All Known Problems at Minimal Conformance (Level A)

Category	Guide line	Failed Success Criteria	Websites affected	Error Frequency	Error percentage
Perceivable	1.1	The image used as an anchor is missing valid Alt text.	23	81	9.47
	1.1	Image elements are missing alternative attribute text.	15	300	35.09
	1.3	The input element, type of “text”, has no text in label.	14	23	2.69
	1.3	Input element, type of “password”, missing an associated label.	2	3	0.35
	1.3	Input element, type of “checkbox”, missing an associated label.	1	1	0.12
	1.3	The input element, type of “password”, has no text in label.	3	4	0.47
	1.3	Select an element missing an associated label.	1	1	0.12

Category	Guide line	Failed Success Criteria	Websites affected	Error Frequency	Error percentage
Operable	1.3	The input element, type of "checkbox", has no text in label.	1	1	0.12
	1.3	Input element, type of "text", missing an associated label.	14	30	3.51
	2.1	The script is not keyboard accessible - onmouseout is missing onblur.	1	5	0.58
	2.1	onmouseover event handler missing onfocus event handler.	1	5	0.58
	2.2	Marquee element used.	2	2	0.23
	2.2	Blink element used.	1	1	0.12
	2.4	Anchor contains no text.	36	314	36.73
Understandable	3.3	The label text is empty.	18	59	6.9
	3.1	The document has an invalid language code.	3	5	0.58
	3.1	Document language not identified.	2	5	0.58
Robust	4.1	The ID attribute is not unique.	15	15	1.75
		TOTAL		855	99.99%

Table 4 shows the known error found at Level AA regarding the POUR principles, the failed success criterion, the error's popularity, and the number of damaged web pages. Four of the top five faults fell into the Perceivable category again. The top five faults were: "i (italic) element used", "the contrast between the color of selected link text and its background is not sufficient", "anchor contains no text", "b (bold) element used" and "the contrast between the color of active link text and its background is not sufficient". While other errors abound in smaller frequencies, the recurrent error at this level emphasizes the typefaces used in the various websites. For example, the error percentage of the "i (italic) element used" returned 39.35%, affecting 34 websites in 990 times. The typeface should be carefully chosen with accessibility in mind, as italicized fonts can be difficult to read.

Table 4. A List of All Known Problems at the Acceptable Conformance (Level AA)

Category	Guide line	Failed Success Criteria	Websites affected	Error Frequency	Error percentage
Perceivable	1.1	The image used as an anchor is missing valid Alt text.	22	65	2.58
	1.1	Image element is missing alternative attribute.	14	76	3.02
	1.3	The input element, "text" type, has no text in the label.	15	26	1.03
	1.3	Input element, type of "password", missing an associated label.	2	3	0.12
	1.3	Input element, type of "checkbox", missing an associated label.	1	1	0.04
	1.3	The input element, type of "password", has no text in label.	3	3	0.12
	1.3	The input element, type of "checkbox", has no text in label.	2	2	0.08
	1.3	A label for the select element is missing.	1	1	0.04
	1.3	Input element, type of "text", missing an associated label.	13	19	0.76
	1.4	The contrast between the colour of the selected link text and its background is not sufficient	1	339	13.47
	1.4	b (bold) element used.	14	150	5.96
	1.4	The contrast between the color of text and its background for the element is not sufficient.	10	227	9.02
	1.4	i (italic) element used	34	990	39.35
Operable	2.1	The script is not keyboard accessible - onmouseout is missing onblur.	1	5	0.2

Category	Guide line	Failed Success Criteria	Websites affected	Error Frequency	Error percentage
	2.1	onmouseover event handler missing onfocus event handler.	1	5	0.2
	2.2	Marquee element used.	2	2	0.08
	2.2	Blink element used.	1	1	0.04
	2.4	Anchor contains no text.	35	317	12.6
	2.4	Header nesting - header following h1 is incorrect.	9	12	0.48
	2.4	Header nesting - header following h3 is incorrect.	5	7	0.28
	2.4	Header nesting - header following h4 is incorrect.	1	1	0.04
	2.4	Header nesting - header following h2 is incorrect.	18	39	1.55
Understandable	3.1	Document language not identified.	2	3	0.12
	3.1	The document has an invalid language code.	3	4	0.16
	3.3	The label text is empty.	16	34	1.35
Robust	4.1	id attribute is not unique.	18	20	0.79
		TOTAL		2516	93.38%

5. Discussion

The review studies cover website accessibility, usability, and compliance with international standards, particularly the WCAG 2.0 guidelines, which assessed the online presence of higher institutions, such as universities in Turkey, Kyrgyzstan, Kazakhstan, Azerbaijan, Ghana, South Africa, and Nigeria as well as top universities in the United Kingdom, Russia, China, Germany, and India. The common problem was the struggle to meet WCAG 2.0 accessibility standards. However, In this study, a different approach was done, which involved evaluating the accessibility of federal university websites in Nigeria based on WCAG 2.1 guidelines. The result showed that most websites did not meet the acceptable WCAG 2.1 conformance levels.

