

# GUIDELINES FOR MAKING WEB ACCESSIBLE FOR DYSLEXICS



By

**Hamna Rao**

Supervisor

**Asst, Prof Dr. Tauseef Ahmed Rana, PhD**

A thesis submitted to the Department of Computer Software Engineering,  
Military College of Signals, National University of Sciences and Technology, Islamabad,  
Pakistan, in partial fulfillment of the requirements for the degree of MS in Computer Software  
Engineering

August 2022

## **ABSTRACT**

Dyslexia is a specific learning disorder that affects the reading, writing, spelling and decoding abilities. The people suffering from dyslexia, experience difficulties while using websites because designers, developers and content writers do not consider the obstacles faced by them. Previous studies provided single or multiple accessibility elements but there is no consolidated key website accessibility guidelines. In this research, the accessibility of some popular websites is evaluated using online accessibility testing tool. The results have shown that most of the websites are not fully accessible because they developed with accessibility barriers (e.g. no support for screen reader). Secondly, dyslexia friendly key website accessibility guidelines have been identified to assist designers, developers, tester, content writers and other website stakeholders. The guidelines are grouped into nine major categories; Fonts, Paragraph, Colors, Writing, Layout, Navigation, Screen Reader Compatibility, Semantic HTML & WAI-ARIA and other guidelines. In addition to the above, a website development framework is suggested to prioritize accessibility from the beginning of development by frequently testing website for accessibility and screen reader compatibility. A website prototype is created and tested using online accessibility testing tool and screen reader. The result has shown that accessibility of websites for dyslexic people can be improved by focusing on accessibility from the beginning of website development projects.

## **DEDICATION**

*Dedicated to my FAMILY, and my TEACHERS whose tremendous support and cooperation led me to this wonderful accomplishment. I am very thankful to them from my true inner being.*

*Indeed, every goodness that comes to me is from the Most Merciful.*

## **ACKNOWLEDGEMENTS**

All praises Indeed due to ALLAH Almighty alone to Whom belongs whatever is in the heavens and whatever is on the earth, the Most High, the Most Gracious, and Allah's blessings for the completion of this dissertation. I am very grateful to Allah for all the opportunities, and strengths that Allah has showered upon me throughout my life. Without the mercy and help of Almighty, I couldn't be able to accomplish it.

# Table of Contents

<b>ABSTRACT</b> .....	<b>II</b>
<b>DEDICATION</b> .....	<b>III</b>
<b>ACKNOWLEDGEMENTS</b> .....	<b>IV</b>
<b>LIST OF FIGURES</b> .....	<b>VIII</b>
<b>LIST OF TABLES</b> .....	<b>IX</b>
<b>ACRONYMS</b> .....	<b>X</b>
<b>1. INTRODUCTION</b> .....	<b>1</b>
1.1 INTRODUCTION.....	1
1.2 PROBLEM STATEMENT.....	4
1.3 OBJECTIVE.....	5
1.4 MOTIVATION.....	5
1.5 RELEVANCE TO NATIONAL NEEDS .....	6
1.6 ADVANTAGES AND IMPORTANCE.....	7
1.7 AREA OF APPLICATION.....	8
1.8 THESIS OUTLINE .....	9
<b>2. LITERATURE REVIEW</b> .....	<b>10</b>
2.1 OVERVIEW .....	10
2.2 DYSLEXIC PEOPLE .....	10
2.2.1 <i>Genius Dyslexic People</i> .....	12
2.3 ASSISTIVE TECHNOLOGIES .....	12
2.4 EXISTING WEB ACCESSIBILITY STANDARDS.....	13
2.4.1 WCAG.....	13
2.4.2 <i>Others Countries Accessibility Laws and Standards</i> .....	16
2.5 RELATED RESEARCH WORK.....	17
2.6 CURRENT STATE OF WEBSITE ACCESSIBILITY .....	28
2.6.1 <i>Website accessibility litigation under ADA Title III</i> .....	28
2.6.2 <i>Accessibility Research Report of 10,000,000 web pages by "AccessiBe"</i> .....	28
2.6.3 <i>The Million Accessibility Report 2022 by "WebAIM"</i> .....	30
2.6.4 <i>Screen Reader Survey 2021 by "WebAim"</i> .....	32
2.6.5 <i>Increasing Demands of Web Accessibility Experts</i> .....	34
2.7 FINDINGS AND DISCUSSION .....	35
2.8 SUMMARY .....	39
<b>3. RESEARCH METHODOLOGY</b> .....	<b>40</b>

3.1 OVERVIEW .....	40
3.2 WEBSITE DATASET .....	40
3.3 ACCESSIBILITY EVALUATION TOOLS .....	40
3.3.1 AccessScan .....	41
3.4 ACCESSIBILITY EVALUATION REQUIREMENT CHECKLIST.....	43
3.5 ACCESSIBILITY EVALUATION DETAILED RESULTS.....	45
3.6 SUMMARY .....	52
<b>4. DYSLEXIA FRIENDLY WEBSITE GUIDELINES .....</b>	<b>54</b>
4.1 OVERVIEW .....	54
4.2 WHAT IS NEEDED? .....	54
4.3 SCOPE DESCRIPTION .....	55
4.4 GUIDELINES FOR MAKING DYSLEXIA FRIENDLY WEBSITE.....	56
4.4.1 Font .....	58
4.4.2 Paragraph.....	58
4.4.3 Color .....	58
4.4.4 Writing.....	59
4.4.5 Layout.....	60
4.4.6 Navigation.....	61
4.4.7 Screen Reader Compatibility .....	63
4.4.8 Others .....	64
4.4.9 Semantic HTML and WAI-ARIA .....	67
4.5 EXAMPLES OF GUIDELINES WITH CODE (SEMANTIC HTML AND WAI-ARIA) .....	68
4.5.1 Declare Document Language .....	69
4.5.2 Layout Elements (Page Regions & Landmark Roles) .....	69
4.5.3 Headings.....	73
4.5.4 Images .....	74
4.5.5 Buttons.....	75
4.5.6 Links .....	76
4.5.7 Keyboard Navigation.....	79
4.5.8 Forms.....	80
4.5.9 Semantic Elements.....	84
4.6 BENEFITS OF GUIDELINES .....	85
4.7 BRIEF SUMMARY OF GUIDELINES.....	85
<b>5. PROPOSED FRAMEWORK .....</b>	<b>87</b>
5.1 OVERVIEW .....	87
5.2 NEED OF AN FRAMEWORK.....	87
5.3 PROPOSED APPROACH.....	88
5.4 BENEFITS OF THE PROPOSED APPROACH.....	89
5.4.1 Benefits of Automated Accessibility Testing .....	89
5.4.2 Benefits of Screen Reader Accessibility Testing .....	90
5.4.3 Benefits of the Combined Approach.....	90
5.5 SUMMARY .....	91
<b>6. EVALUATION RESULTS .....</b>	<b>92</b>
6.1 OVERVIEW .....	92

6.2 TOOLS USED FOR EVALUATION.....	92
6.3 WEBSITE PROTOTYPE .....	92
6.4 RESULTS.....	95
6.5 SUMMARY .....	96
<b>7. LIMITATIONS .....</b>	<b>97</b>
7.1 LIMITATIONS .....	97
<b>8. CONCLUSION &amp; FUTURE WORK .....</b>	<b>99</b>
8.1 CONCLUSION.....	99
8.2 FUTURE WORK .....	101
<b>REFERENCES .....</b>	<b>103</b>

## LIST OF FIGURES

<b>Figure 1.1:</b> Thesis Outline.....	9
<b>Figure 2.1:</b> ADA Title III Website Accessibility Lawsuits from 2017 to 2021.....	28
<b>Figure 2.2:</b> Percentage of failed elements against WCAG 2.1 AA compliance .....	29
<b>Figure 2.3:</b> Percentage of Failed Home Page Elements.....	30
<b>Figure 2.4:</b> Mobile App or Website.....	32
<b>Figure 2.5:</b> Web Accessibility Progress.....	33
<b>Figure 2.6:</b> Skip Links.....	33
<b>Figure 2.7:</b> Heading Levels.....	34
<b>Figure 2.8:</b> Finding Information.....	34
<b>Figure 3.1:</b> AccessScan Clear Results.....	42
<b>Figure 3.2:</b> Other Tools Vague Results.....	42
<b>Figure 3.3:</b> Result Overall Summary.....	47
<b>Figure 3.4:</b> Average Score of Various Categories.....	48
<b>Figure 4.1:</b> Need for Dyslexia Friendly Website Guidelines.....	55
<b>Figure 4.2:</b> Major Groups of Accessibility Guidelines.....	57
<b>Figure 4.3:</b> Layout.....	70
<b>Figure 5.1:</b> Proposed Framework.....	88
<b>Figure 6.1:</b> Screen Reader used for Testing Website.....	92
<b>Figure 6.2:</b> Website Development Phase.....	93
<b>Figure 6.3:</b> Home Page of Website.....	93
<b>Figure 6.4:</b> Game Categories Page of Website.....	94
<b>Figure 6.5:</b> Products Page of Website.....	94
<b>Figure 6.6:</b> Contact Us Page of Website.....	94
<b>Figure 6.7:</b> Evaluation Results of Proposed Website Using "AccessScan" Accessibility Evaluation Tool.....	95
<b>Figure 6.8:</b> Proposed Website Compliant according to WCAG 2.1 Level AA.....	95
<b>Figure 6.9:</b> Testing with Screen Reader.....	96
<b>Figure 6.10:</b> Testing with Screen Reader.....	96



## LIST OF TABLES

<b>Table 2.1:</b> Summary of Work Done on Accessibililty of Dyslexics.....	26
<b>Table 2.2:</b> Percentage of Failed Home Page Elements from 2019 to 2022.....	31
<b>Table 2.3:</b> CMS, No. of Home Pages and Average number of Errors.....	31
<b>Table 3.1:</b> Accessibility Evaluation Tools.....	40
<b>Table 3.2:</b> Requirement Checklist for Clickables, Titles and Orientation.....	43
<b>Table 3.3:</b> Requirement Checklist for Menus, Graphics and Forms.....	44
<b>Table 3.4:</b> Requirement Checklist for Document and Readability.....	45
<b>Table 3.5:</b> Compliance Results and Meaning.....	45
<b>Table 3.6:</b> Accessibility Evaluation Category Wise Results of Popular Websites.....	45
<b>Table 3.7:</b> Result Overall Summary.....	47
<b>Table 3.8:</b> Average Score of Various Categories.....	47
<b>Table 3.9:</b> Score Symbol and Description.....	48
<b>Table 3.10:</b> Requirement Score.....	49
<b>Table 3.11:</b> Requirement Score.....	50
<b>Table 3.12:</b> Requirement Score Summary.....	51
<b>Table 4.1:</b> Summary of Major Accessibility Barriers and Guidelines for Fixing.....	86

## ACRONYMS

Corona Virus Disease 2019	COVID-19
World Health Organization	WHO
World Wide Web Consortium	W3C
Web Accessibility Initiative	WAI
Web Content Accessibility Guidelines	WCAG
Americans with Disabilities Act	ADA
Artificial Intelligence	AI
British Dyslexia Association	BDA
Application	APP
Accessibility Rich Internet Applications	ARIA
Hyper Text Markup Language	HTML
International Dyslexia Association	IDA
United States	US
World Wide Web	WEB
User Interface	UI
International Organization for Standardization	ISO
International Electrotechnical Commission	IEC
Scalable Vector Graphics	SVG
Extensible Markup Language	XML
Hypertext Markup Language Revision 5	HTML 5
Cascading Style Sheets	CSS
Uniform Resource Letter	URL
Alternative	ALT

## **INTRODUCTION**

### **1.1 Introduction**

The term dyslexia is derived from the Greek words “dys” and “lexia”. The word “dys” means poor, abnormal or inadequate and the word “lexia” means language or words [1]. Dyslexia is therefore, recognized as a learning disorder characterized by difficulties in recognition of words, spellings, reading, writing and information processing skills [1]. However, assistive technologies are available that can help dyslexic people to overcome their difficulties in education as well as while using the digital technologies and internet. Dyslexia is often inherited and originates in the brain [7].

According to the World Wide Web Consortiums (W3C) [2], Web accessibility means that websites, applications, tools, and technologies should be designed, coded and maintained in a way so that people with various disabilities can also be able to understand, perceive, navigate and interact with them. Inaccessible or poorly designed websites create barriers for disable people. An accessibility barrier is defined as anything which makes it harder or impossible for disable people to use the Web [2]. Web accessibility guidelines include disabilities related to hearing, cognitive, neurological, speech, visual (blindness and low vision) and physical inabilities [3]. Accessibility of websites plays an essential position for people with disabilities in the same manner as it is for all others. But the barriers discourage these people to use websites, and nowadays, being excluded from the web is a huge disadvantage. Therefore, it is essential to create high quality websites that will assist all people and does not exclude disable people from using the products or services. Fully achieving accessibility for all the diverse groups of disabilities is very challenging. Considering that dyslexia is the most common learning disability among the public and internet users [4], it is reasonable to recommend that dyslexia and

accessibility should be given great attention. This research particularly focuses on key website accessibility recommendations for dyslexic people.

The W3C Web Accessibility Initiative (WAI) [2] creates Web standards internationally for HTML, CSS, XML and many more. W3C standards provide accessibility guidelines, technical specifications, strategies and supporting material that describe solutions to developers so that they can understand and implement accessibility. These standards are considered international web accessibility standards. W3C has issued the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) [3] with the goal of providing knowledge to make web accessible so that it addresses the needs of all people along with people with various disabilities. According to WCAG, web content refers to the information contained on a web page that includes text, pictures, sounds, videos, code or markup describing structure and presentation etc. WCAG 2.0 was published in 2008 and is also now ISO standard: ISO/IEC 40500:2012. WCAG 2.0 has already been adopted and referenced by many organizations and governments around the world. Countries where only ISO technical standards are used, can now adopt WCAG 2.0 by referencing ISO/IEC 40500. The WCAG 2.0 [3] is the most adopted set of guidelines. It covers a wide range of recommendations. While searching how WCAG [3] treats dyslexia, the guidelines references for cognitive group elaborate about the problems of diverse group of cognitive disabilities. Additionally, one success criterion (i.e. 3.1.5 Reading Level) of WCAG 2.0 directly mentions dyslexia [3]. In WCAG guidelines, the concept of dyslexia is indirectly considered, however, without a clear reference, WCAG [3] readers can ignore reading disabilities.

Though presenting an objective approach, the W3C does not present any guidelines specifically addressing dyslexia with code references and examples.

Dyslexic people find ways to get out of website accessibility issues, i.e., by using assistive tools they can overcome reading difficulties. Mostly they use screen readers (software that speaks the text aloud) but despite using screen readers they still face problems because websites are neither screen reader friendly nor accessible visually. In such situation, we recommend that it is very necessary to take effective measures to make websites accessible visually as well as work accurately via screen readers.

Despite numerous available knowledge over the last few years to encourage and compel web developers to fulfill the responsibility of making websites accessible, websites continue to

display serious accessibility issues. Specific choices of color, size, fonts, layouts and complex navigation and writing style can make it harder and more stressful for these people to use and learn via websites.

