An Efficient Evaluation of Web Accessibility for E- Learning websites using Multi-tool for visually challenged users.

Abstract: Nowadays, using a website is practically necessary to communicate information, learn new things, etc. in daily life. Web accessibility gives a wide range of people, regardless of age, language, culture, handicap, nationality, or other factors, access to online information. For scholars and website creators, the topic of websites' worldwide accessibility remains paramount. Numerous studies are conducted to assess the online accessibility of various websites. E-learning websites have become the most significant websites in recent times since they serve as the foundation for the learning process. Since e-learning technology benefits students of all skill levels, it is important to assess the website's accessibility.In recent years, there has been a global surge in the variety of e-learning websites. Laws have been established in numerous nations to ensure that websites adhere to online accessibility guidelines and standards, thereby ensuring that these websites are also accessible to students with disabilities. However, not every website complies with web accessibility standards. This study assesses the online accessibility of nearly all Indian e-learning websites. This study uses accessibility evaluation techniques to provide web accessibility compliance statistics. Using seven industry-standard web accessibility assessment tools—AChecker, WAVE and Cynthia Says, Evalaccess 2.0, Hera 2.1, TAW, and Tenon—we examined 25 e-learning websites for this work. The main finding of this study suggests that there is a lot of room for improvement in terms of web accessibility for many Indian e-learning websites. The outcome suggests that websites should be improved so that everyone can view them.

Keywords: e-Learning, Web accessibility, WCAG 2.0, EvalAccess2.o, Hera2.1, TAW, TENON

1. Introduction

The internet is now accessible to everyone because to the information technology industry's explosive rise in recent years. Nearly half of all people use the internet in their daily lives, according to a July 2017 study (MM Group, 2016). The International Telecommunication Union (ITU) estimated that 3.2 billion people were online by the end of 2015. Out of 3.2 billion users, 62% are from developing nations and 38% are from developed nations.

As the internet grows more and more important in daily life for information exchange, knowledge acquisition, etc., web accessibility becomes a bigger concern for researchers and website creators. Web accessibility gives people of all ages, languages, cultures, disabilities, nationalities, and other characteristics access to online information. According to Burgks et al. (2006), accessibility refers to the standard of websites that ensure effective use, straightforward navigation, and comprehension of their structure without taking into account any physical or other constraints. According to the World Wide Web Consortium (W3C), web accessibility is designed for all users, including those with disabilities and those with a range of abilities, preferences, and needs. It serves users who have slow Internet connections, are older or have limited time, or have restrictions with their devices' screen sizes, browsers, or other technological features (Providenti and Zai, 2007; De Andrés et al. 2010). Web Content Accessibility Guidelines (WCAG) are the successor to the Web Accessibility Initiative (WAI), which was initiated by W3C. For accessibility, all websites must adhere to the WCAG criteria. This recommendation becomes the accepted benchmark for assessing web accessibility (Rømen and Svanaes 2012). The late 1990s saw the emergence of the

WCAG 1.0 standard, which provides guidelines for designing websites that are accessible to a wide range of users. It has 67 checkpoints with three levels of priority for each checkpoint, and 14 regulations. Checkpoints are employed in order to determine WCAG 1.0 conformity. Three priority levels in total are mentioned below.

• Priority 1: In order to make the website accessible, the checkpoints must be completed by the web content.
• Priority 2: removing issues that a particular user group confronts, ensuring that checkpoints are met
• Priority 3: The checkpoints may be met in order to increase the website's accessibility.

The World Wide Web Consortium (W3C), 2008) created WCAG 2.0, an expansion of WCAG that includes a variety of recommendations for website accessibility (Peters and Bradbard, 2010). There are 12 rules total, divided into 4 principles, 61 success measures, 3 levels for each success measure, and 5 conformity requirements.Perceivable, Operable, Understandable, and Robust (POUR) are the four ethics. Similarly, Section 508 of the United States Rehabilitation Act of 1973 tackles several obstacles that individuals with disabilities encounter while attempting to access websites. US federal entities are required by Section 508 to provide equal access to electronic and information technology applications. According to WebAIM (2013), the Act offers sixteen web components for designing and presenting websites that are accessible. Many studies are conducted to assess how accessible certain websites are on the internet.Nowadays, the most significant websites are those run by learning and development companies, since it is through these types of sites that learning takes place. A few of the e-learning resources are Adobe Captivate, Trello, Google Drive, Twitter, Paper.li, and YouTube. Since students of all skill levels can benefit greatly from e-learning technologies, it is important to assess the website's accessibility.

Contribution of the paper:

We looked into 25 e-learning websites for web accessibility in this report. Three common tools for evaluating web accessibility are used: the Checker, WAVE and Cynthia Says, Hera 2.1, TAW, and Tenon tool. In light of the tool's findings, sections 6 and 7, respectively, offer recommendations and a suitable discussion aimed at enhancing these websites' web accessibility.

Formulation of the paper

This is how the rest of the paper is structured. In Section 2, the earlier works on web accessibility are covered. Section 3's Research Questions.Section 4 provides an explanation of the techniques used to assess the websites for online accessibility. The websites are examined and the findings are described in Section 5. In this paper, section 6 is discussed.Section 7 provides recommendations derived from the research. Limitations and feature work based on study are covered in section 8. Section 9 concludes the paper.

2. Related Work

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Given the importance of web accessibility, numerous studies have been conducted in a variety of settings, including government sectors (Serra et al. 2015; Kamoun and Basel Almourad, 2014; Baowaly and Bhuiyan, 2012), hotels and restaurants (Williams and Rattray,

2005), and libraries (Comeaux and Schmetzke, 2007). Several studies have documented that higher education institutions are accessible on the internet. Using the HERA and WAVE technologies, (Adepoju and Shehu, 2014) generated a significant amount of content that complied with accessibility criteria for 36 federal university websites in Nigeria. Similarly, Chacon-Medina et al. (2013) analyzed 74 university websites in Spain and discovered that they complied with accessibility standards to varying degrees, ranging from low to medium. Using WCAG 2.0, (Laitano, 2015) examines public university websites in Argentina. The findings point to several serious problems with the majority of the websites, particularly with syntax, presentation, and text readability. According to a study (Shawar, 2015) on a few Middle Eastern and English higher education institutions, the accessibility level is higher than that of websites in developing nations. As stated by Rashid et al. (2014), websites are demonstrating significant progress in terms of accessibility, even though e-government practices are being improved in Malaysia. Aziz et al. (2010) conducted an investigation of 120 websites belonging to higher education institutions, which revealed many issues with accessibility and usability. Next, using three automated assessment techniques, a study on the websites of Malaysian public higher education institutions reveals a modest improvement in web accessibility over a two-year period (Abuaddous and Basir, 2013). Conversely, (Latif and Masrek, 2010) gathered multiple perspectives on web accessibility through their analysis of the state of e-government websites.The outcome shows that not a single website satisfies the lowest level of accessibility compliance (Priority 1). According to (Bavani, 2014), photos, hyperlinks, and page layouts on websites do not meet the needs of visually impaired individuals when it comes to accessibility from the perspective of people with disabilities. The authors of (Li et al. 2016) examined the current state of thirty-two Chinese government websites and gathered multiple perspectives on web accessibility. The outcome indicates that the majority of websites require development in order to become accessible. (Hayfa et al. 2016) carried out a survey that offers comments and solutions to get rid of the problems with web accessibility, along with some recommendations. Furthermore, they emphasized how important it is to adequately train web developers to take accessibility issues into account while they are programming. The websites of Jordanian Universities are examined in (Kamal et al. 2016); the study is conducted by combining several web accessibility metrics from multiple accessibility tools. According to the study, while utilizing different accessibility tools to evaluate websites, there were modifications made to web accessibility guidelines. In 2016, two automated techniques are used to assess the accessibility of Indian university homepages based on WCAG criteria (Ismail and Kuppusamy, 2016). The findings demonstrated the crucial rules that must be adhered to in order to increase a website's accessibility. Leporini and Paternò (2008) presented a list of fifteen selected criteria aimed at improving the usability of websites from both a quantitative and qualitative standpoint. It reduces navigation time by 37%, and 15 design principles make webpages more easily readable for people with visual impairments.According to several research (Hackett et al. 2004; Yu and Parmanto, 2011), accessing government websites is easier than that of commercial websites. A lengthy analysis conducted by the authors in (Hanson and Richards, 2013) over a 14-year period from 1999 to 2012 revealed that government websites had significantly improved with the fewest accessibility breaches. The Kyrgyz Republic's government websites are now in poor condition, thus the authors of (Ismailova, 2017; Ismailova and Kimsanova, 2017) studied this and came to several conclusions about web accessibility.According to the results, the majority of websites achieve a lower usability

mistake rate than accessibility; nevertheless, these websites also have lower security. Table 1 presents a comparison of earlier studies assessing the web accessibility of different colleges. A comparative analysis is conducted based on multiple factors, including readability test values, total error count, known, likely, and potential errors, number of institutions, applied standards, evaluation tools, and zero errors.

3.Research Questions

The primary goal of this e-learning is the accessibility evaluation of learning corporate websites for all users. Based on the fundamental idea that something must first be measured in order to be developed, this learning is grounded. This research presents the web accessibility component of learning corporate websites.

The following is a list of the study's overall research objectives:

1. To ascertain the current state of e-learning site accessibility using various accessibility assessment methods.
2. To divide these e-learning homepages into three categories according to the degrees (A, AA, and AAAA) at which they comply with accessibility requirements.
3. To identify the common web accessibility issues among e-learning portals.
4. To offer several approaches to address accessibility issues.
5. To offer suggestions on how to improve website accessibility in light of WCAG 2.0
6. Comparison of multiple tool accessibility.

4. Web Accessibility Tools for Data Collection and Analysis

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The websites of the top 25 e-learning and development companies were collected from the internet between September and November of 2017. Using five widely used web accessibility evaluation tools—EvalAccess2.0, TAW, Tenon, Run FAE, and Hera—the subsections investigate the accessibility results of the 100 websites stated above. Five evaluation tools examine the homepages of the websites to identify problems and produce a report in accordance with WCAG 1.0, WCAG 2.0, and Section 508 guidelines. The five assessment instruments are Run FAE, TAW, Tenon, Hera, and EvalAccess 2.0. These tools evaluate websites by simply sending the website's URL to the assessment tools' main page. Finding the total number of values in equation (1) that are displayed below

$$\sum_{i=0}^{N} x_i \text{ or } \sum_{i=0}^{N} f_i x_i \quad (1)$$

where xi denotes the total number values added together. to determine the Average value in equation (2), as seen below.

$$\frac{\sum_{i=1}^{N} f_i x_i}{\sum f_i} \text{ or } \frac{\sum_{i=1}^{N} x_i}{N} \quad (2)$$

where xi denotes the total number sum and the total number. To determine the standard deviation value indicated in equation (3) below

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(x_i - \overline{x}\right)^2} \text{ or } \sqrt{\frac{1}{N}\sum_{i=1}^{n}(x_i-\mu)^2} \quad (3)$$

Where $\mu = \frac{1}{N}\sum_{i=1}^{N} x_i$, N=total number of frequency, x_i means total observations.