The research conducted in this work evaluates the accessibility of all federal university websites in Nigeria, as opposed to some works that select only a few websites based on popularity, usage, or performance [3],[5]. The results of this study agree with[19] and [10] that many websites do not fully adhere to all accessibility standards. It has, however, shown the weak areas of web developers in Nigeria's education domain. A general observation from the results reveals that the top faults usually fell under the Perceivable category of the POUR principle. This suggests that educational websites should endeavor to create text alternatives for non-text content, provide other options for time-based media, create adaptable content for different structures, and ensure that all content can be seen or heard by users very clearly. Apart from the absence of descriptive alternate texts in most websites, the "Anchor contains no text" in the Operable category is also a high failed success criterion in the Acceptable Conformance level, affecting 35 websites. This shows that the provision of navigation controls is essential to the users operations. As such, developers should provide ways to help users find content and easily determine where they are.

6. Conclusions

In this study, we evaluated the conformity of federal university websites in Nigeria to WCAG2.1 standards. The study aimed to identify aspects of the websites where accessibility needs to be improved and promote diversity and inclusiveness for users with different abilities to have equal access to web content. The results showed that the majority of the evaluated websites did not meet WCAG2.1 acceptable conformance levels, thereby putting many users at a disadvantage. The study highlighted the urgent need for efforts to remove access barriers on the affected websites by exposing the various failures to address the success criteria of the guiding principles. Although most of the examined websites violated all POUR standards, accessibility flaws were primarily related to information perception and operability. These findings suggest that web developers may lack knowledge of accessibility guidelines and often prioritize aesthetics over the needs of diverse users. To address this problem, there is a need to increase awareness and provide proper education and training for developers and

webmasters on making the web more accessible for users of different backgrounds and abilities. This will enhance the creation of a more effective OER for the benefit of all. Furthermore, making and enforcing laws that require educational websites to conform to accessibility standards can ensure equal access for all users.

Author Contributions: Conceptualization: Emeka Ogbuju.; methodology: Emeka Ogbuju; software: Victoria Yemi-Peters; validation: Ihinkalu Olalekan, Emmanuel Ajulo and Yemisi Jaiyeoba; formal analysis: Yemisi Jaiyeoba; investigation: Emeka Ogbuju; resources: Emeka Ogbuju; data curation: Yemisi Jaiyeoba.; writing—original draft preparation: Emeka Ogbuju.; writing—review and editing: All authors; visualization: Yemisi Jaiyeoba.; supervision: Victoria Yemi-Peters and Emmanuel Ajulo.

Funding: This research received no external funding.

Data Availability Statement: The dataset used in this research are available in the Appendix section of this article.

Acknowledgments: We acknowledge the technical laboratory assistance provided by Oyiza Kharimat Usman and her group in the classroom course on Systems Performance Evaluation at the Federal University Lokoja.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix: List of the 42 universities under review

University	Website
Abubakar Tafawa Balewa University, Bauchi	https://atbu.edu.ng
Ahmadu Bello University, Zaria	https://abu.edu.ng
Bayero University, Kano	https://buk.edu.ng
Federal University Gashua, Yobe	https://fugashua.edu.ng
Federal University of Petroleum Resources, Effurun	https://fupreonline.com
Federal University of Technology, Akure	https://futa.edu.ng
Federal University of Technology, Minna	https://futminna.edu.ng
Federal University of Technology, Owerri	https://futo.edu.ng
Federal University, Dutse, Jigawa State	https://fud.edu.ng
Federal University, Dutsin-Ma, Katsina	https://fudutsinma.edu.ng
Federal University, Kashere, Gombe State	https://fukashere.edu.ng
Federal University, Lafia, Nasarawa State	https://fulafia.edu.ng
Federal University, Lokoja, Kogi State	https://fulokoja.edu.ng
Alex Ekwueme University, Ndufu-Alike, Ebonyi State	https://funai.edu.ng
Federal University, Otuoke, Bayelsa	https://fuotuoke.edu.ng
Federal University, Oye-Ekiti, Ekiti State	https://fuoye.edu.ng
Federal University, Wukari, Taraba State	https://fuwukari.edu.ng
Federal University, Birnin Kebbi	https://fubk.edu.ng
Federal University, Gusau Zamfara	https://fugusau.edu.ng
Michael Okpara University of Agricultural Umudike	https://mouau.edu.ng
Modibbo Adama University of Technology, Yola	https://mautech.edu.ng
National Open University of Nigeria, Lagos	https://nou.edu.ng
Nigeria Police Academy Wudil	https://polac.edu.ng
Nigerian Defence Academy Kaduna	https://nda.edu.ng
Nnamdi Azikiwe University, Awka	https://unizik.edu.ng
Obafemi Awolowo University,Ile-Ife	https://oauife.edu.ng
University of Abuja, Gwagwalada	https://uniabuja.edu.ng
Federal University of Agriculture, Abeokuta	https://unaab.edu.ng
University of Agriculture, Makurdi	https://uam.edu.ng

University of Benin	https://uniben.edu.ng
University of Calabar	https://unical.edu.ng
University of Ibadan	https://ui.edu.ng
University of Ilorin	https://unilorin.edu.ng
University of Jos	https://unijos.edu.ng
University of Maiduguri	https://unimaid.edu.ng
University of Nigeria, Nsukka	https://unn.edu.ng
University of Port-Harcourt	https://uniport.edu.ng
University of Uyo	https://uniuyo.edu.ng
Usumanu Danfodiyo University	https://udusok.edu.ng
Nigerian Maritime University Okerenkoko, Delta State	https://nmu.edu.ng
Nigerian Army University Biu	https://naub.edu.ng
Federal University of Health Technology, Otukpo Benue State	https://fuhso.ng

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