Currently, many websites make it difficult for dyslexic people to use them because they developed with accessibility barriers. This discourages these users from using the websites. Internet is built for everyone, but it won't be unless we all including designers, developers, content writers, businesses and the government make efforts to control and fix accessibility issues. Measures to ensure website accessibility are not growing appropriately. Whenever a website is inaccessible, there are chances that the people behind it have not done it intentionally; they might not know the basic needs of dyslexic people. Poorly designed websites can create many hurdles, therefore, we need to control the increasing number of inaccessible websites. It's time for a mindset shift because there is not the knowledge gap to improve accessibility but actually there is action gap.

To understand the matter clearly, we start by studying the accessibility issues of some of the most visited websites by using accessibility testing software. The results showed that currently most of the websites are not fully accessible. The key issues faced by dyslexic people are identified as: confusing website layout, unclear navigation, text size too small, poor selection of colors, too much textual data, no use of graphics, use of complicated language and finally no support for screen readers. Secondly, we have provided basic guidelines for designer, developer and content writers so that they can play their role to lessen these issues with a proposed development framework by utilizing minimum use of resources. Finally, a website prototype is created and evaluated using accessibility evaluation tool and also tested by screen reader software. From evaluation results, it is observed that the proposed website model has considerably lessened the key issues. This research suggests that instead of being something to check off at the end, accessibility should be considered as a starting point and should be focused throughout the software development life cycle. Frequent accessibility testing approaches should be adapted from the beginning of website design and development to minimize the cost of fixing it later. We further recommend that accessibility concerns can easily be accommodated only if websites are designed, developed, tested and maintained appropriately according to the guidelines.

## 1.2 Problem Statement

Existing web accessibility standards such as WCAG are built to provide accessibility to diverse groups of disabilities. Thus, it seems very difficult, time consuming and challenging task to fully ensure accessibility for wide array of disabilities. WCAG guidelines along with guidelines for diverse cognitive group of disabilities, some of the dyslexia friendly practices are mentioned. However, these standards do not provide the main set of guidelines to achieve accessibility specifically for dyslexic users in regards to websites user interface (UI) requirements.

Unfortunately, many technology experts are unaware of the accessibility standards. Many designers and developers are non disable so, they make the mistake of assuming that everyone sees and uses the website in the same manner. Accessibility of websites for dyslexic users is often overlooked because developers are unaware of how dyslexic users use the websites, what types of barriers they face, what are their needs, and how they use assistive technologies such as screen reader.

Businesses stakeholders may also think that digital accessibility is not applied to their product, service or website. Though they agree it is important, competing priorities, limited availability of resources (time, budget, tools, people) often push accessibility at the backside. Also, digital accessibility is often considered an afterthought especially in countries where it is not strictly enforced to follow accessibility standards.

Previously, researchers have conducted experimental studies by involving dyslexic people to identify attributes such as suitable font size, font type, background color, text color, spacing specifications and other attributes etc. Efforts were made to research about dyslexia and web accessibility issues but many of the existing studies have tested and recommend specifically an individual attribute such as suitable font size for dyslexics. While some other studies have focused on multiple sets of attributes, but there is no work that consolidates all the main recommendations and a framework to suggest a roadmap to developers about how to make websites accessible for dyslexics by using limited available resources and by considering accessibility as a development priority.

### 1.3 Objective

- To understand the accessibility issues, some popular websites are evaluated using automated accessibility testing tool.
- To determine the key/basic website accessibility guidelines associated with dyslexic people.
- To provide a framework for developing accessible websites for dyslexics.
- To develop a prototype according to proposed guidelines and framework and finally to evaluate the prototype using online accessibility testing tool and screen reader.

### 1.4 Motivation

The decision to work on the web accessibility for dyslexic users is motivated by following reasons.

- **Dyslexia is widespread**

There are almost 8 billion people in the world [6][8]. According to “World report on disability” [8], produced mutually by the World Bank and World Health Organization (WHO), there are over one billion disable people that is about 15% of the world population and their number is increasing with time due to the rapid spread of chronic diseases, population ageing, as well as improvements in the disability measurement methodologies [8]. Dyslexia is generally thought to affect around 10% of the population, 4% severely. Prevalence is often recorded at 10 percent, however, according to statistics published by the Dyslexia Center of Utah [5] it is the most common language based learning disability among users that approximately affects 20 percent of the United States population. International Dyslexia Association (2022), states that 15-20 percent of the world population experience at least one symptom of dyslexia throughout their lives [7].

- **Web is an Important Source of Information**

The Web is an increasingly important source that serves in many aspects of life such as education, commerce, entertainment, employment, government, healthcare and many more. Accessibility of web is becoming an extremely important topic in our digital first world because the internet has become integral in our lives and there is hardly anything

that we can do without it. Whether we want to learn, entertain, shop, eat, travel or work we can easily do so by visiting a website or app by clicking just a few buttons or links. Internet is becoming less a luxury and more a necessity for all of us but not everyone has good experience while using websites especially disable people suffers because their needs are different and they use websites in a different way. The excellence and power of the web is its universality. The Web is primarily designed to work for all people. Undeniably, access to information and communication technologies is recognized as a basic human right. Therefore, in an increasingly digital world, everyone should have been given equal opportunity to be able to easily understand the online content. Designing and building accessible website is very crucial and should be respected and understood by all with the utmost priority.

## **1.5 Relevance to National Needs**

The decision to work on the web accessibility for dyslexic users is motivated by following reasons relating to its social relevance and national needs:

- **It is helpful for designers, developers, content writers, businesses and government of Pakistan**

Along with designer and developer these guidelines will be helpful for content writers to create dyslexia friendly content. These guidelines will also be beneficial for government policy makers to set some criteria and policies for making government and other websites accessible. Disability should be given a development priority because of its higher prevalence especially in lower income countries and also because disability and poverty perpetuate and reinforce one another. Therefore, this study will assist our country because there is a need to strictly adopt digital accessibility laws and regulations to control the number of inaccessible websites. So, Pakistan can create its own set of standard guidelines for web accessibility or may adopt the exiting standards to ensure that websites and mobile applications are accessible.

- **It will reduce illiteracy and unemployment rate in Pakistan**



People with disabilities including dyslexics are often forgotten while developing websites due to which they continue to face exclusion and discrimination. And even though these people are vulnerable, their needs are overlooked. Due to the obstacles and the lack of opportunities available to them, they face learning, employment and health related issues. Therefore, efforts to reduce illiteracy, unemployment and poverty can only be effective if we include these people in every aspect of life and make learning easier and better for them.

- **It will increase the audience reach and website profit**

Accessibility is important because of its ethical and economic reasons. It is the right, smart and essential thing to do for individuals, businesses and society because making websites available to a wider audience will enhance user experience, satisfaction, increase web traffic, engage the users to use websites and ultimately leads to more sales and profit.

## **1.6 Advantages and Importance**

- Accessibility is a crucial factor for the organizations to be considered on their websites because it is directly related to profit, legislation, and the reputation of the organization in a society.
- Web developers can have a major impact on the lives of dyslexic learners. To achieve accessibility and maximum benefit, developers need not to be a professional developer, but they need to be aware of what dyslexia really is, the basic needs of these users, how it can influence learning and awareness about key guidelines and how to resolve their accessibility issues.
- Accessible websites improve overall user experience and satisfaction of dyslexic users as well as other users such as older users, visually impaired users and users with low literacy skills. Accessibility guidelines that are good for dyslexics are good for all other users. The use of dyslexia friendly accessibility guidelines are beneficial not only for dyslexic users but are also good for all users since these practices ease the problems faced by most of the internet users, as well as other disabled users [9][10][11].
- By producing accessible content and websites for dyslexic people, we, as a society, ensure that dyslexics can become talented and productive member of the society.

Accessible websites will support and encourage these learners to learn easily via web and become successful in life. Any kind of disability, especially reading disability, can harm the child's academic achievement and now a days being excluded from the web is a great disadvantage that will often result in emotional and behavioral problems.

- Another benefit of web accessibility compliance is lawsuit prevention. Web accessibility is required by law in many countries and its violation may lead to serious consequences. This topic needs to be focused due to the legal reasons such as increasing number of digital accessibility lawsuits being filed in countries like United States [13]. Digital accessibility has received increased attention in the past few years. During the COVID-19 epidemic, people with disabilities are extremely impacted [12]. The COVID-19 pandemic has brought the importance of digital accessibility further into public eye.
- There is no need for the installation of additional software. Online tools are available to identify the accessibility issues and helps developers in removing those issues easily. The proposed guidelines and development methodology will help developers in making accessible websites in an efficient way. Developers can detect main issues using free tools and it is the easiest and cheapest way to control website accessibility issues around the world to a great extent.
- This research will encourage the researchers to investigate other challenges of web accessibility that have not much focused in the past.

**Briefly, the four key benefits of accessibility are:**

**Business:** Increase in profit due to increase in audience reach.

**Legal:** Meet to anti-discrimination laws.

**Technical:** Easy to maintain and clean code.

**Social:** Being a socially responsible business that contributes to build a better world.

## **1.7 Area of Application**

Web accessibility recommendations can be easily applied in development of websites including:

- Government websites
- Educational and Entertainment websites
- News websites

- Banking, Healthcare, Business and E-commerce websites
- Portfolio websites and Blogging websites
- E-magazines and E-books
- Public Forum Websites and others

## 1.8 Thesis Outline

The rest of the thesis is organized into six chapters. Chapter 2 provides the background, available standards, current challenges, motivation and need for providing a better solution. Chapter 3 presents the accessibility evaluation results of some most visited websites to give a brief review of the extent to which standards are currently met. In Chapter 4, our proposed guidelines are discussed followed by a website development framework in Chapter 5. Chapter 6 presents corresponding evaluation results of the proposed solution. In Chapter 7 limitations are discussed accompanied by the conclusion and future scope of this research in Chapter 8. A brief thesis outline is also shown in Figure 1.1.

<b>Chapter 1: Introduction</b>	<ul style="list-style-type: none"> <li>• Problem Statement</li> <li>• Advantages and Importance</li> </ul>
<b>Chapter 2: Literature</b>	<ul style="list-style-type: none"> <li>• Existing Accessibility Standards</li> <li>• Related Work on Accessibility of Dyslexics</li> <li>• Current Website Accessibility Statistics</li> </ul>
<b>Chapter 3: Accessibility Evaluation</b>	<ul style="list-style-type: none"> <li>• Accessibility Evaluation of Existing Websites</li> <li>• Discussion on Evaluation Results</li> </ul>
<b>Chapter 4: Proposed Guidelines</b>	<ul style="list-style-type: none"> <li>• Scope Description</li> <li>• Dyslexia Friendly Website Guidelines</li> </ul>
<b>Chapter 5: Proposed Framework</b>	<ul style="list-style-type: none"> <li>• Proposed Website Development Framework</li> <li>• Benefits of Proposed Framework</li> </ul>
<b>Chapter 6: Evaluation</b>	<ul style="list-style-type: none"> <li>• Development of Dyslexia Friendly Website Prototype</li> <li>• Evaluation using Automated Tool and Screen Reader</li> </ul>
<b>Chapter 7: Limitations</b>	<ul style="list-style-type: none"> <li>• Limitations of guidelines and framework</li> </ul>
<b>Chapter 8: Conclusion &amp; Future Work</b>	<ul style="list-style-type: none"> <li>• Conclusion</li> <li>• Future Work</li> </ul>

**Figure 1.1:** *Thesis Outline*

# LITERATURE REVIEW

## 2.1 Overview

In this chapter, we have briefly explained the problems faced by dyslexic people, some genius dyslexic people, available assistive technologies to overcome their problems and existing web accessibility standards. Furthermore, previous work done on web accessibility describing the problems experienced by dyslexic people and current website accessibility statistics explaining the need and importance of web accessibility are also discussed in this chapter. Finally, we have presented the discussion about the findings and what is missing in the literature.

## 2.2 Dyslexic people

Dyslexia is a difficulty in information processing which mainly affects reading, writing, spellings and working memory [7]. Working memory is the part of human brain that helps us to retain and act upon information recently given to us. Some of the challenges faced by dyslexic people are mentioned below:

- They read slowly, hesitantly or may misread words [14].
- They have bad writing skills and write slowly.
- They have poor or inconsistent spellings.
- They face difficulty while matching sounds to letters. They might see, read or write letters as reversed, flipped or mirror image e.g. they often put letters in the wrong way such as confused between "f" and "t" or read letter "d" as "p" or "b" or "q" [14]. They may also put figures in the wrong way (such as writing "9" instead of "6").
- When letter "g" is written using Times New Roman font, they may mistakenly read letter "g" as number "8". They might read "modern" as "modem" because "r" and "n" together look like "m". They also find it difficult to read the material if unusual or stylish font

faces are used. Hence selecting appropriate font face and appropriate letter spacing is also very significant.

- They can also confuse the order of letters in words and thus disordered letters and words while reading or writing [14].
- They feel letters as floating, blurred, reversed, not in line or moving around on the page.
- They forget what they have just read or been told. Thus it is difficult for them to comprehend.
- They face trouble while reading large blocks of text. They find it difficult to understand comprehension as they easily forget the article they just read [14].
- They often switch off and start day dreaming.
- They easily get tired while reading or writing.
- They are slow learners so need to read sentences numerous times just to understand the meaning.
- They face difficulty in concentrating and maintaining focus to stay on the task.
- They are easily distracted by advertisements, audio or video noises when they visit websites.
- They have issues with working memory so words fall out of their heads very literally.
- Remembering multiple instructions is very difficult for them.
- They struggle to meet deadlines.
- They need longer to read so fast moving text on websites is also problematic for these people.

The symptoms also vary for different age groups. Preschool signs may include late speaking, slow learning of new words, difficulty in remembering rhymes or difficulty in naming or learning letters etc. School going children signs may include trouble in reading, decoding, remembering weekdays, months, spellings, sequences or selecting the correct word etc. Young people may read slowly, mispronounce words, or face trouble in memorizing etc. Dyslexia affects everyone differently. Not all dyslexic people face all these difficulties. The symptoms may vary from person to person. Some people have mild symptoms while some have severe [7]. Another fact is that people are born with it and struggle with it not just in childhood but throughout their lives [7]. If it is diagnosed early it can be treated early. However, many people are not diagnosed until they become adults, therefore, it is also known as a hidden disability.

### **2.2.1 Genius Dyslexic People**

Dyslexic people are often intelligent, creative thinkers and extraordinary gifted in certain areas [16]. Thomas Edison, Albert Einstein, Henry Ford, Tom Cruise, Steve Jobs, Muhammad Ali and many other famous and extremely talented people are also dyslexic [15]. Muhammad Ali said that his teachers were not aware of dyslexia so they labeled him as slow, stupid, lazy etc. No doubt dyslexic people can succeed in life but the main obstacle for them is that they lose confidence when people label them as slow or stupid. They became demotivated, stressed and gave up due to bad behavior of society as nobody understands them. Initially, the motivation and guidance from teachers and parents at school level is vital for these people. Additionally, in order to help dyslexic people, developer can also play an important role to make their life easier by making more and more dyslexia friendly websites, apps, tools and technologies.

### **2.3 Assistive Technologies**

There are numerous hardware devices and software applications that can assist dyslexic people by making their life easier and better [17]. By using these technologies people of all ages can perform their tasks easily. These technologies can effectively improve their confidence in reading, writing and understanding of content.