Variances are the squared variations from the mean averaged together.

4.1. Accessibility Checker (a Checker) Tool:

A Checker is used to provide the URL of a webpage and upload the HTML source code of the page in order to examine the HTML content and check for accessibility issues.
Table 1: List of e-Learning Websites, including URLs and Names.

E-learning websites.	Name of E-learning tools
https://trello.com/	Trello
https://www.google.com/	Google Drive
https://ifttt.com/	IFTTT
https://accounts.google.com	Momentum
https://www.tableau.com/	Tableau
https://www.elucidat.com/	Elucidat
https://chrome.google.com/	Google Calendar
http://storify.com/	Storify
https://articulate.com/	Articulate Storyline
https://www.youtube.com/	YouTube
http://www.ispringsolutions.com/	iSpring Pro
https://products.office.com/	Microsoft Office Suit
http://www.adobe.com	Adobe Captivate
https://www.google.com/	Google Docs
https://www.reddit.com/	Reddit
https://www.surveymonkey.com/	SurveyMonkey
https://www.quora.com/	Quora
http://www.scoop.it/	Scoop.it
https://www.apple.com	Podcasts
https://www.linkedin.com/	LinkedIn
https://twitter.com/	Twitter
https://slack.com/	Slack
https://www.tinyletter.com/	Tiny Lette
http://paper.li/com	Paper.li
https://www.techsmith.com/	camtasia/techsmith

Fig. 1 displays a screenshot of the webpage for the aChecker utility. The purpose of the AChecker tool is to determine which online material is suitable for all users by testing for compliance with accessibility standards. Numerous methods are available for examining the webpages. Priority 1, Priority 2, and Priority 3 were the three priority levels we used for this study in order to assess accessibility in accordance with WCAG 1.0 principles.Priorities 1, 2, and 3 were the three priority levels we used for this study in order to assess accessibility in accordance with WCAG 1.0 principles.In addition, three levels—Level 1, Level 2, and Level 3—are utilized to assess accessibility in accordance with WCAG 2.0 principles. In accordance with Section 508 requirements, online pages are also assessed using a Checker. Websites are first tested using automatic assessment methods, and then they are manually tested. AChecker produces the result by applying the selected guidelines from Section 508,

WCAG 2.0, and WCAG 1.0. It is employed to identify known, likely, and potential concerns, in that order.

• Known problems: These are impediments to accessibility that need to be removed.
• Likely problems: Although changing the pages and resolving the issues requires manual labor, this is seen as a likely obstacle.
• Possible problems: AChecker does not recognize them, hence a manual judgment is required.

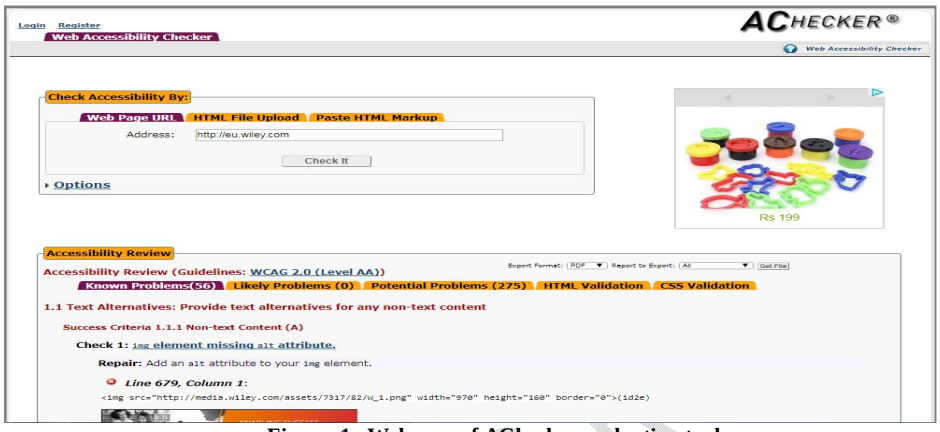

Figure 1. Webpage of AChecker evaluation tool

4.2. Web Accessibility Versatile Evaluator (WAVE):

A screenshot of the webpage for the Checker tool is seen in Fig 2.By including icons and indicators on the page, WAVE is an automatic assessment tool that is used to check if the content of a website is accessible. The full inquiry procedure is carried out within the computer browser. Fig. 2 displays a screenshot of the WAVE utility webpage. Web developers can create a more accessible website with great assistance from the WAVE results. Three categories of accessibility information are provided: Contrast, Non-Styles, and Styles.The WAVE tool is simple to use; all you have to do is launch it and enter the URL of the website that has to be assessed. The result will be generated with embedded indicators and icons after you click the form's submit button. The web page has the following errors, which are detailed below, according to the WAVE tool.

- Errors
- Alerts
- Features
- Structural Elements
- HTML5 and ARIA
- Contrast Errors

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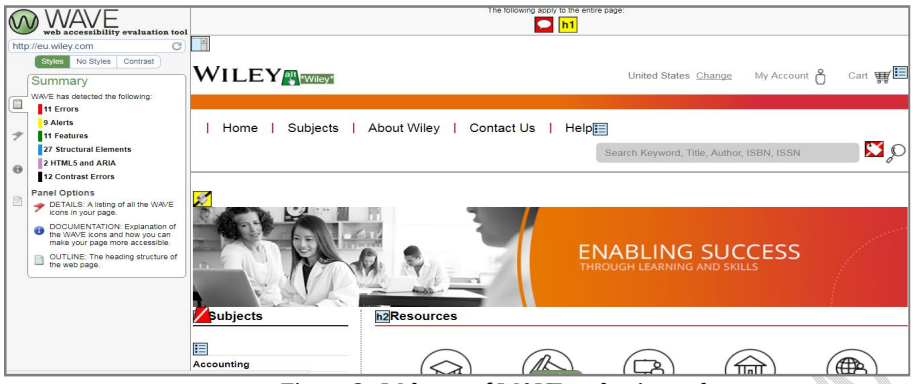

Figure 2. Webpage of WAVE evaluation tool

4.3. Cynthia Says evaluation tool:

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Fig3. displays a screenshot of the Cynthia says tool webpage.Another crucial assessment tool used in this work to verify web accessibility is Cynthia Says. It explains to users the principles underlying website accessibility and is intended for private, noncommercial use informing the public about appropriate website design and content. The main benefit of this technology is that it makes it simpler and easier to comprehend the websites' analysis reports, which are used to determine whether users are permitted to access certain pages or the entire website. First, the tool's webpage is loaded with the URL of the website that needs to be assessed. Every webpage on the website is scanned by the Cynthia Says tool to see if it complies with accessibility requirements.

Figure 3. Webpage of Cynthia Says evaluation tool.

i. Web Page URL: You must provide the website's whole URL. The input is a valid http:// or https:// URL. In the event that http:// is not inputted, it will be added right away. Furthermore mentioned is the fact that the entered URL shouldn't lead to another URL.

ii. Compliance Mode: The user can choose from four compliance mode options offered by the Cynthia Says tool. The following is a list of available Compliance Modes. Tables 5 and 6 contain tabulations of the Section 508 WCAG checklists (A, AA, and AAA), respectively.

a. Section 508
b. WCAG 2.0 A
c. WCAG 2.0 AA
d. WCAG 2.0 AAA

4.4. EvalAccess2.0 :

The University of the Basque in Spain presents EvalAccess2.0. In order to comply with Section 508 and WCAG 1.0, it accesses both the single pages and the entire website. Multiple webpage evaluations are offered on a subscription basis. Three methods are available for evaluating the web accessibility:

• Examining a URL: To evaluate a webpage, input its URL.
• Assessing HTML Markup: By applying the HTML source code, the HTML source code can be evaluated.
• Evaluating a complete website: the entire website can be readily evaluated.

It generates the report in a simpler format and doesn't require any additional installation steps once the input URL is provided. Fig. 4 shows a screenshot of the EvalAccess2.0 utility webpage.You can use this tool by giving the URL of the website that needs to be tested. When the form's assess button is clicked, a report with embedded icons and indications will be generated. This tool displays the website's faults and warnings according to the three priorities P1, P2, and P3.

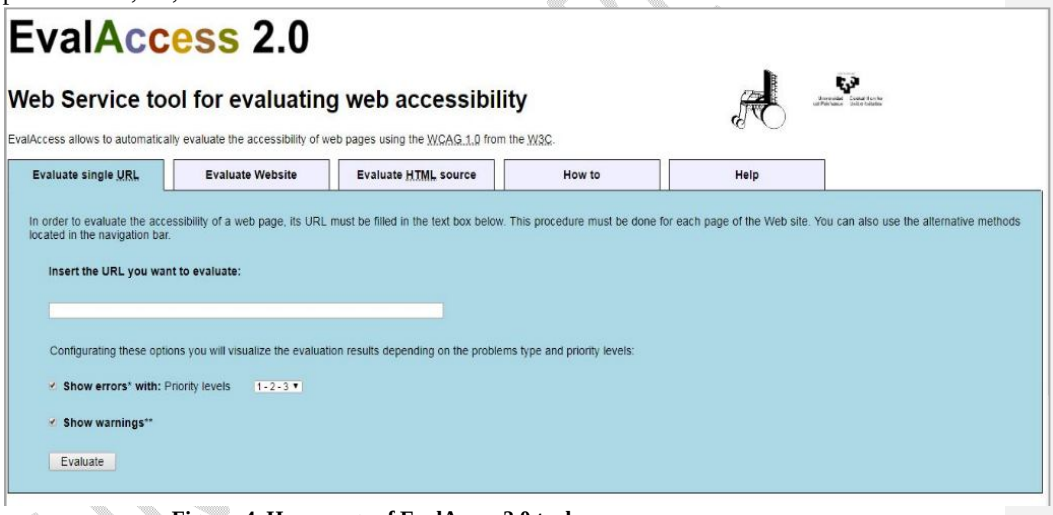

Figure 4. Home page of EvalAccess2.0 tool

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4.5. TAW

CTIC Centro Technologic developed TAW, an accessibility testing tool that evaluates a website's usability in accordance with WCAG 1.0 and 2.0. TAW provides several tools for TAW3 Analysis Engine, including TAW3 Standalone for Desktop, TAW3 Web Start for Java-based software, and TAW3. The website's URL needs to be tested in order to use this tool. Upon selecting the "Analyze" button on the form, a report detailing the issues, cautions, and lack of evaluation in terms of observable, functional, comprehensible, and resilient aspects will be produced. Fig. 5 displays a screenshot of the TAW tool webpage.