Some of the technologies that make writing process easier are:

- Spell checker
- Grammar checker
- Word prediction
- Speech to text converter

Some of the technologies that make reading process easier are:

- Screen Readers (Software that convert text to speech)
- Screen Magnifiers
- Highlighters (Highlight Text while reading)
- Colour Overlays
- Handheld Devices (i.e. Hand reading pens)

- Plugins
- Extensions

Many such tools are available that overcome the challenges faced by dyslexic people in everyday life such as in education and while using computers. Some examples of technologies that can be used while interacting with computers are:

- Read Aloud: Text to Speech Reader
- Pen Friend XL: Predicts the next word user want to type.
- Claro Screen Ruler Suite: Highlight part of screen, change color contrast.
- Help me read: It is a chrome extension. It allows users to change various features of a Web page. It can also enlarge one word at a time. This feature maintains the focus on each single word, thus overcoming the difficulty of losing focus.
- Some other helpful technologies are Text help, Kurzweil, Dragon, Zoom Reader, Learning Ally, Speak It and Read2Go.

## **2.4 Existing Web Accessibility Standards**

The widely used web accessibility standards are discussed below.

### **2.4.1 WCAG**

The Web Accessibility Initiative (WAI) by World Wide Web Consortium (W3C) [2] creates international Web standards for HTML, CSS, XML and many more to promote accessibility. W3C standards provide accessibility guidelines, technical specifications, strategies and supporting material that describe solutions to developers so that they can understand and implement accessibility. These standards are widely accepted and adopted web accessibility standards. W3C has issued the Web Content Accessibility Guidelines 2.0 (WCAG 2.0) [3] with the goal of providing knowledge to make web accessible so that it addresses the needs of all people along with people with various disabilities. According to WCAG, web content refers to the information contained on a web page that includes text, pictures, sounds, videos, forms, code or markup describing structure and presentation etc. WCAG 2.0 has already been adopted and referenced by many organizations and governments around the world. The WCAG 2.0 [3] is the most adopted set of guidelines. It covers a wide range of recommendations.

### ***2.4.1.1 WCAG Brief History***

Accessibility Guidelines Working Group (AGWG) of W3C has developed WCAG guidelines. AGWG is issuing guidelines since 1999 and its version evolves with time. This series of guidelines that continues to evolve periodically and its first version WCAG 1.0 was released in 1999. WCAG 2.0 is the most adapted version that was issued in 2008 (later became ISO standard named ISO/IEC 40500 in 2012). Later WCAG 2.1 was released in 2018 then WCAG 2.2 in 2021 and currently working on WCAG 3.0 (formally named as Silver) that is not published yet but it will be published soon in future. WCAG 1.0 was outdated because it had many limitations such as it was technology dependent and HTML focused. As technology is rapidly evolving, so to address new issues, WCAG 2.0 has proposed a new guideline approach that is more accurate, more easy, not technology specific and works well with emerging technologies such as CSS, Java Script, PDF, HTML, XML, XHTML. Guidelines are written in technology neutral language so they are applicable for numerous technologies including web browsers, websites, mobiles phones, tablets, laptops, desktops, applications, tools, plugins, assistive technologies, media players, e-books etc.

The WCAG guidelines are organized under four major principles. Every principle further contains various guidelines along with advisory techniques and the evaluation criteria for each guideline based on three defined conformance levels. Over many years, guidelines about accessibility exist in form of checklists along with hyperlinks that provide further detailed explanations, examples and testable criteria.

### ***2.4.1.2 WCAG Principles***

WCAG principles make it easy for developers to understand that which recommendation influences which part of web and also assist developer to find relevant guidelines. Four principle of WCAG are:

- **Perceivable:** Present web content in different ways that are easy to perceive by all people. Content should also work well with assistive technologies without changing original meaning. Providing image text alternatives allows user agents such as screen reader to read images for people who cannot see. Also provide all audio or video content in written form so that people who cannot hear can read it.



- **Operable:** This principle focus on providing an easy way to perform required task such as giving support to people to complete task via keyboard, provide enough time to read, provide easy navigation that help to interact with interface and browse web content easily. For instance, offer multiple ways to find material because some users prefer search functionality while others rely on hierarchical navigation.
- **Understandable:** Web information should be easy to understand. Provide input assistance, readable text and avoid unusual or complex words.
- **Robust:** This principle focus on making web compatible with other tools. The web content should be interpreted reliably by various user agents such as assistive technologies.

#### ***2.4.1.3 WCAG Conformance Levels:***

Success criteria are defined using three testable conformance levels where single A is the lowest level while triple A is the highest level. These levels are prioritized according to the importance of the requirement. Each guideline can be evaluated using these levels:

- **A:** It is priority 1 level checkpoint that must be satisfied by developers. It provides basic accessibility level and it seriously affects the people with disabilities.
- **AA:** It is priority 2 level checkpoint that should be satisfied by developers. It provides intermediate accessibility level that ensures desirable accessibility.
- **AAA:** It is priority 3 level checkpoint that may be satisfied by developer. It provides high accessibility level that ensures full accessibility.

These criteria help to identify required conformance levels to reach the goal of accessibility. Each conformance level indicates an increasing accessibility level. For a website or webpage higher level conformance indicates that lower level has also achieved conformance. For example conformance to level AA indicates that both the level A and AA conformance have met.

#### ***2.4.1.4 WCAG is created for whom***

WCAG and other WAI resources are created primarily to assist:

- Web developers, page writers, designers, etc.
- Tool developers including Web authoring tools, accessibility evaluation tools etc.
- Other who need a standard either for mobile or web accessibility including various organizations, managers, and policy makers of countries laws etc.

W3C has issued several other guidelines as well because different components work together in the web so for making it accessible different web technologies are needed to become accessible on which web depends such as web browsers, user agents, authoring tools and websites etc.

#### ***2.4.1.5 Other guidelines by W3C***

Some other guidelines proposed by W3C are:

- Authoring Tool Accessibility Guidelines (ATAG)
- User Agent Accessibility Guidelines (UAAG)

ATAG guidelines can enhance authoring tools while UAAG guidelines can enhance various user agents such as text to speech software.

#### **2.4.2 Others Countries Accessibility Laws and Standards**

Web accessibility has gained significant attention and has attracted many governments and researchers across the world. Many nations have developed standards, laws and policies for providing digital accessibility. Laws were put into place because many businesses do not prioritize accessibility. Therefore, these laws safeguard the rights of disable people on the internet and violation of laws could lead to lawsuit.

WCAG guidelines are widely adopted around the world including some local web accessibility legislation and policies:

- Americans with Disabilities Act (ADA)
- Australian Disability Discrimination Act (DDA)
- Accessibility for Ontarians with Disabilities Act (AODA)
- UK Public Sector Bodies (Websites and Mobile Applications)

Some other countries and regions that have released their own accessibility guidelines include:

- USA: Section 508
- UK: British Standard 8878 (BS 8878)
- Canada: Common look and feel (CLF)
- Spain: Norma UNE 139803
- Sweden: Swedish National Guidelines for Public Sector Websites (2006).
- Italy: Stanca Act4 (Italian accessibility guidelines)

However, some organizations or companies have also developed accessibility guidelines such as:

- IBM Web Accessibility Checklist (IBM 2017)
- BBC (2018) issued their own guidelines and many of them are inspired by W3C guidelines.

#### ***2.4.2.1 Americans with Disabilities Act (ADA) and Section 508 Standards***

The ADA protects the rights of people with disabilities in public places, employment, as well as over the websites. ADA was passed in 1990 in US and applicable to websites since 2003. Section 508 of US set of regulations state to provide access to electronic information related to federal government agencies. According to the ADA Title III, websites must be accessible and acknowledge WCAG as a standard. ADA Title III web accessibility lawsuits are increasing [61]. Many companies have received ADA lawsuits due to providing inaccessible services. Sometimes same company received multiple lawsuits for providing inaccessible website or mobile apps by different peoples regardless of the fact that how many times the company has settled the issue. Therefore, the best way of defending lawsuits is to work on accessibility. Several tools have also been developed to evaluate the accessibility of websites against different standards. Most of the existing tools focus on detecting errors based on WCAG guidelines.

## **2.5 Related Research Work**

Al Wabil [18] has presented an exploratory study to investigate how dyslexic people experience while surfing the Web. He conducted semi-structured interviews of 10 dyslexic people to know their difficulties while browsing, navigating and searching. The interview of single person was completed in 50 to 60 minutes. During the interview, sample website slides were displayed on projector to provide illustrative navigation approaches for further discussion. Navigation patterns

while navigating within a website were discussed. Use of search box, site maps, site index, navigation menus, back and forward buttons was examined in this study. Participants shared the thought that they get frustrated with complex navigation structures. The authors conclude that they interviewed a fairly small number of people but the analysis indicated the existence of navigation problems. This paper has reported only the participant's behavior, problems and preferences while navigating the Web without providing clear guide to remove these barriers. This paper has highlighted that Web has many navigation problems for dyslexic people and developers and designers need to think more widely than their assumed Web audience.

Luz Rello and Ricardo Baeza Yates [19] have conducted an experimental study by using eye tracker to evaluate how the font types can impact the reading performance. They tested 12 different fonts on 48 dyslexic people to discover the best fonts. The most popular and common fonts were selected for the study. These fonts include: Arial, Courier, Arial Italics, Helvetica, Computer Modern Unicode, Myriad, Garamond, Open Dyslexic, Times, Open Dyslexic Italics, Verdana and Times Italic. Twelve different text paragraphs were used and each paragraph has same number of words (60 words). The length of word is also nearly same and same layout was used for all text paragraphs: left justified, font size 14 points, black text on white background etc. Eye tracking and reading was recorded when participants read these twelve different texts with different fonts. The reading time and fixation duration was examined. The study concluded the font type effect of readability of dyslexic people. Best fonts that improve reading speed of dyslexic people are suggested as Helvetica, Arial, Courier, Computer Modern Unicode and Verdana while italics should be avoided because they decrease the readability. This study has presented a set of accessible fonts for dyslexia people.

Gregor and Newell [20] examined 12 computer literate dyslexic people to check how different typeface, font sizes, background and foreground colors, spacing between characters, spacing between words, spacing between lines, column widths can improve the readability of documents created using "MS Word". Questionnaires, interviews as well as think aloud techniques were used to gather data for evaluation. The participants were asked to use MS Word software and were allowed to change default settings as they found it easier to read. Everyone has done settings which were better for them and make reading process easier than the default settings. Extremely varied screen layouts were developed to use by these people and this act has

highlighted that everyone has their own preference. Participants have selected their favorite colors combination while some reported that their own color settings make reading better for them. Mostly, participants picked Sans Serif Arial typeface and they agreed that it is best due to its simplicity and clarity. This font was preferred over complicated or flowery fonts. Most of the participants agree that using bold will decrease readability because it makes letters more compacted together. Most participants choose font size larger than 12 points and prefer increased spacing between lines, words and characters. It was also observed that they tend to read two words in combination if too small spacing was used. The study also found out that some people are unaware of how some simple changes can dramatically improve their reading speed. Furthermore, according to preferences, he developed a prototype of text reader having easy to configure interface that allows users to alter some variables. The evaluation results showed that participants are highly satisfied. The results of this study were included by Peter Gregor and Anna Dickinson in "SeeWord" tool that provides word processing environment [21]. The findings also revealed that users changed the document features in highly individualized ways when asked to change settings according to their preferences, showing the lack of a consistent "dyslexic" profile [21]. Later on, Dickinson et al. investigated "SeeWord" tool with six participants and results showed that reading comfort and accuracy has improved using this tool [22].

Kurniawan and Conroy [23] performed an experimental study with 27 dyslexic university students to investigate online reading performance with different color schemes and complexities. They observed the effect of comprehension complexity level and colors on reading speed and accuracy. The participants were asked to read five online articles having varied complexity levels. To check their understanding level, they have to give answers to questions related to comprehension. Participants made more mistakes as the reading material became complex. This study has found that for complex articles the participants' understanding was poorer because participants gave wrong answers to questions. However, by using color overlays, the dyslexic people don't read slowly when the articles are presented using their preferred color scheme. They also agreed with the idea that every individual choice is different. This study further explored that technical aids such as screen readers and color overlays are also used by these people but these tools cannot overcome comprehension difficulties.

Santana et al. [24] developed an extension named "Firefixia" for Mozilla Firefox. This extension was developed to overcome the difficulties of dyslexic people. Customization settings allow changing the text color, background color, font size, font type, column width, line spacing, letter spacing etc. Four dyslexic users evaluated "Firefixia" in detail on a website and they appreciate customization. This work explored that Web browser customization toolbar has improved the Web accessibility because they allow users to customize the web page presentation according to their preferences. Participants have also provided feedback via questionnaires. They agree that customization features are helpful, easy to use, easy to access and explore. They further reported that color, text size and alignment are the most useful features. The toolbar succeeded in achieving its objectives by pointing a new and interesting direction of website end user customization.

O'Brien et al. [25] measured reading speeds of dyslexia and non-dyslexic children (age 6-10 years) using 12 different font sizes with different age groups. They demonstrated how dyslexic people read fits the same curve as skilled read, with stable reading rates for large font sizes and a sharp decrease in reading rates below a critical font size. This study has shown the developmental change of preferred font size with age. The results have shown the critical print size reduction with age. This study suggested that younger children need larger critical font size to optimize their reading performance.

Zorzi et al. [26] performed an experiment with 74 dyslexic children (40 French and 34 Italian, aged 8-14) to find a way that could allow them to read more words in lesser time because reading is one of the main problems. These children were asked to read texts presented on paper with normal letter spacing and extra broad letter spacing (a 2.5 pt. increase in the standard letter spacing using Times font with size 14 points). The findings conclude that texts represented with greater letter spacing lead to improve reading accuracy and speed. Dyslexic people are affected by crowding therefore extra-large spacing helps them to clearly read the material with ease.

Rello et al. [27] conducted a user study by involving 23 dyslexic people. Interviews and questionnaires were used to gather qualitative data while quantitative data was collected using an eye tracker that was used to carry out different tests. By analyzing both types of data, this study has presented a set of dyslexia-friendly guidelines to make web text more readable. Most favorite color

scheme chosen by participants was yellow/black combination while eye tracker data showed that it was hardest to read. To improve Web accessibility, the authors have presented guidelines related to font color, background color, font size, font type, line spacing, paragraph spacing, character spacing and column width. Later on, the results of this study were used to build two tools that allow text modification. The Web service Text4All [28] developed for websites and the Android IDEAL dyslexia friendly eBook reader [29] developed for eBooks both has integrated the results of above study. Using the think aloud procedure with 14 dyslexic people [30], its usability and functionality were assessed. The participants reported a subjective improvement in reading and comfort.

Rello et al. [31] later presented another study about text presentation because the way text is presented has a major impact on readability of dyslexic people. This study used eye tracker to measure performance of 92 people. This work studied same eight parameters but this time 46 participants were dyslexic and 46 participants were non dyslexic. This study has found that for both types of participants, large text size and large character spacing leads towards faster reading. This study finally concludes that there are so many other factors as well that affect readability. The suggested approach has covered only text presentation guidelines and ignored the content related guidelines.

McCarthy and Swierenga [32] reviewed the existing literature knowledge regarding intersection of dyslexia and web accessibility generated until 2010. They found that in comparison to studies about other groups with special needs, few literature studies covers dyslexia and accessibility. The majority of accessibility initiatives are focused on serving users who are blind or visually impaired or quiet to a lesser extent focusing on people who have cognitive disabilities. The existing work placed dyslexia in the background of other disabilities which hides particular needs of dyslexia people while interacting with the Web. The authors share that some dyslexic accessible practices overlap with low vision or cognitive impairments. The study uncovered that numerous guidelines are available for dyslexia friendly interfaces, however, only few studies exists that have conducted usability testing. By reviewing existing guidelines, it is argued that dyslexia friendly accessibility practices redress the difficulties faced by every internet user. This study summarize that great work has been done to research dyslexia as well as Web accessibility, however studies that address both these topics simultaneously are scarce. The study also tells that

many dyslexic people use screen readers so efforts are needed make websites that optimally work with screen readers even if the target audience of screen readers is widely assumed to be blind people [33]. This study mainly presented the indicators, without objectively showing how to apply guidelines for eliminating the existing barriers. As the websites are continuously avoiding dyslexic accessible guidelines therefore this topics needs further attention.

Santana et al. [34] conducted a survey and compiled 41 Web accessibility guidelines for different stakeholders involved in making websites so that these guidelines can help them in making Web an accessible place for dyslexics. They also identified that dyslexia is not widely understood therefore it is often not included in Web accessibility studies. To remove existing barriers they have presented guidelines for content producers, developers and designers. These 41 guidelines belong to nine groups: navigation, colors, text presentation, writing, layout, image / charts, customization by end users, markup, video and audio. This study has only suggested guidelines without conducting any user study to evaluate the accessibility.

Luis et al. [35] have developed chrome browser extension named "WebHelpDyslexia" to assist dyslexic people of the Web. The implemented features of extension were based on results of previous extensive empirical studies. This extension make it easier to read web content by allowing user to change many layout features such as font type, font size, foreground & background color, paragraph spacing, alignment, remove italics & underlines. It also allows users to search synonyms, highlight text and provide fading option to help them concentrate on specific parts using screen ruler. They suggested such tools that allow customization can have significant impact to make Web more accessible.

Rello et al. [36] conducted empirical study with 62 people (31 dyslexic people) using eye tracker study to explore the effect of highlighting key words and main ideas using boldface. They found that highlighting main ideas and key words have improved the comprehension and readability. This practice is especially used by teachers to teach these people. The participant's preferences were gathered via questionnaires. Based on direct observations and quantitative analysis, it is recommended by authors to use this approach while presenting text material on computer screen.

Freire et al. [37] conducted an empirical study using a think-aloud protocol with 13 dyslexic participants on 16 websites. The study found 693 usability and accessibility problems and most



frequent problems were related to information presentation (illogical information ordering, irrelevant information), navigation, mal functioning (search, autocomplete), content (captchas, abbreviations) and language issues. This research has only identified the problems without recommending any approach towards solution.

Rello and Barbosa [38] analyzed different tools used by dyslexic people to check whether they are beneficial or not. They analyzed Kindle, Firefixia, iBooks, SeeWord, Text4All and IDEAL eBook Reader. The main features provided by these tools were summarized. These tools allows to change font size, font type, colors, brightness, letter spacing, line spacing, word spacing, paragraph spacing, synonyms, column width and provide text to speech facility. They further found that none of these tools provide the features altogether that are of great use for dyslexics.

Katja Kous and Gregor [39] have empirically investigated the response of 6 dyslexic people to a customized website. Questionnaires, interviews, thinking aloud protocol, and usability testing technique were used to record feedback. The website customization was enabled with the help of integrated assistive technology that offers to adjust website according to their individual preferences and needs. This customization feature allows changing only three main parameters that are font type, font size and color (text and background) and ignored all other parameters such as spacing, layout etc. The results of this empirical work showed that customization improve accessibility in terms of satisfaction and performance as compared to default website.

Rello and Bigham [40] have analyzed the impact of background colors on readability of dyslexic and non-dyslexic people. 341 participants (89 dyslexic participants) were involved in study and with evidence this study has proved that selecting certain colors can enhance readability. Mouse movements (distance moved by mouse) and reading time was recorded to measure readability. 10 different background colors were tested with black font color. Results have proved that for both type of participants, warm background colors such as peach, yellow and orange have significantly enhanced readability while cool background colors like blue, green and blue grey have decreased readability.

Renaud et al. [41] presented the password related difficulties faced by dyslexic people. Later on, Renaud et al. [42] analyzed struggles of 13 dyslexic people with alphanumeric authentication methodologies. This work has collected empirical data via interviews. Passwords are often

essentially required to be alphanumeric and with passwords dyslexics experience many difficulties, therefore, the main contribution of this study is to highlight with evidence that passwords are inaccessible as authentication methodology. This work has not proposed any alternative solution.

Berget et al. [43] analyzed the impact of autocomplete function while searching information from Google search engine. Due to spelling mistakes, dyslexic people often choose to complete the search query using autocomplete options and they found it an interesting searching behavior because spellings should be correct for effective search results. 40 participants (20 dyslexic participants) were observed using eye tracker and results showed that although auto complete function is very helpful and reduced the searching struggles however, for some misspellings they have to suffer. Therefore, more extensive autocomplete is needed that may tolerate more errors and further improve performance in certain queries. Such technology may also be used in keywords that employ possible spellings sequences that dyslexic people may type. Wessel et al. [44] identified from interviews (31 dyslexic people and 71 non-dyslexic) and literature work that within site search function needs modifications such as autocomplete, compensating spelling errors to improve accessibility.

Miniukovich et al. [45] presented 61 readability guidelines in series of workshops with dyslexic users and experts. These guidelines have just focused on readability guidelines such as text simplicity (avoid italics, underlines, abbreviations etc.), navigation, functionality (internal website search, site map etc.), visual appearance (font size, font type, spacing, contrast etc.). These guidelines have ignored guidelines to making screen reader friendly websites. Also, no clear approach is given to developers to make accessible website. In another research, Miniukovich et al. [46] presented 39 text presentation related readability guidelines.

The accessibility and usability of e-government websites have been evaluated in several nations. Many researches have put efforts and used different methods for evaluation. Some researchers conducted studies on both usability and accessibility, while others concentrated solely on one of them. Some have used manual testing mechanism by experts, some have conducted interview to know about user preferences while some have evaluated using automated tools. Several nations including China [46] [47], India [48], Saudi Arabia [49] [50], Pakistan [51] Libya [52] and many

others have evaluated the accessibility, usability or both for government websites or against WCAG and mostly researchers have found that the majority of websites exhibits significant problems and they did not even meet the minimum levels of WCAG accessibility. Azwa et al. [53] analyzed Malaysian news website and results also found out many accessibility problems. Carlos et.al [54] have evaluated top 15 university websites home pages of three countries separately including Chile, Mexico and Spain using automated tools that evaluate against WCAG 2.0. Just like previous studies results showed existence of many accessibility problems.

Frazaio et al. [55] presented a study after analyzing eight well known Chrome's accessibility plugin extensions that are widely and freely used by developers through Web Store. These automated tools include: WAVE, aXe Plug-in, Microsoft Accessibility Insights, Tenon, ARC Toolkit, ACCESS Assistant Community, Total Validator and Lighthouse. These tools were compared according to the features set and evaluation results produced by top websites homepages. This study reveals that individual tools have limited feature set coverage and therefore this study suggested that developers are required not to rely on single tool to overcome its limitations use of multiple tools is recommended [55]. Abascal et al. [56] also reported that for better results aggregate the results produced by different tools but Abascal et al. [56] additionally reported that analyzing, summarizing and aggregating results from different tools is a difficult task.

Freire et al. [57] asserted that web accessibility is highly considered as the responsibility of developers and designers because they provide standards, guidelines, tools and develop systems, websites, apps etc. This study observed a gap among developers and accessibility standards due to which website remains inaccessible. Further accessibility issues identified include lack of developer technical knowledge about accessibility standards, lack of accessibility awareness, lack of training or understanding, lack of time and also developers also ignore accessibility because is not demanded as a feature or requirement by customers in web development projects.

Now turning back to research about dyslexia, BDA (British Dyslexia association) [58] is an organization that has suggested 32 guidelines for developers, publishers, teachers, businesses, content writers etc. to create dyslexia friendly digital and printed content. These guidelines are about readable fonts, headings, colors, layout and content writing style.

There is a common agreement among developers that dyslexia friendly guidelines make the web accessible, simpler and easier for all users [23] [27]. It is also widely pointed out that use of complicated content is one of the significant problems that dyslexic users encounter while using internet [27]. Some accessibility guidelines for blind or low vision people overlap with guidelines for dyslexic people [59]. Dyslexia friendly accessibility guidelines also help elderly people (whose abilities have declined due to age) and low literacy people [60] [27]. Even if the target audience of screen readers is blind or visually impaired people, many dyslexic people also use screen readers for assistance, so screen reader friendly guidelines can also be used to improve websites to support dyslexic people.

Bulk of dyslexia related research sources focused on educational, neurological and development skills [32]. The work done on accessibility of dyslexic people is scarce when compared with other users groups such as blind, cognitive impairments etc. [32]. Existing researches have mostly involved limited dyslexic users and provide results about some website elements based on preferences of involved users. Researches about web accessibility for dyslexic people are scarce and there are shortcomings in existing work. Therefore, our work will narrow down all the core set of guidelines and an easy to implement approach that can assist developers to improve website accessibility for dyslexic people. A brief summary of some of the work done on the accessibility of dyslexics so far is also summarized in Table 2.1.

**Table 2.1:** Summary of Work Done on Accessibility of Dyslexics

S.No	Researcher	Methodology	Studied	Findings & Remarks
1.	Al Wabil [18]	Semi-structured interviews (10 dyslexics)	Navigation Problems	No solution proposed.
2.	Luz Rello [19]	Eye Tracker (48 dyslexics)	Tested 12 Fonts	Avoid Italics. Suggested fonts are Arial, Verdana, Courier.
3.	George [20]	Questionnaire, Interview, Think aloud Protocol (10 dyslexics)	MS Word (typeface, font size, color, spacing)	User preferences vary. Preferred font : Sans Serif Arial. Preferred Size: 12 or more. Provide enough spacing.

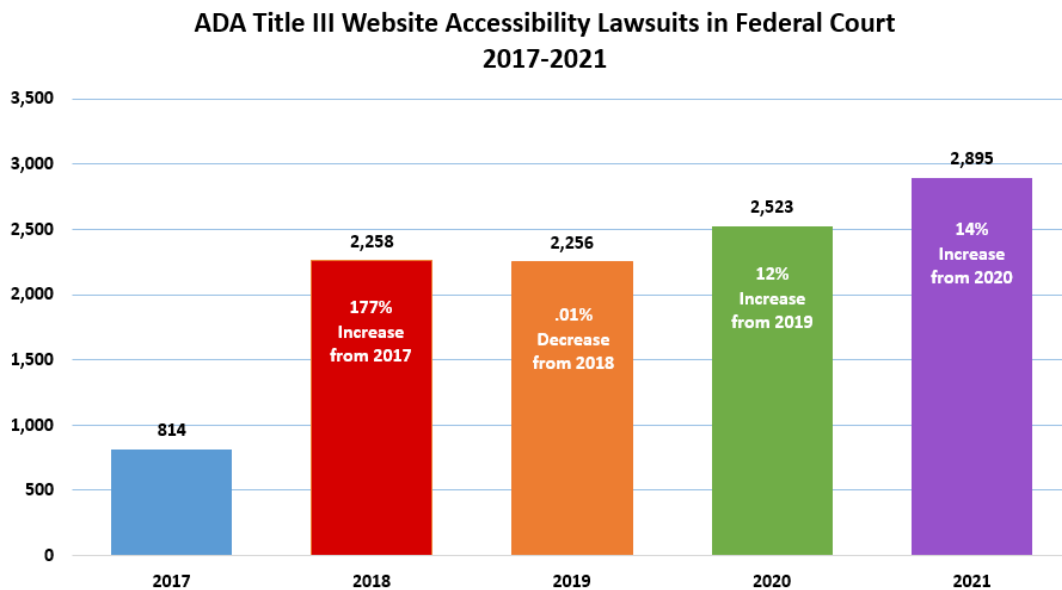
4.	Kurniawan [23]	Observation (27 dyslexics)	Tested comprehension complexity effects on 5 online articles & color schemes.	Poor understanding of complex articles. Individual color preferences. Screen readers are used by dyslexics.
5.	Santana [24]	Interview, Observations Questionnaire	Developed and Tested Mozilla Firefox ToolBar “Firefixia”	Allowed customization (Color, Spacings, Fontface, Font size). Customization improves satisfaction.
6.	Rello [36]	Questionnaires, Observations, Eye tracker (31 dyslexic)	Impact of Highlighting keywords and main ideas.	It will improve comprehension understanding.
7.	Babrosa [38]	Observation and Interview	Analyzed 7 tools: Kindle, Firefixia, iBooks, SeeWord, Text4all, Ideal eBook reader.	Tools allow customization but no single tool contains all the features.
8.	Renaud [41]	Interview	Password related difficulties.	Not proposed any alternative solution.
9.	Berget [43]	Eye Tracker (20 dyslexic people)	Using Autocomplete option while searching query from Google.	Suffer due to wrong spellings. Need of more extensive autocomplete.
10.	Bigham [40]	Reading Time was recorded. Tested 10 background colors with black font. (89 dyslexics)	Impact of background colors on readability.	Preferred : peach, yellow and orange. Not preferred: blue, green and blue grey.
11.	BDA (British Dyslexia Association) [58]	None	Proposed Writing Style Related Guidelines.	These guidelines are for digital and printed content. BDA guidelines are for developers, publishers, teachers, businesses, content writers etc.

## 2.6 Current State of Website Accessibility

Some latest statistical reports describing the state of website accessibility are discussed in this section.

### 2.6.1 Website accessibility litigation under ADA Title III

Since 2013, the number of ADA lawsuits brought out each year has been monitored by the law firm "Seyfarth Shaw" [61]. The results illustrate that ADA Title III website accessibility lawsuits are increasing every year. From year 2017 to 2021, the total number of lawsuit filings per year and the percentage increase when compared with previous year are shown in Figure 2.1.