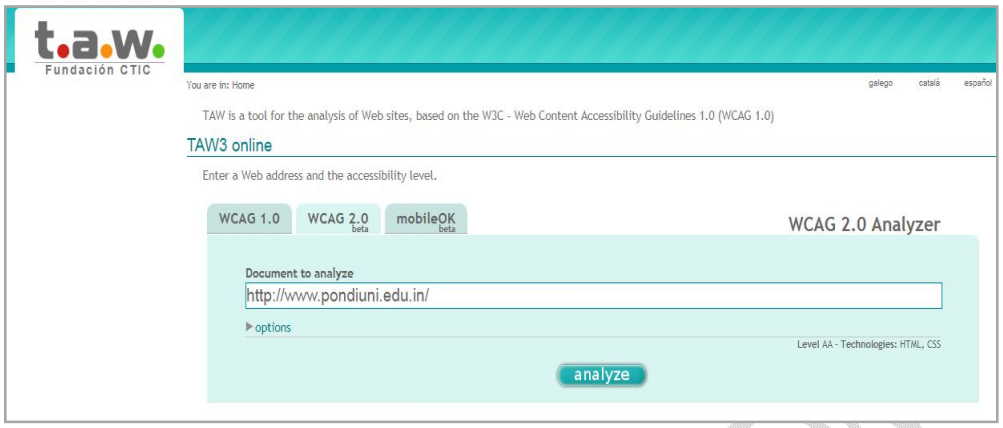

Figure 5. Home page of TAW tool

4.6. TENON:

WCAG 2.0 and Section 508 compliance is evaluated on websites using Tenon, an assessment tool. The unit testing, acceptance testing, system testing, and issue tracking tools can be seamlessly integrated with the use of APIs. For the accessibility issues outlined, Tenon APIs are available at the moment.
The checkout screen's TEN-850 State/Province field is labelless.
Ten-Seven-26 On the other hand, results charts lack organization and are unclear.
Tentative ENS-1861 There's no good substitute for the charts on Dashboard.
Ten-1862 Keyboard trap when attempting to exit the Dashboard's "Test Now" section by shifting and tab .
Ten-1860 The "My Account Menu" has no discernible purpose.
The test results are finally produced by Tenon API in JSON String format, and they comprise a Result Set node that contains a variety of difficulties. Figure 6 displays an image of the Tenon tool webpage.

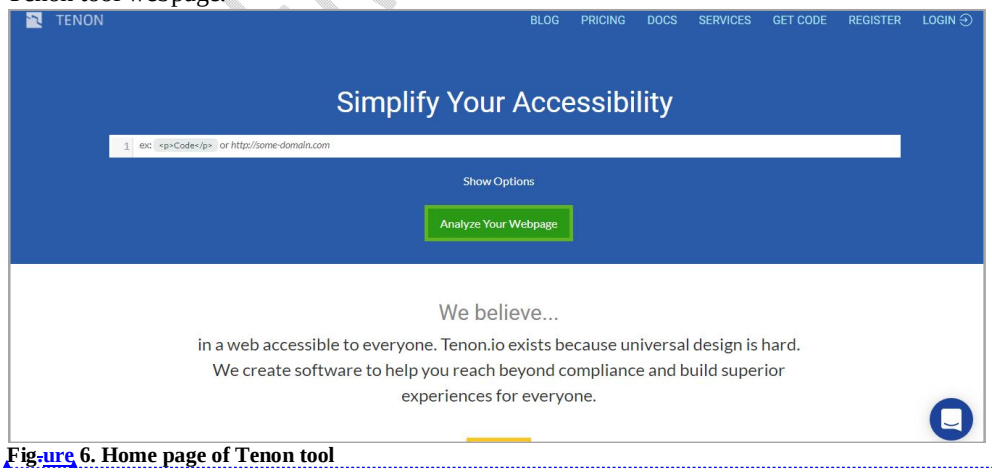

Figure 6. Home page of Tenon tool

4.7. Hera 2.1:

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Web pages are tested for accessibility using Hera according to WCAG 1.0 guidelines. It runs some checks on the page and detects bugs or checkpoints; checkpoints need more human review. To determine whether a page is accessible, human intervention is required.Hera 2.1 facilitates manual revision by outlining the sections of the page that need to be tested, providing guidance on how to carry out the validation, and offering two views of the page with the important components marked with colors and icons for easy verification. The report can also be created in PDF, RDF / EARL, and XHTML forms for printing or saving. Fig. 7 displays a screenshot of the Hera 2.1 tool homepage.The website's URL needs to be tested in order to use this tool. When the form's click button is pressed, a report detailing the number of pass, fail, and unavailable items for each of the three priorities—P1, P2, and P3—will be generated.

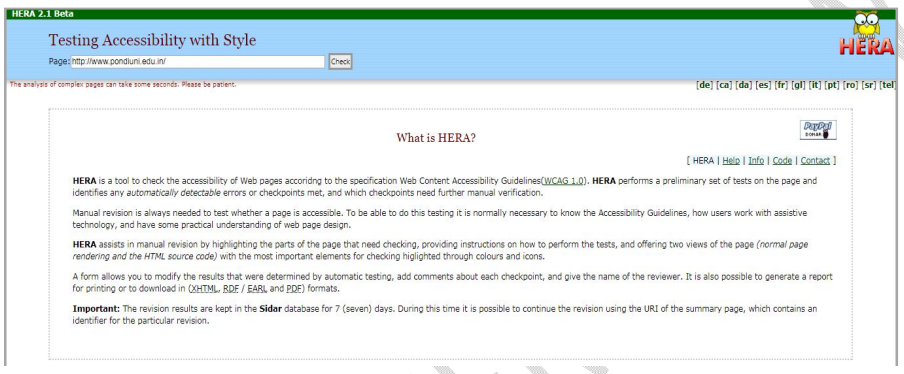

Fig. 7. Home page of Hera tool

5. Experiential Results

The websites of the top 25 learning and development companies were collected from the internet between September and November of 2017. Using five widely used web accessibility evaluation tools—EvalAccess2.0, TAW, Tenon, Run FAE, and Hera—this section examines the accessibility results of the 100 websites that were previously listed. Five evaluation tools examine the homepages of the websites in order to identify problems and produce a report in accordance with WCAG 1.0, WCAG 2.0, and Section 508 criteria. The parts that follow provide an explanation of the 25 websites' results. Table 2-20 presents the tabulated statistical findings for each instrument. Table 22 provides a Comparison Report of multi-tool works on the evaluation process of e-learning websites with parameters.

5.1. Web accessibility results using Cynthia Says:

The accessibility ratings of 25 websites that were assessed using Cynthia Says' assessment technique are provided in this section. The websites are examined using three levels of conformance in accordance with WCAG 2.0 recommendations. The table below shows the overall number of mistakes for each of the four sets of learning and development websites for each of the three conformance levels. Table 2 tabulates the statistical findings of the inaccuracies identified by the Cynthia Says tool. Together with the standard deviation and average, it displays the overall number of errors. Figs. 8 compare the overall number of faults found by the Cynthia Says tool across three degrees of conformity for 25 websites.Table 2

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presents the statistical findings from the Cynthia Says tool, including the total number of errors for 25 websites under each of the three conformance categories (A, AA, and AAA). According to Table 2, there are 87 errors overall for Conformance Level A, with an average of 3.78 and a mean of 1.65, respectively. Similarly, at conformance level AA, there are 74 total mistakes, with a mean value of 0.59 and an average of 3.21.

Table 2. Cynthia Says tool report all issues on top 25 e-Learning tool Website

	ALL ISSUES			
CYNTHIASAYS	LEVEL-A	LEVEL-AA	LEVEL-AAA	TOTAL
Total	87	74	108	269
Average	3.78	3.21	4.69	11.69
Stdev	1.65	0.59	1.71	2.85

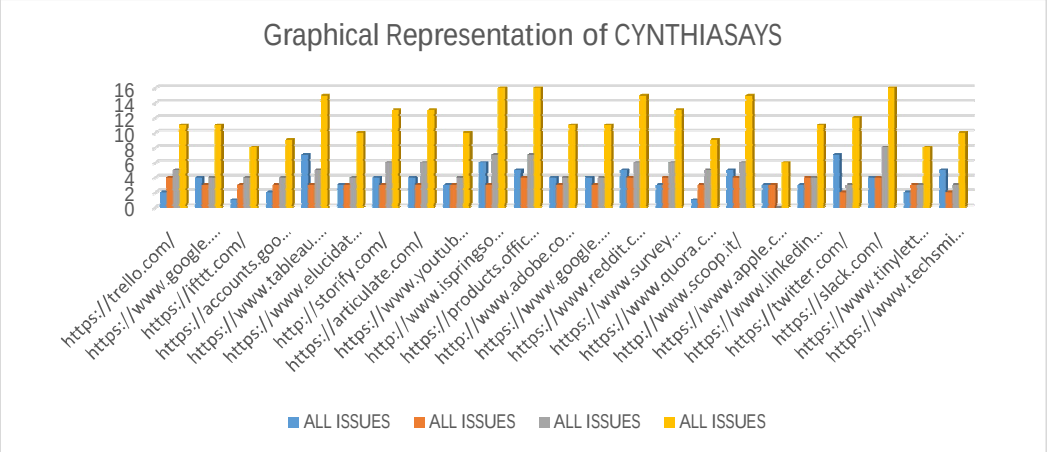

Figure 8.Cynthia Says Tool: Graphical Representation of e-Learning Websites.

5.2. Performance analysis using Hera:

The accessibility results of 25 websites that Hera has validated are explained in this subsection. Figs. 3 compare the findings obtained for 4 groups of websites in terms of needs checking, pass, and fail. Table 3 presents the statistical outcomes of the Hera tool, including the total number of pages that require verification, as well as pass, fail, and not available statuses for each of the three priority (P1, P2, and P3). The P2 value of 1468, mean of 16.87, and standard deviation of 2.48 represents the maximum number of pages that require verification. With a value of 225, a mean of 2.58, and an SD of 1.176, P2 displays the maximum pass value. The maximum fail value, which is 283, has a mean of 4.453 and a standard deviation of 1.642 at P2, in a similar manner. According to this, P2 has the highest pass value, which is 102 with a mean of 4.25 and a standard deviation of 1.87. P1 displays the highest N/A value of 199, mean 8.29, and standard deviation of 1.04, respectively.