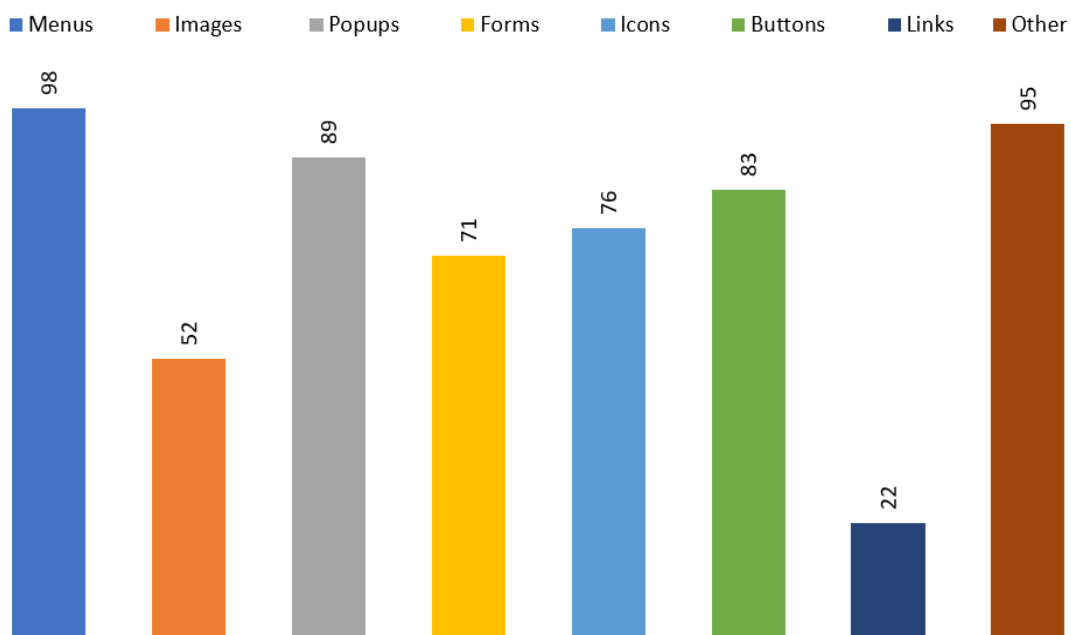
**Figure 2.1:** ADA Title III Website Accessibility Lawsuits from 2017 to 2021[61]

The total number of website accessibility lawsuits filings reported in federal court was 2895 in 2021. While in year 2020, reported lawsuits filings were 2523, which means in year 2021 it has increased by 372 more filings. The lawsuits filings in 2021 have increased by 14% from 2020. It clearly explains that the situation is becoming serious and needs to be addressed.

### 2.6.2 Accessibility Research Report of 10,000,000 web pages by "AccessiBe"

"AccessiBe" is a web accessibility problem solving technological company that uses AI (Artificial Intelligence) techniques. It has trained their AI engines by fully scanning thousands of

websites. Using AI engines, it has scanned and remediated 154,408 small and large businesses websites until now. A report is published by "accessiBe" after analyzing thousands of websites including remediated clients websites and others as well [62]. 85 percent of selected websites were hosted in US and Canada while 15 percent websites were hosted in Asia and Europe. 65 percent of selected websites belongs to top level domains (such as .com, .org, .net etc.) while others belong to next levels. The published report has break down the failure compliance percentages of important elements according to WCAG 2.1 AA. The research results collected after scanning and analyzing 10,000,000 web pages are concluded in Figure 2.2.

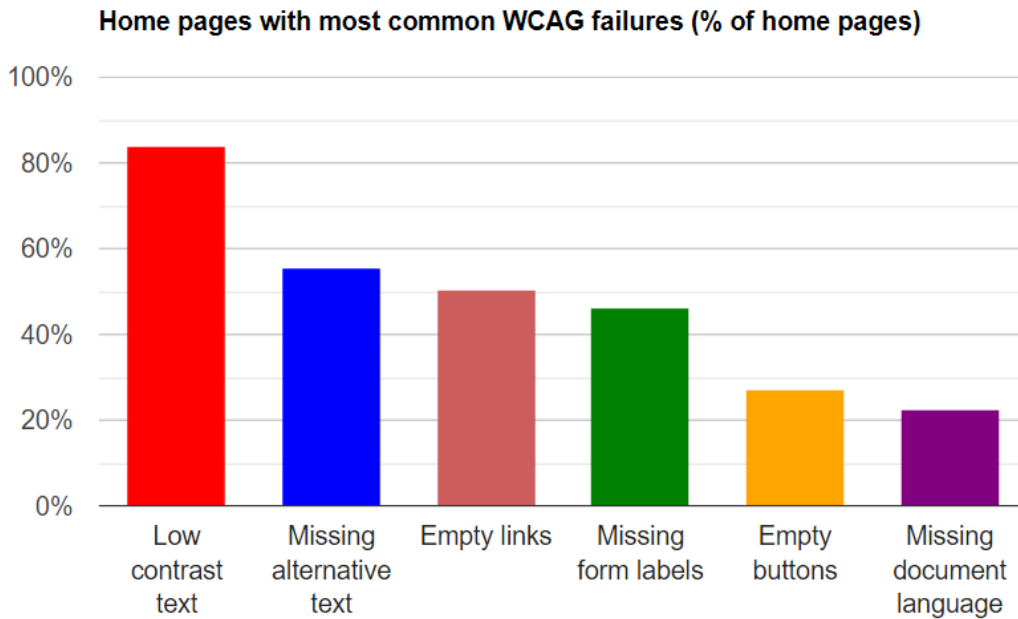


**Figure 2.2:** Percentage of failed elements against WCAG 2.1 AA compliance [62]

The percentage of all pages that did not adhere to the WCAG accessibility rules for menus, images, pop-ups, forms, and other elements are displayed using vertical bars. Figure 2.2 is explaining the bitter truth about the bad shape of websites accessibility. Menus of 98% of the websites have failed to meet the compliance level. 52% image, 89% popups, 71% forms have failed in accessibility and so on. One chief executive officer of "accessiBe" has said that manually achieving accessibility will be extremely difficult so he recommend using their AI based services that automatically make websites accessible by detecting and removing accessibility issues.

### 2.6.3 The Million Accessibility Report 2022 by "WebAIM"

"WebAIM" (Web Accessibility in Mind) is an institute that is providing accessibility solutions, policies, practices, tools and technical skills since 1999 to empower organizations to make accessible content. The Million report published by "WebAIM" in 2022 has analyzed and presented the accessibility status of top 1,000,000 home pages [61] [63]. Results from February 2022 are shown below in Figure 2.3.



**Figure 2.3:** Percentage of Failed Home Page Elements [63]

Almost 84% homepages have color contrast issues and 55% have missing alt text from images. Other common issues highlighted in this work include empty links, empty buttons, missing form labels and missing document language. The WAVE accessibility tool was used to carry out the evaluation. WAVE tool detects WCAG failures. WCAG 2.0 deficiencies were found on 96.8% of website's home pages [63].

Consecutively from four years, "WebAIM" is evaluating the accessibility of the top 1,000,000 websites home pages. The findings provide a summary of the situation regarding current website accessibility as well as trends over time. Percentages of failed home page common elements from 2019 to 2022 are illustrated in Table 2.1.



**Table 2.2:** *Percentage of Failed Home page elements from 2019 to 2022[63]*

WCAG Failure Type	% of home pages in 2022	% of home pages in 2021	% of home pages in 2020	% of home pages in 2019
Low contrast text	83.9%	86.4%	86.3%	85.3%
Missing alternative text for images	55.4%	60.6%	66.0%	68.0%
Empty links	50.1%	51.3%	59.9%	58.1%
Missing form input labels	46.1%	54.4%	53.8%	52.8%
Empty buttons	27.2%	26.9%	28.7%	25.0%
Missing document language	22.3%	28.9%	28.0%	33.1%

96.5% of all the detected errors belong to one of these six categories. For past four years, these six most common mistakes have remained the same. Hence, just by fixing a couple of these kinds of problems would significantly increase web accessibility.

There is still a lot of work to be done to make the web accessible to all users, although in the 2022 analysis very slight improvements in accessibility and WCAG conformance were found.

### **2.6.3.1 Technologies**

On the one million home pages, over 1,200 different types of web technology were found [63]. Almost 1,200 different web technologies were found in these one million pages. Table 2.2 presents the list of popular technologies seen in more than 5,000 home pages, ranked from "best" to "worst".

**Table 2.3:** *CMS, No. of Home Pages and Average number of Errors [63]*

CMS	# of home pages	Avg. # of errors
Squarespace	6,438	19.2
Wix	7,066	22.7
Drupal	26,393	43.3
Typo3	5,173	47.0
Joomla	8,885	47.9
WordPress	305,429	53.7
Rocket	25,029	54.1
Elementor	42,708	54.3
Blogger	7,446	120.0

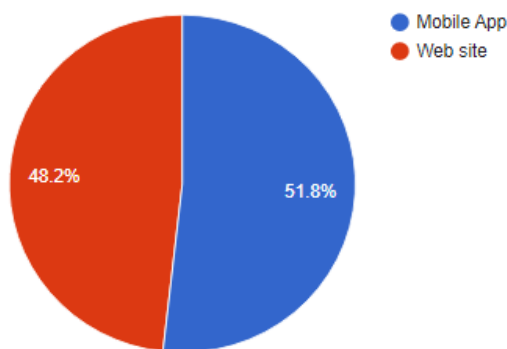
From results it is clear that using technologies does not confirm to accessibility and there is a diversity of impact of CMS (Content Management System). CMS choice is significant as the impact of every technology is different for example home pages using "Blogger" had six times more problems as those using "Squarespace".

#### **2.6.4 Screen Reader Survey 2021 by "WebAim"**

In 2021 May-June, "WebAIM" surveyed 1568 screen reader users to know their preferences [64]. To represents global screen reader users, the involved participants belong to America, Europe, Asia, Australia and Africa (Middle East). Among these participants 92% people use screen readers due to some disability while 8% users do not have any disability. Most of the participants are blind, visually-impaired/ low vision, hard of hearing or have cognitive or motor disabilities. Some relevant statistics from this survey are shared below.

##### **2.6.4.1 Mobile App or Website**

Figure represents the percentage of responses against question "Which would you prefer to use among a mobile app and a website, to carry out basic online tasks like shopping or banking?"

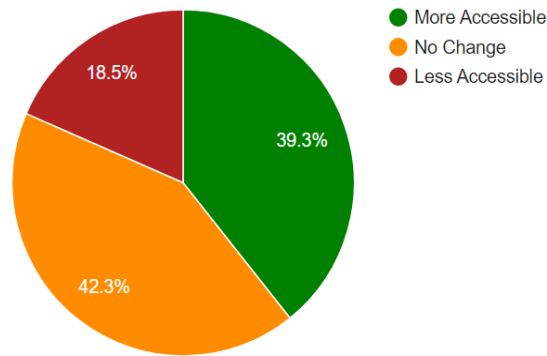


**Figure 2.4:** *Mobile App or Website [64]*

For performing common online tasks, slightly more respondents indicated that they use a mobile app than a website.

##### **2.6.4.2 Progress of Web Accessibility**

Figure 2.5 represent the percentage of responses against question "Which option best describes your feelings about how accessible web information has become over the past year?"

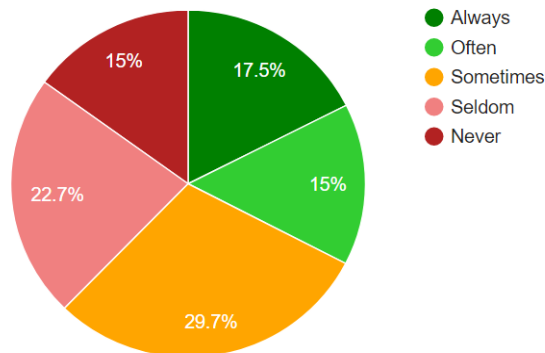


**Figure 2.5:** *Web Accessibility Progress [64]*

Perception of the state of web accessibility has generally not changed in recent years. Respondents without disabilities are more likely to feel positive about recent accessibility progress

### 2.6.4.3 "Skip" Links

Figure 2.6 represent the percentage of responses against question "How frequently do you use a web page's "skip to main content" or "skip navigation" links?"

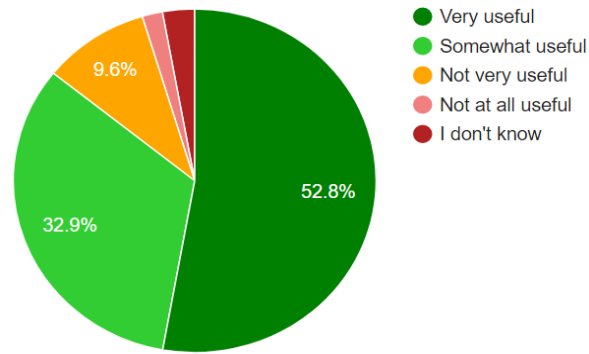


**Figure 2.6:** *Skip Links [64]*

"Skip" links are not often used by screen reader users. Despite varied usage among screen reader users, it's crucial to remember that "skip" links offer clear advantages for sighted keyboard users.

### 2.6.4.4 Heading Levels

Figure 2.7 represent the percentage of responses against question "How much helpful the heading levels (e.g. Heading 1, Heading 2 etc.) are to you while navigating a web page?"

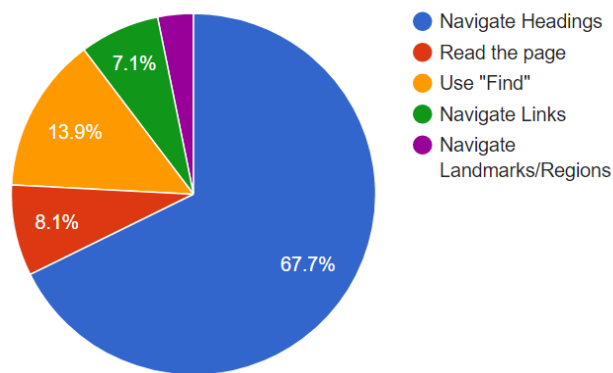


**Figure 2.7: Heading Levels [64]**

85.7% of respondents believe heading levels to be very useful or somewhat useful, the convenience of appropriate heading structures is fairly high.

#### 2.6.4.5 Finding Information

Figure 2.8 represents the percentage of responses against question "Which of the following method you mostly use when looking for information on a lengthy web page?"



**Figure 2.8: Finding Information [64]**

The predominant technique for finding information is still through the headings. This method is very common among proficient screen reader users.

#### 2.6.5 Increasing Demands of Web Accessibility Experts

In an American Newspaper named "The Wall Street Journal", a published article has indicated that many companies are searching for skillful professionals having accessibility expertise [65]. LinkedIn said that the number of job listings with the title "accessibility" between August 2020

and July 2021 were about 12,000. This listing has increased 78% in 2021 when compared with previous year according to LinkedIn. From August 2019 to July 2020, this listing has increased 38% according to professional networking website of Microsoft corporation. "Zip Recruiter" is an American based employment website for job seekers listed that on 27 January 2022 there were about 45,000 positions mentioning "web accessibility".

Accessibility specialist jobs are increasing rapidly because companies struggle to make their products or services more accessible. The need of jobs in the field of accessibility will continue to rise. This need is being driven by various factors:

- Accessibility is legally required and the legal risk has increased. Lawsuits in US, due to digital (websites, apps, videos etc.) inaccessibility are increasing continuously as shown by "Seyfarth" recent data [61]. Digital lawsuits have significantly increased awareness of the need to ensure that everyone should be given equal right to use any digital product. Due to increasing lawsuits the job demand for web accessibility experts has also increased because the companies don't want to face legal issues or become prominent for providing inaccessible services to people with disabilities such as Domino pizza lawsuit was highlighted for providing inaccessible website where a blind person could not successfully complete his order so he bring the case to court and the case is finally resolved after six years [66].
- "WebAIM" Million Report 2022 has exposed that home pages of top websites did not confirm to accessibility guidelines [63].
- Covid-19 pandemic has also raised the need because disable people also become fully dependent on digital tools but found them inaccessible. Covid-19 has made people aware about the importance and need of digital accessibility [67].

## **2.7 Findings and Discussion**

Efforts have been made in the literature to research about the preferences of dyslexic people as well as about the Web accessibility. However, there are not many researches that address both these concepts simultaneously. In existing studies, guidelines are mainly collected via user testing methods that include observations, questionnaires, interviews or think aloud protocol. These studies are evaluated by a sample of limited number of representative dyslexic people.

Results of user's studies may varied because there is no single profile of dyslexic people and results may be confusing or unreliable if the selected sample does not accurately reflects the needs of target users as dyslexia symptoms vary from person to person. Every person have their own preference about colors, font style and other elements so instead of suggesting a specific color or font just by analyzing limited set of users, we should select those that are widely adopted and according to standards such as WCAG. Dyslexia friendly website guidelines can also be collected by narrowing down existing standards keeping in view the difficulties faced by these people and assistive tools used by these people.

To remove the barriers to access, some researchers have offered tools that can customize websites and allows users to do multiple adjustments while some have investigated various website elements. The study of literature reveals that text presentation greatly impact on readability and therefore text guidelines (font, spacing, color etc.) are focused by many researchers in user studies but dyslexia friendly key website guidelines are not properly documented in existing studies and no practical approach exist that assist the developers in making accessible websites. Moreover, dyslexics people especially those having severe dyslexia often used screen readers. Therefore, websites should also be created screen reader friendly rather than considering it as an option.

Current state of websites reflected in evaluation studies are also sufficient to argue that by providing access to dyslexic people a matter that need to be focused and in fact it provides access for everyone. Additionally, the largest source for providing information is web. To address web accessibility for dyslexic people standard set of guidelines and previous studies guidelines are available but still most of the websites are inaccessible. Therefore, it is greatly needed to access and prioritize the major problems so that developers use limited resources during website development to ensure accessibility.

Major accessibility problems that exist in most of the website include:

- Confusing layout
- Unclear navigation
- Poor colour schemes
- Too much textual data, lack of headings, lists, summary etc.

- Lack of graphics
- Improper font size and font style
- Use of complicated language
- No support for screen readers (inaccessible forms, missing alt text from images etc.)
- No support for keyboard navigation

Startup developers and others may find WCAG guidelines too complicated, confusing and detailed thus making adaptation of these a slow and tiring process. Major barriers to accessibility faced by developers include:

- Lack of awareness about accessibility and its importance
- Lack of knowledge about existing standards (WCAG) and tools
- Lack of training, support about when and how to work on accessibility
- Lack of time, cost, resources
- Not asked as a feature by customers
- Not a legal requirement (in many countries)
- Considered accessibility as an afterthought

Unfortunately, business owners prioritize marketing, sales, customer services but not accessibility so it is designers and developers' duty to ensure accessibility. Efforts to guarantee accessibility of websites are not yet growing rapidly despite the fact that many guidelines are available. From previous researches, it is widely accepted among researchers that web accessibility is a problem for dyslexic people. Still it is a problem because not enough developers take proper action. Another important reason for not understanding the difficulties is that designers and developers are not disabled therefore to understand the difficulties developers should use assistive tools also to test the websites to get better understanding of needs of dyslexic people. Under these assumptions, we work on a new innovative solution that will give awareness and proposed actionable approach will motivate developers in a positive manner and will be beneficial to eliminate or reduce these barriers efficiently.

Moreover, for many people it is hidden disability which means people are dyslexic but remain undiagnosed. Such people continue to face readability, understandability and concentration problems and might not know about the availability of assistive tools that allows customization.

Tools can allow changing few website elements but have some limitations i.e. they cannot resolve complex website navigation problems and they cannot change the complex written content etc. Another challenge is to find the right tools according to needs among variety of tools. Also, single tool may not cater all problems so learning to use multiple tools might also be difficult or may be unproductive. Therefore, web developers themselves should provide the desired accessible website features as much as they can such as suitable texts size, color, font, spacing, simple navigation, simple textual data etc.

It can also be clearly seen from the accessibility evaluation results that using templates and plugin do not confirm to accessibility. Additionally, the templates or plugins are being used by website developers who typically have little or might have no knowledge about best development practices, coding or accessibility. Without considering accessibility, plugins simply use a system that click the buttons to get what users want as soon as possible. Moreover, using website templates without accessibility modifications leads towards inaccessibility, therefore, template also require some alterations related to accessibility best practices.

Furthermore, neither overlays nor assistive technologies can completely ensure accessibility [68]. Many lawsuits list overlays as barriers. Assistive technologies work well when developers follow all development best practices that aid assistive technologies such as use of alt text for images. Same is the case with overlays. Some companies suggest automated accessibility solutions for ADA and WCAG the periodically review the website and do all necessary modifications using AI (Artificial intelligence) tools. Assistive technology users i.e. screen reader users have installed their own screen reader and may find it difficult to use the unfamiliar new one offered by overlays. Also overlays cannot provide semantic headings, descriptive links and alt text etc. AI alone was not able to read minds to accurately know the intentions of headings, images etc. Therefore the ultimate solution is that website developers themselves should allow users to consume website content without any additional assistance and website should continue to provide accessibility.

What was missing in existing literature was an AI tool based and screen reader testing based approach. AI is undeniably positively affecting the field of software engineering. Most of the researchers have analyzed the accessibility problems by involving dyslexic people and get



feedback from them. There is little previous research on existing AI based accessibility testing tools and how they can help the developer in making accessible websites. Automated testing is quite helpful to improve accessibility for example while considering websites, the color schemes applies not only in foreground and background, but many other places as well such as in buttons, links, menus, mouse hover etc. So all these elements are required to check for accessible color combinations as color is one of the feature that majorly impact readability. By using automated tools we can check all these color combinations whereas existing user studies focused only on text and background colors. AI tools can speed up the process to build accessible website because manual process is expensive and time consuming. Furthermore, assistive technologies will work efficiently only when developers built the website by keeping assistive technologies such as screen reader guidelines in mind. We hope that this research will influence developers to improve accessibility.

## **2.8 Summary**

This chapter provides a detailed literature review of the work done on the accessibility for dyslexic people. Many evidences have showed that the state of website accessibility is not improving and this issue is becoming serious. This chapter has highlighted the importance of providing accessible website. So, practitioners must not ignore website accessibility anymore and need to learn from existing knowledge, standards, tools and facts like past mistakes such as rising lawsuits. Designers, content writers, developers, testers, managers, accessibility experts, policy makers, business owners, content management system providers and even all of us whatever role we are playing in organization must plan a path that includes website accessibility as an essential process rather than an afterthought.

## RESEARCH METHODOLOGY

### 3.1 Overview

In this chapter, existing websites are evaluated for accessibility to have an idea where currently the websites are standing and to know about the common accessibility issues. The procedure starts with the selection of websites and selection of automated accessibility evaluation tool.

### 3.2 Website Dataset

By using results provided by Alexa.com (amazon service), top websites are selected and tested for accessibility. The selected website set consists of different types of websites including: news, e-commerce, entertainment, and educational websites etc. According to the criteria, the most visited websites are selected. However, some websites are skipped because when we have tried to test them for accessibility, the server has blocked the request and gave “Website Connection Error” message. These websites were rare that cannot be accessed by web crawlers including tiktok, linkedin, instagram, amazon and canva. In this chapter, total 37 websites are assessed.

### 3.3 Accessibility Evaluation Tools

Tools for evaluating accessibility are software programs or online services that help to determine whether website content complies with accessibility requirements or not. A variety of accessibility evaluation of tools is available and the complete tool list is present on W3C website.

**Table 3.1:** *Accessibility Evaluation Tools*

Accessibility Evaluation Tools	
Complete Tool List	URL: <a href="https://www.w3.org/WAI/ER/tools/">https://www.w3.org/WAI/ER/tools/</a>
Selected Tool: AccessScan	URL: <a href="https://accessibe.com/accessscan">https://accessibe.com/accessscan</a>

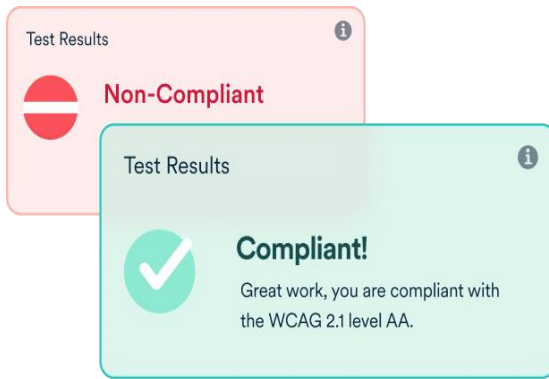
### **3.3.1 AccessScan**

After trying different accessibility evaluation tools (including WAVE, AChecker etc.), the AccessScan tool powered by accessiBe was selected for this study. AccessScan is fully automated auditing tool designed to give accurate audit results of websites compliance status. AccessiBe is a leading technology company (developed in 2018) that uses AI (Artificial Intelligence) to solve web accessibility problems. AccessiBe is trusted by thousands of websites and a market leader for providing accessibility.

#### **3.3.1.1 Why AccessScan**

AccessScan tool is selected because of the following reasons:

- It is free and easy to use.
- It is fast and provides accessibility testing results immediately within seconds.
- It provides clear, accurate and reliable results. It checks website against WCAG 2.1 level AA compliance which is widely adopted.
- AccessScan utilizes AI engines to extract accessibility errors and present them in a way that can be fully and easily understood.
- It tells about the compliance level of website. It gives clear and straight forward remarks about the website whether the website is accessible or not.
- It provides detailed results with code snapshots of passed and failed elements. It also describes what needs to be done in order to fix issues.
- Other testing tools typically give ambiguous messages without a clear, practical solution while AccessScan gives clear messages and assist in fixing problems in the code.
- Most of the elements tested by this tool are also among those requirements that can create dyslexia friendly websites.



**Figure 3.1:** AccessScan Clear Results



**Figure 3.2:** Other Tools Vague Results

### 3.3.1.2 How AccessScan Works

AccessScan takes few seconds from start till completion of process. Following steps briefly describe its workflow:

1. Enter the website domain.
2. AccessScan uses an AI powered technology to scan entire website for finding accessibility errors.
3. It provides accurate and elaborate audit results with score and explanations for each test.
4. The audit results can be reviewed or downloaded. This report contains all the deficiencies and it can be shared or discussed with team members to completely remediate the website.

### 3.3.1.3 Auditing Categories of AccessScan

AccessScan scans the website for the following categories:

- **Clickables:** Links, Button, controls etc.
- **Orientation:** Popups, focus etc.
- **Menus:** Dropdowns, navigations etc.
- **Graphics:** Alt text, spacers etc.
- **Forms:** Labels, validations etc.
- **Document:** Language, landmarks etc.
- **Readability:** Font size, color contrasts, headings etc.

### 3.4 Accessibility Evaluation Requirement Checklist

Complete requirements list along with detailed description against which the “accessScan” test the website is shown in Table 3.2, Table 3.3 and Table 3.4.

**Table 3.2:** Requirement Checklist for Clickables, Titles and Orientation

Category and No	Requirement Checklist	Requirement Description	
Clickables	R1	Button functionality elements tagged for assistive technology	Button elements that use other tags such as div, span, a tag etc. include a "role" attribute that should be equal to "button".
	R2	Buttons should not be empty	Include text with button that describes its functionality. If icons are used for buttons then use screen reader only text or “aria label” attribute for description.
	R3	Links should not be empty	Link should contain text that clarifies what page they are leading. For using empty links for layout wrapping element, use screen reader only text or “aria label” attribute for description.
	R4	New tab/window opening links tagged for assistive technology.	In order to inform screen readers that link will open in new tab or window, use either "aria-label" attribute or a screen reader only element.
Titles	R5	A single H1 title on every page	Each page should contain one H1 title, which informs screen reader users about the main subject/topic of the page.
	R6	Titles are not allowed to be empty	Titles (H1 to H6) should have some text. If links or images are used, they should contain alternative or screen reader only text.
	R7	Titles created using text tag should label as heading	A "role" attribute equals to "heading" should be added to elements that visually resemble titles but are coded using non heading tag, or its tag should be fixed for assistive technology.
	R8	There should be consistent hierarchy of titles	No title levels should be skipped, and the hierarchy should be consistent. For example, we cannot use h1 and h3 title without using h2 titles.
Orientation	R9	Interactive elements navigable with keyboard	Buttons, links, form fields and other interactive elements should be navigable with keyboard either by using focusable element (such as button, input, a) or by having "tabindex" attribute set to "0."
	R10	Keyboard focus element outline should be noticeable	Interactive elements that could be navigated with keyboard should have a clear visual outline around them whenever they are focused.
	R11	Active popups tagged for assistive technology	Screen reader users can navigate through active popups if they have an "aria-modal" attribute set to "true" and a "role" attribute set to "dialog".
	R12	Every page include hidden links to allow skipping blocks	Include hidden links in every page so that when a user clicks on them (either with keyboard navigation or using screen reader), they can "skip" certain blocks and go straight to important areas like the main content etc.
	R13	Manipulatively hidden interactive elements excluded from assistive technology	Elements hidden via CSS manipulations (such as with opacity, off-canvas, height or text-indent etc.) should be wrapped inside element with "aria-hidden" attribute set to "false" or directly include it, and should be dynamically updated to "true" when the element becomes visible.
	R14	Manipulatively hidden interactive elements excluded from "tabindex"	Elements hidden via CSS manipulations (such as with opacity, off-canvas, height or text-indent etc.) should include "tabindex" attribute that is below 0 and dynamically updated to 0 when the element becomes visible.