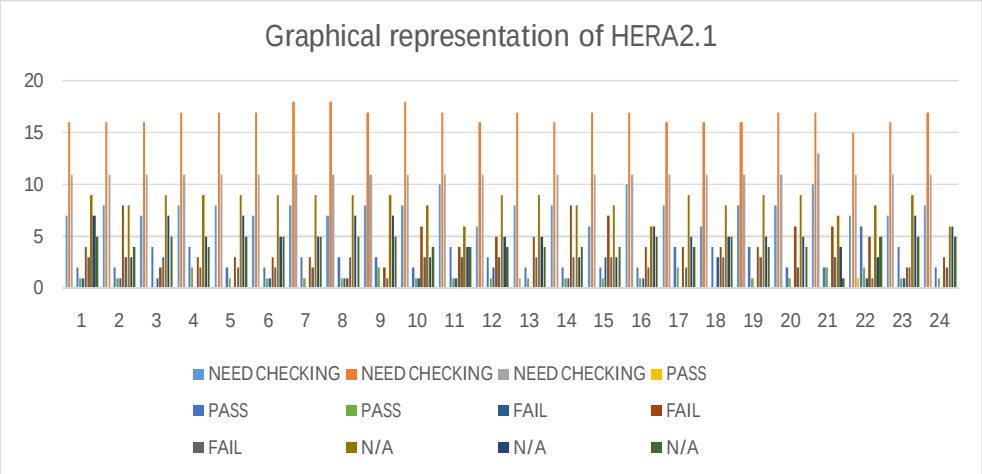

Figure 9. Graphical Representation of e-Learning Websites using HERA 2.1 Tool.

Table 3.Hera2.1 tool report on top 25 e-Learning Websites.

	NEED CHECKING			PASS			FAIL			N/A		
HERA2.1	P1	P2	P3	P1	P2	P3	P1	P2	P3	p1	P2	P3
Total	186	400	256	1	70	27	19	102	59	199	122	105
Average	7.75	16.66	10.66	1	2.91	1.22	1.35	4.25	2.45	8.29	5.08	4.37
Stdev	1.11	0.76	2.09	0	1.10	0.42	0.74	1.87	0.65	1.04	1.44	0.87

5.3. Web accessibility results using a Checker under WCAG 2.0:

The accessibility findings of 100 websites that AChecker examined are provided in this section. The websites are examined using three levels of conformance in accordance with WCAG 2.0 recommendations. The total number of mistakes for 25 e-learning websites across three conformance levels is displayed in Table 4-11. Tables 4, 6, and 8 present the statistical findings of the A Checker tool, indicating the overall number of mistakes under the three compliance levels (A, AA, and AAA) for the WCAG 2.0 recommendations. At level A, there was a maximum potential error of 7383 across 25 websites, with an average and mean value of 307.63 and 238.15, respectively. The highest number of errors for level AA was found on 25 websites, with a value of 8029, and an average and mean of 334.54 and 266.45, respectively. The maximum number of errors for level AAA were found on 25 websites, with a value of 8338; the average and mean values were 347.41 and 278.37, respectively. Figs. 10–13, in that order, compare the overall amount of errors for 25 websites under the three conformance levels, including known problems, likely errors, and prospective errors. The total number of known errors for conformance level A is 264, as indicated by table 4, with an average and mean value of 11 and 11.2 4, respectively. The average value and standard deviation value are 0.62 and 0.87, respectively, and there are a total of 15 possible errors. Similarly, 394 known errors for conformance level AA have an average and mean value of 15.53 and 16.41, respectively.There are 25 possible mistakes in total, with an average value of 1.04 and 1.975. Comparably, 466 known errors for conformance level AAA have an average and mean value of 19.41 and 19.44, respectively. There are 41 possible errors in total, with an average value of 1.708 and 4.44. The Common Error Report summary for the e-

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Learning home page under WCAG2.0 is displayed in Tables 5, 7, and 9 by a Checker (Level-A, AA, and AAA).The entire Common mistake Report summary for the e-learning home page under WCAG2.0 by a Checker (Level-A, AA, and AAA) is displayed in Tables 10 and 11.

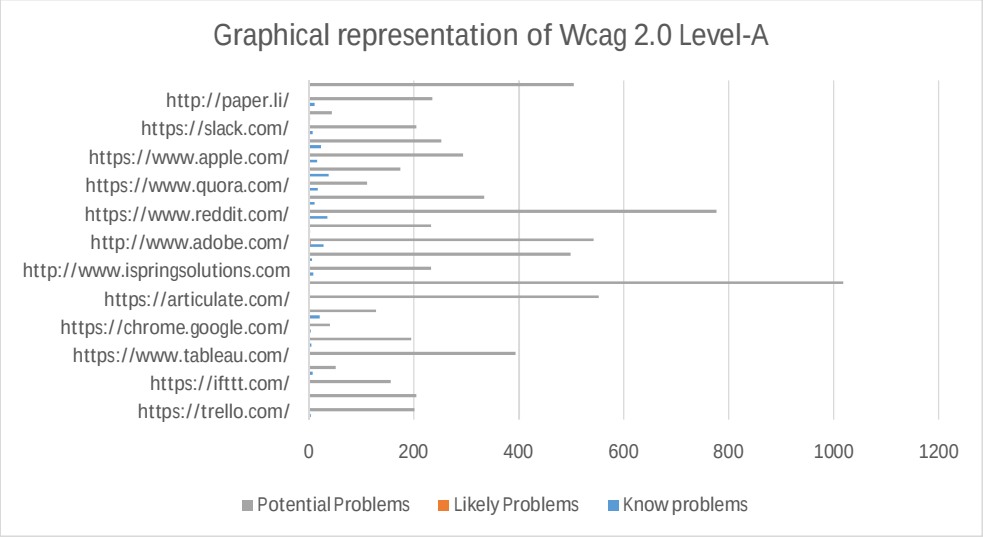

Figure 10.Comparison of total number of errors under WCAG 2.0 by a Checker e-Learning websites

Table 4.Report summary corresponding to e-Learning home page under WCAG2.0 by aChecker

wcag2.0-Level-A	know problems	Likely problems	potential problems
Total	264	15	7383
Mean	11	0.62	307.62
Standard Deviation	11.24	0.87	238.15

Table 5.Common error Report Summary corresponding to e-Learning home page under WCAG2.0 by a Checker (Level-A)

wcag2.0-Level-A	1.1-1.1.1	1.3-1.3.1	2.4-2.4.2	2.4-2.4.4	3.1-3..11	3.3-3.3.2	4.1-4.1.1
Total	138	51	1	8	11	51	4
Mean	8.62	5.66	1	2	1.83	3.92	1
Standard Deviation	9.21	5.67	0	2	0.40	3.66	0

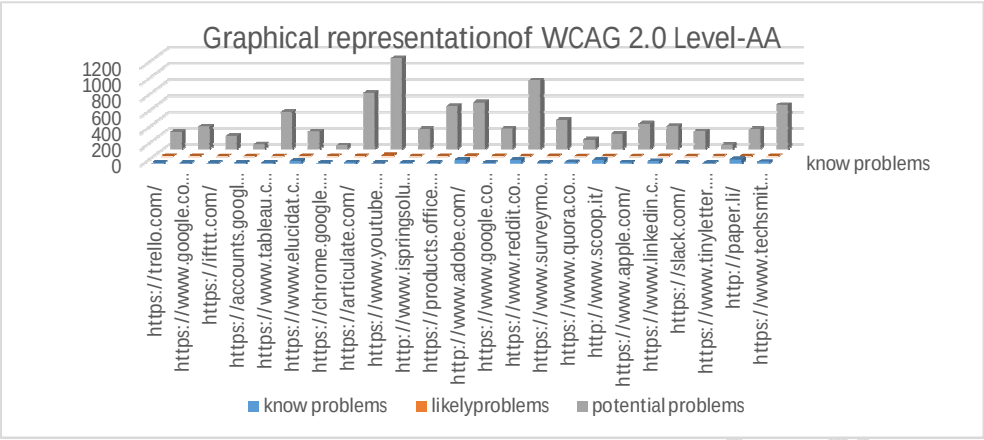

Figure 11.Graphical Representation of e-learning Websites Result under WCAG2.0 by aChecker (Level-AA)

Table 6.Report summary corresponding to e-Learning home page under WCAG2.0 by a Checker.

wcag2.0- level-AA	know problems	likely problems	potential problems
TOTAL	394	25	8029
MEAN	16.41	1.0416	334.54
STDEV	15.53	1.975	266.45

Table 7.Common error Report summary corresponding to e-Learning home page under WCAG2.0 by a Checker (Level-AA).

wcag2.0-level-AA	1.1-1.1.1	1.3-1.3.1	1.4-1.4.3	1.4-1.4.4	2.4-2.4.2	2.4-2.4.4	2.4-2.4.6	3.1-3.1.1	3.3-3.3.2	4.1-4.1.1
TOTAL	112	59	6	110	1	7	35	12	48	4
MEAN	4.67	2.45	0.25	4.58	0.04	0.29	1.43	0.5	2	0.16
STDEV	10.14	5.06	0	13.72	0	1.5	4.69	0.63	4.36	0

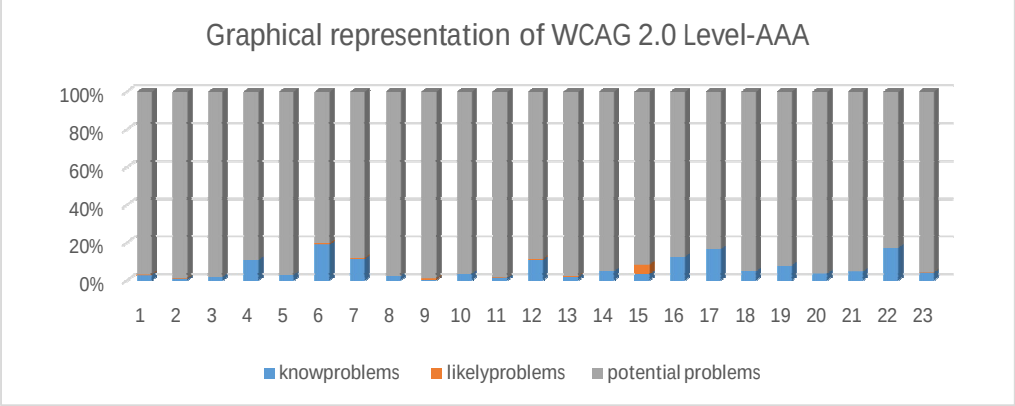

Figure 12.Graphical Representation of e-learning Websites Result under WCAG2.0 by aChecker (Level-AA)

Table 8.Report summary corresponding to e-Learning home page under WCAG2.0 by a Checker.

wcag2.0-Level-AAA	know problems	likely problems	potential problems
TOTAL	466	41	8338
MEAN	19.41666667	1.708333333	347.4166667
STDEV	19.44506806	4.441094478	278.3725218

Table 9.Common error Report summary corresponding to e-Learning home page under WCAG2.0 by a Checker (Level-AA).

wcag2.0-Level-AAA	1.1-1.1.1	1.3-1.3.1	1.4-1.4.4	1.4-1.4.6	2.4-2.4.2	2.4-2.4.4	2.4-2.4.6	3.1-3.1.1	3.3-3.3.2	4.1-4.1.1
TOTAL	143	81	110	7	1	18	27	11	63	4
MEAN	5.95	3.37	4.58	0.29	0.041	0.75	1.12	0.45	2.62	0.166
STDEV	10.84	8.4	13.56	3.53	0	4.04	4.69	0.4	6.94	0

wcag2.0-Level-AAA	know problems	likely problems	potential problems
TOTAL	466	41	8338
MEAN	19.41666667	1.708333333	347.4166667
STDEV	19.44506806	4.441094478	278.3725218

Table 10.Common error Report summary corresponding to e-Learning home page under WCAG2.0 by a Checker (Level-AA).