**Table 3.3: Requirement Checklist for Menus, Graphics and Forms**

Category and No		Requirement Checklist	Requirement Description
Menus	R15	Menus tagged for assistive technology	To indicate navigation landmark for screen readers, menus should either be created using the "nav" element of HTML5 or should have a "role" attribute equal to "navigation" or "menu".
	R16	Menu dropdowns tagged for assistive technology	The "aria-haspopup" attribute is set to "true" for menu items that contains a dropdown menu.
	R17	The dropdown expanded or collapsed state be represented in code.	Menu items with dropdown menu should have "aria-expanded" attribute set to "false" by default but changes to "true" when the dropdown is opened or closed.
Graphics	R18	Objects and images with embedded text described for assistive technology	Use the "alt" attribute with images to describe alternative text description of both the embedded text of images and the objects.
	R19	Background images behaving like standard images should be tagged and described	Images used in background that are not used only for decoration purpose should be treated the same as standard images and include role" attribute set to "img" and include an alternative text description in "aria-label" attribute.
	R20	Non-functional icons/spacers excluded from assistive technology	Images, SVG or font icons that are used as spacers, decoration purpose or any other purpose described in content should have a "role" attribute with the value "none" or "presentation".
	R21	Figure elements have text or excluded from assistive technology	The "role" attribute of figure elements used to display images should be set to "none," and the image itself should give the description using the "alt" attribute.
	R22	Image map areas described for assistive technology	An "alt" attribute should be used to provide an alternate text description for each "area" element of a "map" tag (treat just like a standard image).
	R23	Tracker images (pixels) excluded from assistive technology	Small or hidden tracker pixel images (typically used for the purpose of analytics or marketing) should have a "role" attribute with the value "none" or "presentation" in order to be ignored by screen-readers.
Forms	R24	Form fields labeled properly	Form fields need to include either "aria-label" attribute or a connected LABEL element that describes the field's requirement (name, email, phone etc.).
	R25	Form fields not have duplicate ID selectors	Same ID should not be used for two or more form elements otherwise their corresponding label will give wrong information. ID should be unique.
	R26	Required form fields tagged for assistive technology	Required form fields should include an "aria-required" attribute that equals to "true" so blind users using screen-readers know their validation.
	R27	Validation status of form fields represented in code	Every form element's validity state must always be represented in code using the "aria-invalid" attribute and "true/false" values, and it must update dynamically as the status change.
	R28	Incorrect use of aria-labeledby or aria-describedby	aria-labeledby and aria-describedby attributes should be connected by ID to an element that either has "aria-label" attribute or has text description.
	R29	All forms have associated submission button	Every form must contain a submit button, which must be built as a "button" element, input type set to "submit," or contain "role" tag equals to "button". If the form can be submitted by pressing the Enter key, buttons can be hidden.
	R30	Search forms tagged for assistive technology	To indicate a search landmark for screen readers, search forms should have a "role" tag that equals "search",

**Table 3.4: Requirement Checklist for Document and Readability**

Category and No		Requirement Checklist	Requirement Description
Document	R31	HEAD section include "title" element with page name	Title tag inside HEAD section (that also appear is browser tab) should be present to describe current webpage name to screen reader users.
	R32	HTML section include "lang" attribute	For screen reader users, the HTML element needs to have a proper "lang" attribute that denotes the primary/main language of the website.
	R33	Display scaling of Meta view port should be at least 200%	By setting user-scalable="yes" and maximum-scale="2 or greater" content strings in meta viewport tag, users with vision impairments can be able to pinch-zoom at least twice as large as the standard scaling.
	R34	Page landmarks described and tagged for assistive technology	Either use HTML5 element to build landmarks like footer, main content or use "aria-label" attribute to include description and set "role" tag to "contentinfo" or "main". In other section, landmarks like navigation and search are tested.
Readability	R34	Use large enough font size for ease of reading	For majority font families, at least 11px font size should be used to be readable.
	R36	Use wide enough letter spacing for ease of reading	For the majority font families do not set letter spacing below -1px to be readable.
	R37	Use sufficient contrast between foreground and background colors	All elements that have text should have 4.5:1 minimum contrast ratio among the foreground (usually the color of the text) and background color.

### 3.5 Accessibility Evaluation Detailed Results

When the selected websites are tested for accessibility, accessScan tells about the website compliance level by using one of the three remarks that are described with meaning in Table 3.5.

**Table 3.5: Compliance Results and Meaning**

Result	Meaning
<b>Non-compliant</b>	Website does not comply with WCAG and there is a long way to achieve WCAG 2.1 compliance. So, currently website is not accessible to disable people.
<b>Semi-compliant</b>	In website, some WCAG 2.1 AA elements are noticed. Although efforts are noticeable, but some important elements are missing so there is still a way to go to achieve full compliance.
<b>Compliant</b>	Website does comply with WCAG 2.1 level AA means great work is done and website is open to disable people and they can easily use the website.

The websites accessibility score against different categories is analyzed. Category wise score and overall compliance remarks of websites are shown in Table 3.6.

**Table 3.6:** Accessibility Evaluation Category Wise Results of Popular Websites

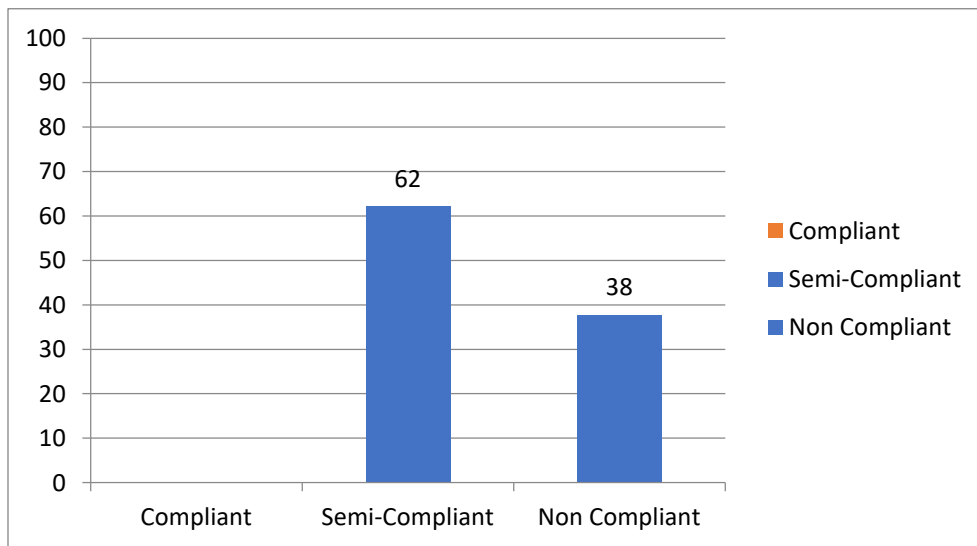
No	Popular Websites	Evaluation Score								Overall Remarks
		Clickable	Titles	Orientation	Menus	Graphics	Forms	Document	Readability	
W1	BBC	88	67	33	100	54	45	92	94	Semi-compliant
W2	Wikipedia	75	100	67	N	50	100	50	72	Semi-compliant
W3	Hmari Web	50	33	67	67	76	N	75	68	Non-compliant
W4	Dawn	47	33	N	N	43	N	92	43	Non-compliant
W5	Olx	35	33	N	N	38	N	92	56	Non-compliant
W6	Printerest	N	50	75	N	N	N	50	100	Semi-compliant
W7	Stack Overflow	60	50	33	N	84	74	67	81	Semi-compliant
W8	Quora	54	50	17	N	14	50	67	96	Non-compliant
W9	Daily Pakistan	24	67	N	33	42	N	75	49	Non-compliant
W10	Pay Pal	N	50	75	N	N	N	N	100	Non-compliant
W11	Duniyanews	76	100	33	100	52	33	50	47	Semi-compliant
W12	Microsoft	73	100	33	33	100	100	100	90	Semi-compliant
W13	Netflix	96	67	67	N	N	100	58	100	Semi-compliant
W14	Ali Express	67	50	N	N	45	33	25	94	Non-compliant
W15	Bing	87	67	22	N	50	58	75	100	Semi-compliant
W16	Ary News	73	67	33	N	79	N	83	40	Non-compliant
W17	Tribune	37	100	N	33	45	50	58	66	Non-compliant
W18	W3Schools	59	50	N	N	54	33	92	96	Non-compliant
W19	Apple	100	50	67	N	64	100	75	66	Semi-compliant
W20	Food panda	52	75	N	100	43	67	75	47	Semi-compliant
W21	Office	100	100	25	33	50	100	100	97	Semi-compliant
W22	Grammarly	50	33	33	N	100	N	92	70	Semi-compliant
W23	Zoom.us	88	58	33	67	51	93	92	64	Semi-compliant
W24	Github	100	75	33	33	84	83	100	56	Semi-compliant
W25	live.com	50	50	67	100	41	100	100	90	Semi-compliant
W26	Google	100	50	67	N	97	100	33	70	Semi-compliant
W27	Shopify	100	75	100	33	44	94	100	67	Semi-compliant
W28	Upwork	63	33	33	N	100	N	100	79	Semi-compliant
W29	Twitter	82	67	21	N	100	75	50	79	Semi-compliant
W30	Blogger	44	33	67	N	59	N	75	67	Non-compliant
W31	Pakwheels	69	67	33	N	75	50	78	90	Non-compliant
W32	Azadseo	56	67	N	100	72	25	67	59	Semi-compliant
W33	FreePik	41	50	N	7	88	33	100	98	Non-compliant
W34	Whatsapp	75	50	33	N	50	N	42	90	Non-compliant
W35	Youtube	62	100	10	N	34	100	67	62	Semi-compliant
W36	Wordpress	100	25	100	44	45	67	100	91	Semi-compliant
W37	Indeed	100	67	67	N	18	100	75	91	Semi-compliant



Accessibility evaluation overall results summary is presented in Table 3.7 and Figure 3.3. From evaluation results, it can be clearly seen that none of the website fully address the accessibility requirements. For this limited set of websites 62 percent websites are semi compliant, 38 percent websites are non-compliant and none is fully compliant. From this, we can conclude that the results would be more severe if we include more number of website or include those websites that are not much popular and created by non-professional developers.

**Table 3.7: Result Overall Summary**

	<b>Compliant</b>	<b>Semi-Compliant</b>	<b>Non-Compliant</b>
<b>No. of websites</b>	0	23	14
<b>Percentage</b>	0	62	38

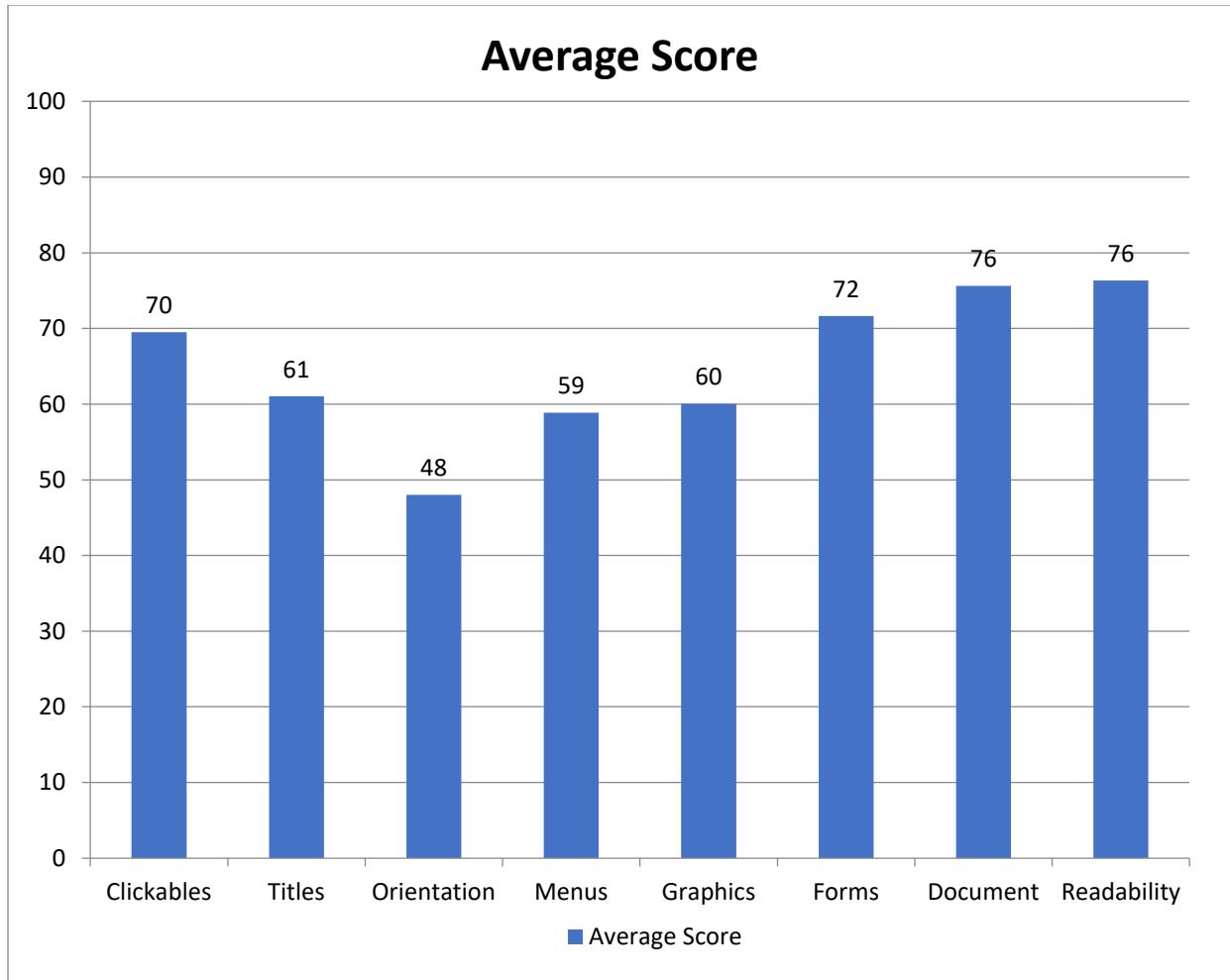


**Figure 3.3: Result Overall Summary**

The average score was calculated for each category and results are shown in Table 3.8. Orientation average score is 48 which is least among others. All these categories need to be fixed because the average score is not very good.

**Table 3.8: Average Score of Various Categories**

<b>Average Score</b>							
<b>Clickable</b>	<b>Titles</b>	<b>Orientation</b>	<b>Menus</b>	<b>Graphics</b>	<b>Forms</b>	<b>Document</b>	<b>Readability</b>
69.51	61.05	48.00	58.87	60.03	71.65	75.61	76.35



**Figure 3.4:** Average Score of Various Categories

After analyzing category wise score, we have further analyzed detail score of each requirement of category. Different symbols were used by accessScan to describe the score of individual requirements. These symbols along with their meaning are shown in Table 3.9. From individual requirement score, a summary is created and shown in Table 3.12

**Table 3.9:** Score Symbol and Description

Score Symbol	Description
✓	Good Score
✗	Bad Score
△	Mediocre Score (Almost half elements with good score and half elements with bad score)
N	Neutral Score: Neutral score elements either do not exist or may be irrelevant to that website, represent that it is non-applicable.