Table 11. Comparison of total number of common errors under WCAG2.0 by a checker (level-A, A&AAA)

	TOTAL									
wcag2.0-Level	1.1-1.1.1	1.3-1.3.1	1.4-1.4.4	1.4-1.4.6	2.4-2.4.2	2.4-2.4.4	2.4-2.4.6	3.1-3.1.1	3.3-3.3.2	4.1-4.1.1
Level-AAA	143	81	110	7	1	18	27	11	63	4
Level-AA	112	59	6	110	1	7	35	12	48	4
Level-A	138	51			1	8		11	51	4

Table 12. Comparison of total number of common errors under WCAG2.0 by a checker (level-A, A&AAA)

Checkpoint	Errors	Level-A	Level-AA	Level-AAA	Total
1 .1	Text Alternatives: Provide text alternatives for any non-text content				
1.1.1	Non-text Content (P)	138	112	143	393
1.3	Adaptable: Create content that can be presented in different ways without losing information or structure				
1.3.1	Info and Relationships (P)	51	59	81	191

1.4	Distinguishable: Make it easier for users to see and hear content including separating foreground from background				
1.4.4	Resize text (P)		6	110	116
1.4.6	Contrast (Enhanced) (P)		110	7	117
2.4	Navigable: Provide ways to help users navigate, find content, and determine where they are.				
2.4.2	Page Titled (O)	1	1	1	3
2.4.4	Link Purpose (In Context) (O)	8	7	18	33
2.4.6	Headings and Labels (O)		35	27	62
3.1	Readable: Make text content readable and understandable.				
3.1.1	Language of Page (U)	11	12	11	34
3.3	Input Assistance: Help users avoid and correct mistakes				
3.3.2	Labels or Instructions (U)	51	48	63	162
4.1	Compatible: Maximize compatibility with current and future user agents, including assistive technologies				
4.1.1	Parsing (R)	4	4	4	12

aChecker program is used to analyze the accessibility score of the best e-learning websites according to the WCAG 2.0 requirements. Find the usual mistakes in various levels, such as Level-A, Level AA, and Level AAA, with the aid of this program.Four principles—Perceivable, Operable, Understandable, and Robust—are followed in the WCAG 2.0 criteria. The following checkpoints in Perceivable include errors: 1.1.1-Non-text Content (393), 1.3.1-Information and Relationships (191), 1.4.4-Text Resize (116), and 1.4.6-Contrast (Enhanced) (117). 2.4.2 - Page Titled (3), 2.4.4 - Link Purpose (In Context) (33), and 2.4.6 - Headings and Labels (62) are the Operable Principle check points for errors. The 3.1.1 Language of Page (34) and 3.3.2 Labels or Instructions (162) checkpoints for faults in Understandable Principle are located there.Finally, there is the robust concept, with 4.1.1 - parsing (12) as the error checkpoint.The least value is Page Titled and the highest value is Non-text Content when comparing typical errors.

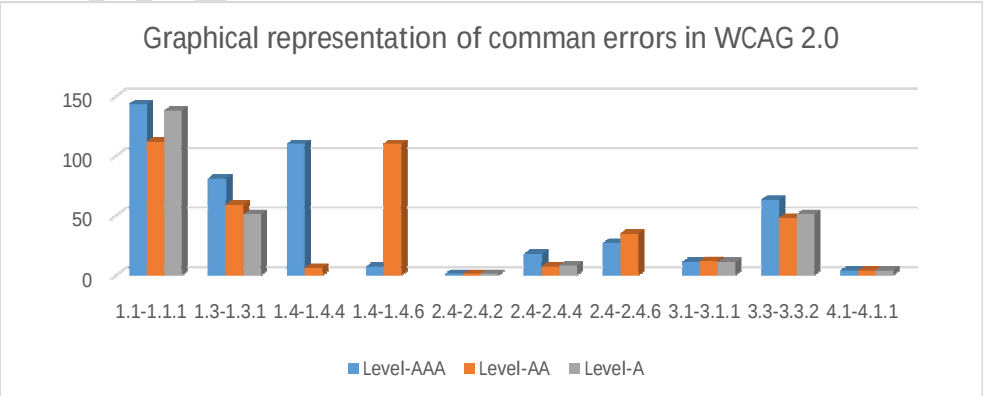

Figure 13. Graphical Representation of Common errors underWCAG2.0 by a Checker (Level-A, AA&AAA).

5.4. Web accessibility results using WAVE:

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The accessibility findings for 25 websites that were assessed using the WAVE assessment tool are provided in this section. The websites are examined using three levels of conformance in accordance with WCAG 2.0 recommendations. Table 12 tabulates the statistical findings of the WAVE reported features, alerts, mistakes, structure, HTML, and contrast. Figs. 14 compare the total amount of mistakes, alerts, features, structure, HTML, and contrast for 25 websites under three different conformance levels. Table 12 displays the statistical findings of 25 websites for three levels of conformity. Table 12 indicates that there are 443 total mistakes, with an average and standard deviation of 19.26 and 48.02, respectively. There were 1191 warnings in all, with an average and standard deviation of 51.78 and 105.87. There are 382 features in all, and the average, mean, and standard deviation are 16.60 and 30.14, respectively. Similarly, there are 1032 structural elements in total, with an average and standard deviation of 44.86 and 72.568, respectively. There are 1871 HTML pages, with an average and standard deviation of 81.34 and 181.58, correspondingly. There are 567 contrasts in all, with an average and standard deviation of 24.65 and 51.51, respectively.

Table 13.Report summary corresponding to e-Learning home page using Wave Tool.

e-learning tools-wave	ERRORs	ALERTS	FEATURES	STRUCTURAL ELEMENTS	HTML5andARIA	Contrast error
Total	443	1191	382	1032	1871	567
Average	19.26	51.78	16.60	44.86	81.34	24.65
Stdev	48.02	105.87	30.14	72.56	181.58	51.51

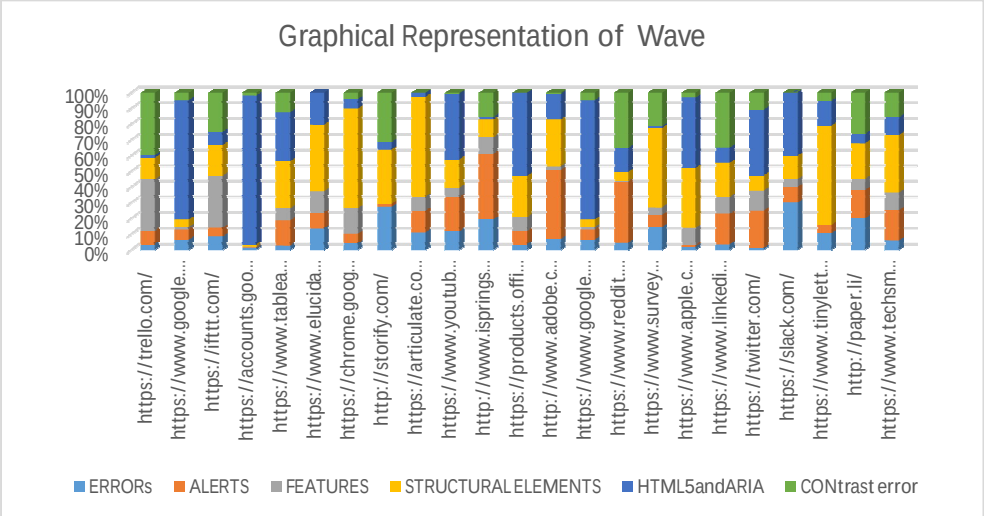

Figure 14.Graphical Representation of Wave tool Report.

5.5. Performance analysis using Tenon

The accessibility findings of 25 websites that Tenon has validated are described in this subsection. Figs. 15 compare the density, problems, and compliance levels for 25 different websites. Table 15 displays the pages that performed the worst according to the Tenon tool, while Table 17 displays the success criterion. Table 16 lists the issues by test id and issue count by text.In addition, as part of the website assessment procedure, the Tenon tool ran 74 tests of the guidelines on websites in order to provide the test results in numerical form, specifically the number of tests that the specific website passed and the number that it failed. Figure 15 displays the overall results of the 74 tests administered by the Tenon tool, both passed and failed, for learning e-learning websites. The two-part test's total, average, and SD values are displayed in Table 13, along with the statistical results of the TENON tool in terms of the number of issues discovered, fail, pass, and total values.Pass and Fail are the options. Table 13 displays the total number of passed and failed tests from e-learning websites out of 74 Tenon tool tests.Table 13 shows the pass value at value (1721), average (68.54), and SD (2.76), and the fail value at value (129), average (5.16), and SD (2.76).Tenon tool indicates that four webpages have a density distribution between 51 and 100, one webpage has a density distribution above 100, and the remaining webpages fall between 0 and 50. Additionally, it was discovered that 73 distinct issues met 61 of the WCAG success criteria. The typical report, measured in number of pages, according to this instrument is as follows:

- Average Errors per page 34,
- Average Warnings per page 0,
- Average issues per page 34,
- Total Distinct Pages 25,
- Total Successful 25,
- Total Unsuccessful 0,
- Avg. Issue Certainty 99%,
- Avg. Issue Priority 99%,

The website https://www.techsmith.com/ performs worse than other websites, as Table 12 demonstrates, resulting in a total of 23 faults with error and warning density percentages of 32 and 5%, respectively. With a maximum proportion of 16, it is evident from Table 16 that the "This Link Has No Text inside It" issue happened at position 32. According to Table 17, the link purpose (link only) and link purpose (context) concerns had the highest rate of 46%. Table 13 provides an alternative representation of the TENON tool's statistical analysis based on All Density (AD), Error Density (ED), Warning Density (WD), Total Errors (TE), Total Issues (TI), and Total Warnings (TW).Table 14 shows that there are 781 values for all density, with an average and standard deviation of (31.24) and (35.24), respectively. Likewise, the total values for ED, WD, TE, TI, and TW are 768, 13, 848, 888, and 10; the average values are (70.72, 0.52, 33.92, 34.32, and 0.4) and the standard deviations are (35.95, 1.29, 68.52, 68.39, and 1), correspondingly.Ten sites rank lowest in terms of total issues, mistake density, and warning density among the twenty-five websites included in the Tenon tool confirmation development overall report. Tenon Tool states that Table 15 displays the

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overall ratings of a sizable number of website pages, and the highlighted scores highlight the worst-performing sites. Based on quantifiable analysis of data obtained from Tenon tools, these worst-performing websites also rank lower than average in terms of availability scores.

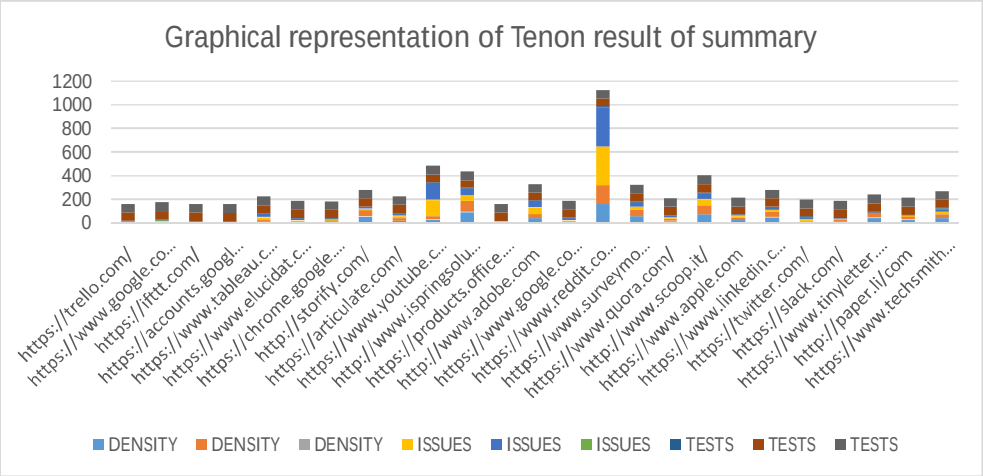

Figure 15.Graphical Representation of Tenon Tool Result

Table 14.Tenon Report about Result of summary worst performing pages.

	DENSITY			ISSUES			TESTS		
	AD	ED	WD	TE	TI	TW	FAILING	PASSING	TOTAL
https://trello.com/	4	4	0	3	3	0	3	71	74
https://www.google.com/	9	6	3	2	3	1	3	71	74
https://ifttt.com/	3	3	0	2	2	0	2	72	74
https://accounts.google.com/	0	0	0	3	3	0	2	72	74
https://www.tableau.com/	12	12	0	25	25	0	6	68	74
https://www.elucidat.com/	4	4	0	14	14	0	5	69	74
https://chrome.google.com/	12	9	3	3	4	1	4	70	74
http://storify.com/	53	**53**	0	**14**	14	0	3	71	74
https://articulate.com/	19	19	0	19	19	0	6	68	74
https://www.youtube.com/	27	**27**	0	**141**	141	0	6	68	74
http://www.ispringsolutions.com	92	**92**	0	**52**	52	0	8	66	74
https://products.office.com/	3	3	0	3	3	0	3	71	74
http://www.adobe.com	38	**38**	0	**53**	53	0	8	66	74
https://www.google.com/	6	4	2	9	13	4	7	67	74
https://www.reddit.com/	159	**159**	0	**331**	331	0	12	62	74
https://www.surveymonkey.com	55	55	0	30	30	0	10	64	74
https://www.quora.com/	16	16	0	13	13	0	3	71	74
http://www.scoop.it/	73	73	0	52	52	0	8	66	74
https://www.apple.com	23	23	0	10	10	0	3	71	74
https://www.linkedin.com/	47	47	0	19	19	0	6	68	74
https://twitter.com/	5	5	0	17	18	1	6	68	74
https://slack.com/	14	14	0	5	5	0	2	72	74

https://www.tinyletter.com/	44	44	0	2	2	0	2	72	74
http://paper.li/com	26	26	0	6	6	0	3	71	74
https://www.techsmith.com/	37	32	5	20	23	3	8	66	74

Table 15.Report summary corresponding to e-Learning home page using Tenon Tool

	DENSITY			ISSUES			TESTS		
Result of summary	AD	ED	WD	TE	TS	TW	FAILING	PASSING	TOTAL
Total	781	768	13	848	858	10	129	1721	1850
Average	31.24	30.72	0.52	33.92	34.32	0.4	5.16	68.84	74
Stdev	35.76	35.95	1.29	68.52	68.39	1	2.76	2.76	0

Table 15. Tenon Report about worst performing pages.

Worst Performing Pages			
Page Title	Total Issues	Error Density	Warning Density
https://www.reddit.com/	331	159%	0%
http://www.ispringsolutions.com/	52	92%	0%
http://www.scoop.it/	52	73%	0%
https://www.surveymonkey.com/	30	55%	0%
http://storify.com/	14	53%	0%
https://www.linkedin.com/	19	47%	0%
https://www.tinyletter.com/	2	44%	0%
http://www.adobe.com	53	38%	0%
https://www.techsmith.com/	23	32%	5%
https://www.youtube.com/	141	27%	0%

Table 16.Tenon Report Major Issues by Test ID of e-Learning Websites.

Issues by Test ID		
Issue Title	Count	Percent
This Option List May Need `&lt;optgroup&gt;Elements`	1	2%
This Object Is Not Embedded Accessibly.	1	2%
This Link Has No Text Inside It.	16	32%
This Image Is Missing An `alt` Attribute.	9	18%
This Image's `alt` Attribute Might Not Be Suitable.	1	2%
The Language Of This Page Is Not Set.	2	4%
This Frame Does Not Have A `title` Attribute.	5	10%
This Element Has A `role` Attribute Even Though Native Semantics Are Available	3	6%
This Link Text Is Uninformative	7	14%
This Link Uses An Invalid Hypertext Reference	4	8%
This List Element Is Nested Immediately Within AnotherList Element	1	2%

Table 17. Tenon Report: Issues by WCAG success criteria of e-Learning Websites.

Issues by WCAG Success Criteria		
WCAG SC (Success Criterion)	Count	Percent
1.1.1 Non-text Content	10 issues found	20%
1.3.1 Info and Relationships	2 issues found	4%

2.4.1 Bypass Blocks	5 issues found	10%
2.4.4 Link Purpose (In Context)	23 issues found	46%
2.4.9 Link Purpose (Link Only)	23 issues found	46%
3.1.1 Language of Page	2 issues found	4%
4.1.2 Name, Role, Value	8 issues found	16%

5.6. Performance analysis using EvalAccess2.0

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This subsection describes how EvalAccess2.0 assessed the assessment results of 25 websites. Three priority levels of problems and warnings are tested for on the websites. Figs. 16 provide a comparison of the overall number of mistakes with the three conformance levels for 25 websites. Figs. 16 compare the total number of warnings for 25 websites under three conformance levels. Table 18 presents the statistical findings from the EvalAccess2.0 tool. It provides the total number of warnings and errors for each of the three priority (P1, P2, and P3) together with the corresponding average and standard deviation (SD) values. At P2, the maximum error value was 97, with a mean of 4.04 and a standard deviation of 7.07. The highest value of warnings, 759, with a mean of 31.6 and an SD of 65.74, was also recorded at P2. The EvalAccess2.0 Tool is used to graphically represent e-learning websites, as seen in Fig. 17. The total number of mistakes and warnings for each of the three priority (P1, P2, and P3), together with a comparison of the average and standard deviation (SD) values, are displayed in Figure 17.

Table 18. Summary Report of EvalAccess 2.0 Tool on e-Learning Websites evaluation process.

	ERRORs			WARNINGs		
	P1	P2	P3	P1	P2	P3
TOTAL	41	97	24	473	759	885
MEAN	1.7	4.04	1	19.7	31.62	36.87
STDEV	7.02	7.07	0.2	37.52	65.74	82.61

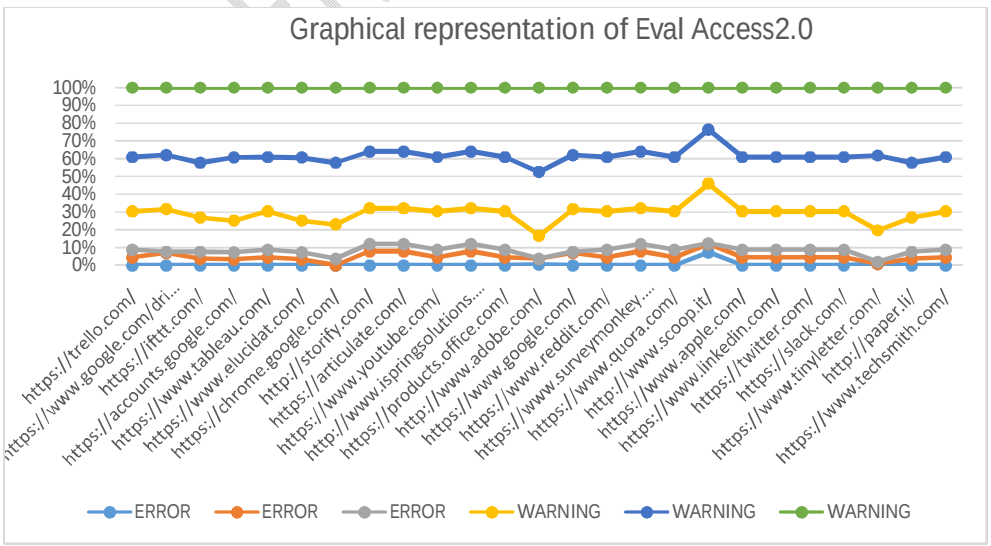

Figure 16.Graphical Representation of e-Learning Websites Result using EvalAccess2.0 Tool.

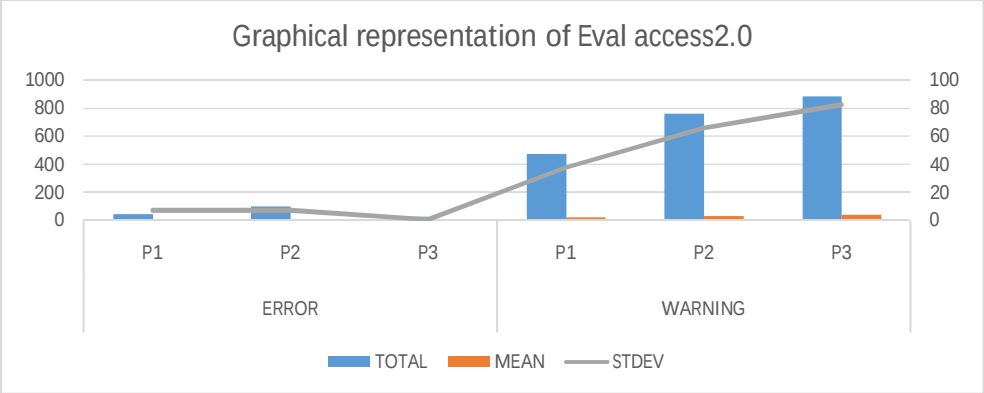

Figure 17.Graphical Representation of e-Learning Websites Using EvalAccess2.0 Tool.

5.7. Performance analysis using TAW.

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The accessibility findings of 25 websites as determined by TAW are explained in this subsection. The websites are not examined for three degrees of priority and are validated for mistakes and warnings. Comparing the problem, warning, and unreviewed items for 25 websites under Level A, Level AA, and Level AAA conformance levels is shown in Figs. 18–20, correspondingly. Table 19 presents the statistical findings of the TAW tool for A, including the total number of issues, warnings, and pages that have not been evaluated.Perceivable (P), Operable (O), Understandable (U), Robust (R), and Successes criteria (S) are used to determine the results. According to the table, there were 521 difficulties at most, with an average value of 20.84 and a standard deviation of 21.34. In a similar vein, there were 16877 warnings issued overall, with an average and standard deviation of 675.08 and 647.50, respectively. There were 151 items in total that were not evaluated, with an average and standard deviation of 6.04 and 0.78, respectively. Similarly, Tables 20 and 21 present the statistical outcomes of the TAW tool about AA and AAA compliance.

Table (19). Summary Report of TAW Tool on e-Learning Websites evaluation process (Level-A).

	PROBLEMS					WARNINGS					NOT REVIEWED				
	P	O	U	R	S	P	O	U	R	S	P	O	U	R	S
TOTAL	330	112	54	521	133	195	213	52	16877	127	76	151	46	7	280
Average	13.2	4.48	2.16	20.84	5.32	7.8	8.52	2.08	675.08	5.08	3.04	6.04	1.84	0.28	11.2
STDEV	13.7	5.71	2.32	24.34	1.54	6.51	10.4	2.91	647.5	2.23	0.2	0.78	0.37	0.45	1.04

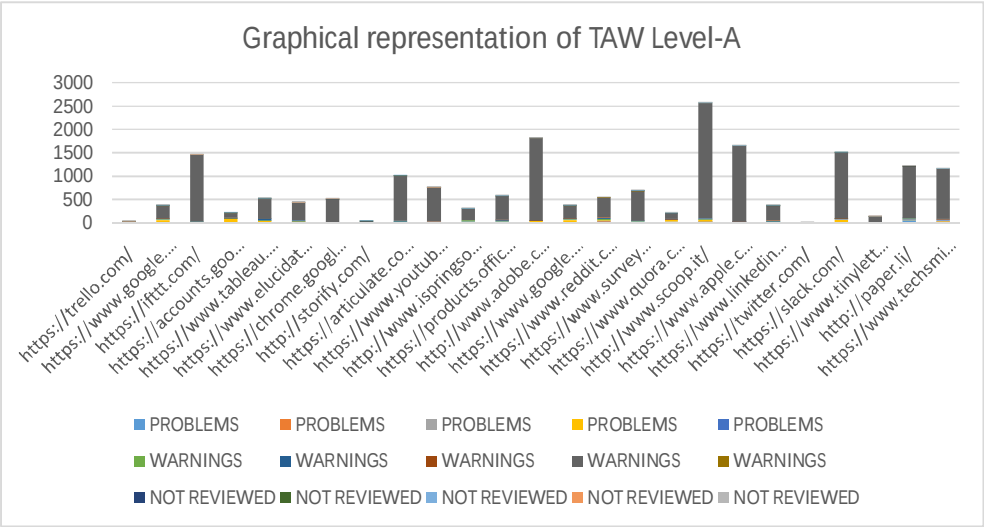

Figure 18.Graphical Representation of e-Learning Websites Using TAW Tool.

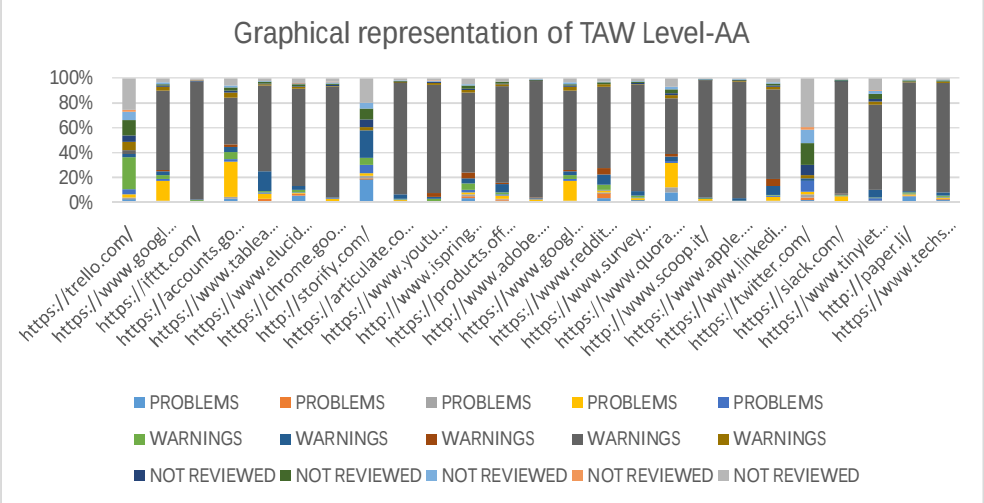

Figure 19.Graphical Representation of e-Learning Websites Using TAW Tool.

Table 20. Summary Report of TAW Tool on e-Learning Websites evaluation process (Level-AA).

	PROBLEMS					WARNINGS					NOT REVIEWED				
	P	O	U	R	S	P	O	U	R	S	P	O	U	R	S
TOTAL	330	112	54	529	133	239	551	156	16877	195	102	192	121	7	418
Average	13.2	4.48	2.16	21.16	5.32	9.56	22.04	6.24	675.08	7.8	4.08	7.68	4.84	0.28	16.72
STDEV	13.7	5.71	2.321	24.18	1.54	7.2	21.06	8.74	647.5	3.52	0.4	1	0.37	0.45	1.67

Table 21. Summary Report of TAW Tool on e-Learning Websites evaluation process (Level-AAA).

	PROBLEMS					WARNINGS					NOTR REVIEWED				
	P	O	U	R	S	P	O	U	R	S	P	O	U	R	S
TOTAL	328	296	58	520	168	243	545	373	16892	238	177	293	220	7	697
MEAN	13.12	11.84	2.32	20.8	6.72	9.72	21.8	14.92	675.68	9.52	7.08	11.72	8.8	0.28	27.88
STDEV	13.66	14.52	2.49	24.33	2.03	7.44	20.71	12.89	647.26	4.45	0.4	1.0214	0.4	0.45	1.33

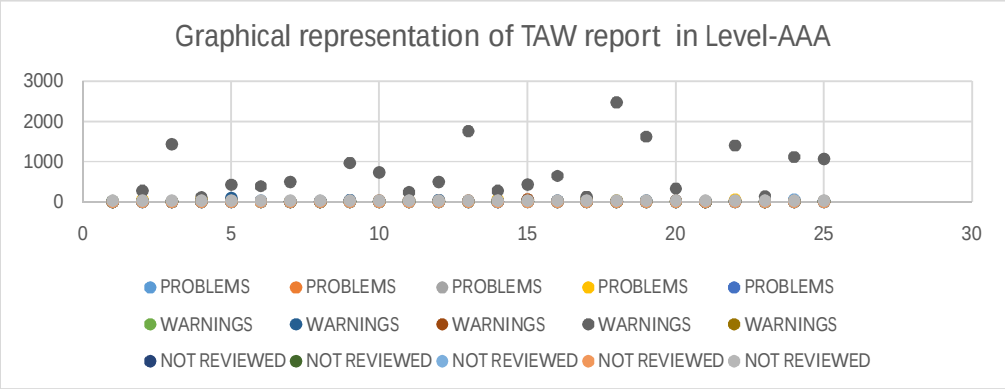

Figure 20.Graphical Representation of e-Learning Websites Using TAW Tool.

Table 22. Comparison Report of multi-tool works on e-Learning websites with problems (parameters).

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Tool/Problems	aChecker	HERA	Tenon	Eval Access2.0	TAW	Cynthia Says	WAVE
Know	Yes	NO	NO	NO	NO	NO	NO
Likely	Yes	NO	NO	NO	NO	NO	NO
Potential	Yes	NO	NO	NO	NO	NO	NO
Level-A	Yes	NO	YES	NO	YES	YES	NO
Level-AA	Yes	NO	YES	NO	YES	YES	NO
Level-AAA	Yes	NO	YES	NO	YES	YES	NO
Warning	No	YES	YES	YES	YES	YES	NO
Errors	No	YES	YES	YES	YES	YES	YES
Alerts	No	NO	NO	NO	NO	NO	YES
Features Structural Elements	No	NO	NO	NO	NO	NO	YES
HTML5 & ARIA	No	NO	NO	NO	NO	NO	YES
Contrast	No	NO	NO	NO	NO	NO	YES
Priority 1	No	YES	NO	YES	NO	NO	NO
Priority 2	No	YES	NO	YES	NO	NO	NO
Priority3	No	YES	NO	YES	NO	NO	NO

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Based on Table 22. With seven tools, we have thirteen parameters. When a tool says "yes," it indicates the parameters are available, and when it says "no," it means they are not.aChecker, Hera 2.1, Tenon, EvalAccess 2.0, TAW, Cynthia Says, and the Wave tool were used to

analyzethe accessibility score of the top 25 e-learning websites. A Checker tool was used to analyze the accessibility score of e-learning websites. The results showed that some barriers, including those marked with the letters Known, Likely, potential, Level A, AA, and AAA, were present, while other barriers, like warnings, errors, alerts, and feature structural elements, were absent. Table 22 shows that HTML5&ARIA, Contrast, Priority1, Priority2, and Priority 3 are all marked with NO letters.Comparably, the other tools go through the same procedure, thus if a tool has a letter in its name, it has some barriers, and if it has a letter in its name, it has no barriers. according to Table 22. Thirteen parameters and seven tools are available.If the response is "Yes," it means that the parameters are included in the relevant tool; if it is "No," it means they are not. an analysis of the accessibility scores of the top 25 e-learning websites using technologies such as aChecker, Hera 2.1, Tenon, EvalAccess 2.0, TAW, Cynthia Says, and the Wave tool. There are a few challenges when using the aChecker tool to evaluate the accessibility score of e-learning websites.

5.8 Comparison of Multiple Tools used with respect to their Attributes

WCAG 1.0 and WCAG 2.0 criteria were followed in the accessibility score study of 25 e-learning websites using various technologies. The accessibility of e-learning websites differs significantly from one another. Regarding the overall quantity of checkpoint violations in the WCAG 2.0 criteria, there is no difference between the many e-learning platforms that are accessible. There is no difference between the different e-learning websites that are available in terms of the overall number of checkpoint violations in the rules of WCAG 1.0.There is no difference between the several e-learning websites that are available in terms of their accessibility score when using these technologies. According to WCAG 1.0 and WCAG 2.0 rules, there is no discernible difference in the amount of errors between the e-learning website graphical representations displayed in Fig. 21. Various tools are utilized in this work to analyze e-learning websites; Table 23 presents an evaluation of these techniques. Using these methods, the study's logical conclusions are covered, covering the "easy-of-access" of numerous e-learning websites from multiple angles.

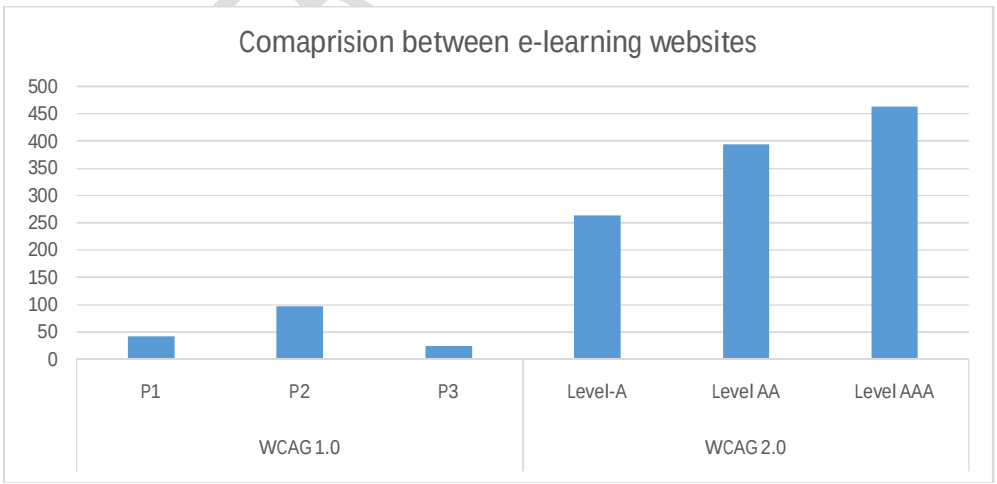

Figure 21.Result of errors and accessibility score of e-learning websites

6. Discussions

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The following suggestions on the design of e-learning websites are the result of a research of the accessibility score of the top 25 e-learning websites using the Tenon tool. These suggestions are related to the recurring issues that the accessibility study found. Information and Relationships, Audio Description or Full Text Alternative, Full Text Alternative, Audio-only and Video-only (Prerecorded), Captions (Prerecorded), Text Resize, Contrast (Enhanced) Title, Role, Value, Language of Page, Labels or Instructions, Help, and Link Purpose (Link Only). Title of Page and Link Objective (In Context).An examination of the best e-learning tool websites' web accessibility scores in relation to the WCAG 2.0 requirements. Table 11 indicates that errors are prevalent at several levels, including Level-A, Level AA, and Level AAA.The four concepts of the WCAG 2.0 rules are perceivable, operable, understandable, and robust. 1.1.1-Non-text Content (393), 1.3.1- Information and Relationships (191), 1.4.4- Text Resize (116), and 1.4.6- Contrast (Enhanced) (117) are the checkpoints for faults in Perceivable.The Operable Principle's 3.2.1 Page Titled, 2.4.4 Link Purpose (In Context) (33), and 2.4.6 Headings and Labels (62) are the checkpoints for errors. Under the Understandable Principle, the language of page (34) and labels or instructions (32) checkpoints for errors are located (162).The final principle is robust, with 4.1.1 - parsing (12) serving as the error checkpoint.Non-text Content has the highest value when compared to frequent errors, while Page Titled has the lowest value. an examination of the best online courses' accessibility score using the Wave tool in relation to the WCAG 2.0 recommendations. There are six different kinds of faults: contrast, HTML5 and ARIA, alerts, features, problems, and structural elements.These errors add up to (443, 1191, 382, 1032, 1871, and 567), in that order. In the same way, the standard deviation values of these mistakes are (48.02, 105.87, 30.14, 72.56, 181.58 and 51.51) and the average values are (19.26, 51.78, 16.60, 44.86, 81.34 and 24.65).When comparing these errors, features have the lowest value and HTML5 and ARIA have the highest value. an examination of the top e-learning websites' accessibility scores using the TAW tool in relation to the WCAG 2.0 requirements. Each of its three levels—Level A, Level AA, and Level AAA—is separated into three categories of errors: Problems, Warnings, and Not Reviewed.Four categories are also used to categorize these issues: perceivable, operational, intelligible, and robust. Robust has the highest value in Level AAA of the challenges, while Understandable has the lowest score. In a similar vein, the warnings for robust value are greatest and perceivable are lowest, and for operable value that is not examined, robust value is lowest and operable value is highest. Comparing the challenges in Level A, Robust has the highest rating while Understandable has the lowest score. In a similar vein, the highest value for the warnings is robust, the lowest value is understandable, and the highest value is operable when operable value is not evaluated, and the lowest value is understandable.Comparing the challenges in Level AA, Robust has the highest rating and Understandable has the lowest value. In a similar vein, the highest value for warnings is robust value; the lowest value is understandable; similarly, the maximum value for operable value is not reviewed; and the lowest value is robust value. an evaluation of the best e-learning websites' accessibility scores using the EvalAccess 2.0 tool in relation to the WCAG 1.0 requirements. This tool distinguishes between two categories of errors: warnings and errors. There are three different priority levels for these two sorts of errors: P1, P2, and P3.When comparing errors, priority 2 (P2) has the highest value and priority 3 (P3) has the lowest. Comparably, priority 3 (p3) has

the highest value in Warnings, whereas priority 1 (p1) has the lowest value. an examination of 25 e-learning websites' accessibility scores. Ten of the twenty-five e-learning websites perform the poorest; these are bolded and shown in Table 12 along with the corresponding score. To improve web accessibility, designers and developers should focus on a few key areas and upgrade their estimation tools to more sophisticated versions in order to get over the current obstacles that we identify through data analysis. That is, certain websites displayed timeout issues, and other websites occasionally gave zero error reports. These kinds of obstacles prevented us from gathering information from such a website. Therefore, in order to improve these evaluation tools, we must conduct further study to determine the causes and solutions of these known and unknown difficulties. When evaluating websites, the requirements for universal accessibility and simplicity of use are also taken into account. We should focus our early efforts on reducing the barriers identified by accessibility evaluation tools in order to increase the accessibility score of websites. We have seven tools and thirteen parameters. based on Table 22. If the answer is "Yes," it indicates that the parameters are present in the appropriate tool; if it is "No," it indicates that they are not. The results of this study help the owners of these websites make their websites more accessible to people with disabilities. The results provided by different automatic assessment tools may not always adhere to all WCAG 2.0 criteria, and some require human judgment. Additionally, many technologies are unable to distinguish between identical barriers based on their relative severity. Thus, it is imperative that we update these technologies in order to achieve better results in terms of web accessibility.

7. Suggestion:

When websites are evaluated using accessibility analysis tools, the results can occasionally be ambiguous and do not always give a comprehensive review of accessibility. It is recommended that web developers and designers receive training on web accessibility principles and be given awareness programs regarding web accessibility in websites and their implementation. The inclusion of features such as text size, accessibility statement, contrast theme, multi-language support, skip to main content, screen reader link, and others must be approved by the website designers in order to make the pages accessible to people with disabilities.

8. Limitations and Future work:

When a person can visit a website without any difficulty, regardless of whether they have physical limitations or not, it is considered accessible. They can use it just like any other user. The use of the internet in education has expanded greatly, and students with physical disabilities can now access e-learning websites and learn alongside their peers. It is predicted that e-learning will revolutionize global education in the future. Therefore, it is imperative that an e-learning website be user-friendly to all users.

9. Conclusion

Based on our investigation using seven web accessibility assessment tools on 25 e-learning websites, we can say that these websites still have a ways to go before they are fully accessible online. There is still need for development, even though the most recent websites are reasonably competent in terms of web accessibility. In terms of web accessibility, our research indicates that Indian e-learning websites lag very slightly behind university and institution websites. Online campuses, including Indian universities, must upgrade their websites with cutting-edge capabilities like ARIA and HTML 5. There are ways to approach

increasing levels of web accessibility, even if being fully accessible is an extremely difficult task. The application of machine learning techniques for classifying web pages according to accessibility obstacles may be studied. Numerous research projects have evaluated various websites' online accessibility. E-learning websites have become more and more popular recently because it starts with these kinds of websites. Several e-learning resources are available, such as Adobe, Storify, LinkedIn, Tiny Lette, You Tube, and others. Because the e-learning space is so beneficial to students at all levels, it is imperative that those websites be accessed for accessibility. In this study, four evaluation tools—EvalAccess 2.0, Run FAE, TAW, Tenon, and Hera 2.1—are used to evaluate 25 e-learning websites.The World Wide Web is currently the primary information access medium. People with disabilities should be able to access and use them. Several accessibility assessment tools were employed in this study to rank educational websites.There are more problems with 25 e-Learning Many website vulnerabilities are found and challenges are faced by the websites. Additionally, we discovered that there are more warnings than errors, thus the goal should be to lower the quantity of warnings. Moreover, there are more errors at Level AAA than in Levels AA and A. The process of evaluating websites for online accessibility reveals that Learning Company websites still require significant work to become accessible webpages for everyone.Additionally, the outcomes of 25 e-learning websites using the various accessibility assessment tools at their disposal are accessible; as a result, the managers of these websites will receive a comprehensive understanding of the accessibility status of these websites. We need to make several accessibility features better, including font size, contrast theme, multi-language support, skip to main content, screen reader link, and accessibility declaration, in order to make the webpages accessible. We will accomplish this such that the sites are typically accessible to everyone.Additionally, by implementing sites in accordance with WCAG guidelines, IT administrators will be able to keep a safe distance from similar violations in the future. This research has offered a comparative analysis of five distinct accessibility testing tools in addition to the accessibility analysis of learning firm websites. Thirteen different parameters are used in this investigation. This comparative analysis will help provide an overview of the characteristics of these five accessibility tools, enabling accessibility enthusiasts to choose the ones that best meet their needs.The last step in minimizing these problems and creating e-learning websites that are accessible to all kinds of people is for website developers and designers to receive awareness training and excellent instruction in accessibility-related fields. The outcome shows that in order to make the websites globally accessible, they need to be improved. Web accessibility guidelines-compliant websites would only help the country's education sector grow, especially in emerging nations like India, where there will be a rise in internet usage in the future, notably in the education sector.It is recommended that developers and designers conduct awareness programs regarding accessibility models and their implementations. This will help them build websites that adhere to accessibility guidelines and principles and increase the websites' online accessibility.

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