Table 3.10: Requirement Score

Requirement Category and Number		Website No and Evaluation Results																	
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18
Clickables	R1	△	✓	✗	✗	✗	N	✗	✗	✗	N	✓	✗	✓	✗	△	✗	✗	✗
	R2	✓	✓	✓	✓	✓	N	△	△	✗	N	✓	✓	✓	△	✓	✓	✗	△
	R3	✓	✓	✓	✓	✗	N	✓	✓	✗	N	✓	✓	✓	✓	✓	✗	✓	✓
	R4	✗	✗	✗	✗	✗	N	N	✗	✗	N	✗	N	N	N	✓	✓	✗	✗
Titles	R5	✓	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✓	✗	✗	✗	✓	✓	✗
	R6	✓	✓	✓	✓	N	N	✓	N	✓	N	✓	✓	✓	N	✓	✓	✓	✓
	R7	N	N	N	N	✗	N	✗	N	N	N	N	N	N	N	N	N	N	✗
	R8	✗	✓	✗	✗	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓
Orientation	R9	✗	✓	✓	✗	✗	✓	✗	✗	✗	✓	✓	✗	✓	✗	△	✓	✗	✗
	R10	✓	✓	✓	✗	✗	N	✓	✗	✗	N	✗	✓	✓	✗	✗	✗	✗	✗
	R11	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R12	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	R13	N	N	N	N	N	✓	N	N	N	✓	N	N	N	N	N	N	N	N
Menus	R14	N	N	N	N	N	✓	N	N	N	✓	N	N	N	N	N	N	N	N
	R15	✓	N	△	N	N	N	N	N	✓	N	✓	✓	N	N	N	✗	✓	N
	R16	N	N	N	N	N	N	N	N	✗	N	N	✗	N	N	N	N	✗	N
Graphics	R17	N	N	N	N	N	N	N	N	✗	N	N	✗	N	N	N	N	✗	N
	R18	△	✓	✓	✓	✗	N	△	N	✗	N	✓	✓	✗	N	N	✓	✓	△
	R19	N	N	N	N	✗	N	N	N	✗	N	N	N	N	N	✗	N	N	N
	R20	✓	✗	△	✗	△	N	✓	✗	✓	N	✗	✓	✗	✗	✓	✗	✗	✗
	R21	N	N	N	✗	N	N	N	N	N	N	✗	N	N	N	N	N	N	N
	R22	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Forms	R23	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R24	N	✓	✗	✗	✗	N	✓	✓	N	N	✗	N	✓	✗	✓	N	✗	✗
	R25	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R26	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	✗	N
	R27	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R28	N	N	N	N	N	N	✓	✗	N	N	N	✓	✓	N	✗	✗	✓	N
	R29	N	✓	✗	✗	N	N	✗	N	N	N	✓	✓	✓	✓	✓	N	✓	✓
	R30	N	N	N	✗	N	N	✓	N	N	N	✗	✓	N	✗	✗	N	✗	✗
Document	R31	✓	✗	✓	✓	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✓
	R32	✗	✓	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓
	R33	✓	✓	✓	✓	✓	✓	✓	N	✓	N	✗	✓	✗	✗	✓	✓	✗	✓
	R34	✓	✗	✓	△	△	✗	△	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗	△
Read-ability	R35	✗	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✗	✗	✓
	R36	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	R37	△	✗	✗	✗	△	N	✗	✓	✗	N	✗	△	✓	△	✓	✗	✓	✓

Table 3.11: Requirement Score

Requirement Category and Number		Website No and Evaluation Results																			
		W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	
Clickables	R1	N	✗	✓	✗	✓	✓	N	✓	✓	✗	△	N	✗	✗	✗	✓	✗	✓	✓	
	R2	N	✗	✓	✓	✓	✓	N	✓	✓	✓	✓	N	△	△	✗	✓	△	✓	✓	
	R3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	N	✓	✓	✓	✓	✓	✓	✓	✓	
	R4	N	✗	N	✗	△	N	✗	N	✓	✗	N	✗	✓	N	✗	✗	N	N	N	
Titles	R5	✓	✓	✓	✗	✗	✓	✗	✗	✓	✗	✓	✗	✓	✓	✓	✗	✓	✗	✓	
	R6	✓	✓	✓	N	✓	✓	✓	N	✓	✓	△	✓	✓	✓	✓	✓	✓	✓	✓	
	R7	✗	✗	N	✗	✗	✗	✗	N	✗	N	✗	N	N	N	✗	✗	N	✗	N	
	R8	✗	✓	✓	✓	✓	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗	✗	
Orientation	R9	✓	✗	✓	✓	✓	N	✓	✓	✓	✓	△	✓	✗	✗	✗	✓	✗	✓	✓	
	R10	✓	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✓	✓	
	R11	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	R12	✗	✗	✗	✗	✗	N	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	
	R13	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R14	N	N	✗	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Menus	R15	N	✓	✓	N	✓	✓	✓	N	✓	N	N	N	✗	✓	✗	N	N	✓	✗	
	R16	N	N	✗	N	✗	✗	N	N	✗	N	N	N	N	N	✗	N	N	✗	N	
	R17	N	N	✗	N	△	✗	N	N	✗	N	N	N	N	N	✗	N	N	✗	N	
Graphics	R18	N	N	✗	✓	△	✓	✗	✓	✗	N	N	✓	✓	✗	✓	✓	✗	△	N	
	R19	✗	✗	N	N	✗	N	✗	N	N	N	N	N	N	N	N	N	N	✗	N	
	R20	✓	✗	✓	N	△	✗	✓	✓	△	✓	✓	✗	✗	✗	✓	✗	△	✗	✗	
	R21	✓	✓	N	N	N	N	✗	N	N	N	N	N	N	N	△	N	N	△	N	
	R22	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	R23	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Forms	R24	N	✗	N	N	✓	✓	N	✓	✓	N	✓	✗	✗	✗	✗	N	✓	✓	✓	
	R25	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	R26	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	R27	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	R28	✓	N	✓	N	△	N	✓	✓	△	N	✓	N	N	✗	N	N	N	N	✓	
	R29	N	✓	N	N	✓	✗	N	✓	✓	N	✗	N	✓	✗	✓	N	✓	✓	✓	
	R30	N	✗	N	N	N	N	N	✓	N	N	✓	N	N	✓	✗	N	✓	✗	N	
Document	R31	✗	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	✓	
	R32	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	R33	✓	✗	✓	✓	✓	✓	✓	N	✓	✓	✗	✗	N	✗	✓	✗	N	✓	✗	
	R34	✓	✓	✓	△	△	✓	✓	✗	✓	✓	✓	✓	✗	△	✓	△	✓	✓	✓	
Readability	R35	✗	✗	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	
	R36	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	R37	✓	✗	✓	✗	✓	△	△	✗	✓	✗	✗	✗	△	△	✓	△	✓	△	△	

**Table 3.12: Requirement Score Summary**

Category and No		Requirement	Percentage			
			✓	✗	△	N
Clickables	R1	Button functionality elements tagged for assistive technology	30	49	8	14
	R2	Buttons should not be empty	57	11	19	14
	R3	Links should not be empty	84	8	0	8
	R4	New tab/window opening links tagged for assistive technology.	11	46	3	41
Titles	R5	A single H1 title on every page	51	49	0	0
	R6	Titles are not allowed to be empty	78	0	3	19
	R7	Titles created using text tag should label as heading	0	38	0	62
	R8	There should be consistent hierarchy of titles	62	38	0	0
Orientation	R9	Interactive elements navigable with keyboard	51	41	5	3
	R10	Keyboard focus element outline should be noticeable	38	57	0	5
	R11	Active popups tagged for assistive technology	0	0	0	100
	R12	Every page include hidden links to allow skipping blocks	8	89	0	3
	R13	Manipulatively hidden interactive elements excluded from assistive	5	0	0	95
	R14	Manipulatively hidden interactive elements excluded from "tabindex"	5	3	0	92
Menus	R14	Menus tagged for assistive technology	35	11	3	51
	R16	Menu dropdowns tagged for assistive technology	0	24	0	76
	R17	The dropdown expanded or collapsed state be represented in code.	0	22	3	76
Graphics	R18	Images with embedded text described for assistive technology	38	22	14	27
	R19	Background images behaving like standard images tagged.	0	22	0	78
	R20	Non-functional icons/spacers excluded from assistive technology	32	46	14	8
	R21	Figure elements have text or excluded from assistive technology	5	8	5	81
	R22	Image map areas described for assistive technology	0	0	0	100
	R23	Tracker images (pixels) excluded from assistive technology	0	0	0	100
Forms	R24	Form fields labeled properly	35	32	0	32
	R25	Form fields not have duplicate ID selectors	0	0	0	100
	R26	Required form fields tagged for assistive technology	0	3	0	97
	R27	Validation status of form fields represented in code	0	0	0	100
	R28	Incorrect use of aria-labeledby or aria-describedby	27	11	5	57
	R29	All forms have associated submission button	46	16	0	38
	R30	Search forms tagged for assistive technology	16	24	0	59
Document	R31	HEAD section include "title" element with page name	76	24	0	0
	R32	HTML section include "lang" attribute	84	16	0	0
	R33	Display scaling of Meta view port should be at least 200%	59	27	0	14
	R34	Page landmarks described and tagged for assistive technology	49	30	22	0
Readability	R34	Use large enough font size for ease of reading	62	38	0	0
	R36	Use wide enough letter spacing for ease of reading	100	0	0	0
	R37	Use sufficient contrast between foreground and background colors	30	35	30	5

This summary can be analyzed easily. It states that in 49 percent of the website, buttons are not tagged for assistive technology. In 46 percent of the websites, links are not tagged for assistive technology. 49 percent of the websites have more than one H1 title in single page. 89 percent of the websites do not have a skip link. 38 percent of websites have not enough font size and 30 percent websites have color contrast issues. Only few results are discussed here, percentage of each requirement is clearly stated in Table 3.12. Requirements whose neutral score was more than 90 percent (R11, R14, R22, R23, R25, R26, R27 ) are indicating that these elements are not very common and do not exist in most of the websites. From these results, it is clear that website developers have given little attention to accessibility and these websites still need to work on accessibility.

### **3.6 Summary**

The current state of accessibility results highlighted in this chapter indicate that still predominant accessibility barriers exist in websites. These barriers are related to readable fonts, sizing, spacing, color contrasts, headings, buttons, graphics and menus etc. From the results it is depicted that the accessibility guidelines are still not followed completely and they should be followed in order to give equal opportunities to disable people.

Earlier, making websites accessible was not as much important as it is in these days. However, in the presence of variety of automated tools, it is neither exhausting nor expensive to make an accessible websites. This chapter has highlighted the accessibility results of popular websites. From these results, we can predict that results would be much more adverse if we include those websites which are not created by professionals. It is also identified that most of the requirements that make the website accessible for dyslexic people are covered by the “accessScan” accessibility testing tool. It audits the website against WCAG 2.1 by using AI powered engines to diagnose accessibility failures and present them in a precise way that is easy to understand. It is an easiest and quickest way to check accessibility errors. The evaluation report clearly explains accessibility issues and by using this report website developer can start work to fully remediate the website. “AccessScan” requirements are also focusing on screen reader compatibility; therefore, we can say that barriers to access for dyslexic people can easily be

removed using such automated tools. By realizing the importance of accuracy, identifying and fixing errors using automated tools is a cost effective and good initial step towards accessibility.

# DYSLEXIA FRIENDLY WEBSITE GUIDELINES

## 4.1 Overview

In this chapter, the need and scope to identify dyslexia friendly website guidelines is discussed followed by the key dyslexia friendly guidelines that can greatly impact on website accessibility. Furthermore, this chapter contains the code examples to explain the role of using correct HTML semantic and WAI-ARIA best practices to enhance website accessibility.

## 4.2 What is needed?

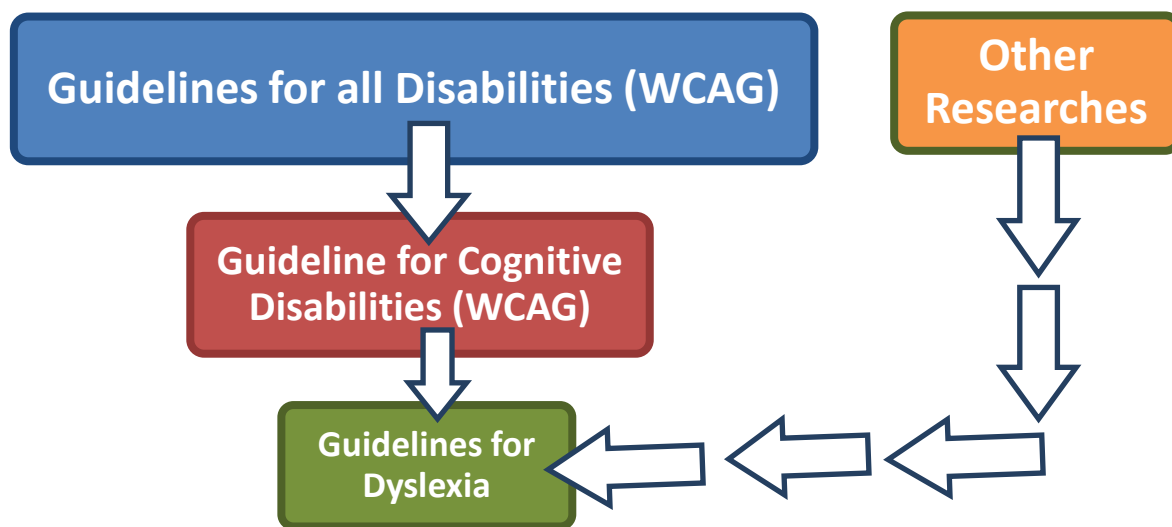
The aim of WCAG by W3C is to provide better web experience to every user including the diverse group of disable users [69]. WCAG guidelines are discussed in detail in background research work. WCAG guidelines is a detailed document that covers wide set of guidelines, success criteria and many techniques to make web accessible for everyone including all disabilities such as auditory, physical, visual, cognitive, speech related numerous disabilities [69]. Keeping in view the time, budget and other constraints, it is not easy to follow these wide set of recommendations to make website fully accessible for all disabilities. Usually, web developers are not trained to think and work for disable users.

WC3 has also published a draft describing difficulties of cognitive group with user stories, problems, needs and techniques to solve accessibility problems for people having various cognitive difficulties [70]. This document also contains so many details because it is covering issues related to several cognitive disabilities [70] including dyscalculia (Math related problems), Dementia, Aphasia, Hemiplegia etc. It is not easy for developer to work on all cognitive disabilities at a time.

Web accessibility is an extremely important topic and its awareness is increasing but websites are still inaccessible because lack of knowledge exist that guide developer how they can improve



accessibility by doing some simple changes that impact greatly on accessibility. Thus, considering that dyslexia affects a large population and the fact that developers are often ill-equipped to create accessible websites, we need to identify recommendations that are beneficial for dyslexic people from these wide set of recommendations so that we can work on improving accessibility for this group of users. By reviewing existing literature, W3C resources (WCAG, WAI-ARIA etc.), BDA guidelines, and other resources we have identified what can be done to improve website accessibility for dyslexic people.



**Figure 4.1:** *Need for Dyslexia Friendly Website Guidelines*

### 4.3 Scope Description

This is our analysis that there are huge numbers of disabilities (physical, cognitive, visual, speech and auditory) and among cognitive group of disabilities there are further huge numbers of disabilities. There are so many variations in the needs of all these people. If we try to analyze and work on every possibility, then the task will be too big and difficult and we may not achieve anything. Due to this reason, we can start implementing accessibility as a phased approach where we can select and work on one disability at a time then move to next. Within the limited scope developers can achieve something useful. The contributed work has focused on dyslexia because its high prevalence and dyslexic people face several difficulties on websites but not enough developers are aware of how they can take action to improve accessibility.

## **4.4 Guidelines for Making Dyslexia Friendly Website**

Anything from the choice of the typeface, spacing, color, navigation, text, lighting or glare etc. from a digital screen can affect dyslexic people and others learning and understanding process. Some key set of guidelines to build better and accessible websites for dyslexic people are identified and are split into nine major categories as show in Figure 4.2.

# Major Groups of Accessibility Guidelines



## Fonts

Font Size, Font Face, Case, Spacing  
Style (Use Bold, Do not use Italic & Underline)



## Paragraph

Alignment (Left, Center, Right, Justify) , Line Spacing , Paragraph Spacing,  
Paragraph Size.



## Colors

Text color, Background color (Use single color), Contrast Ratio between Text and  
Background.



## Writing

Use simple, short and easy sentences. Be concise. Use Bullets, Numbering,  
Images, Charts etc. to support text. Write text considering screen readers  
compatibility guidelines.



## Layout

Avoid using too complex layout. i.e too many Columns (as used in newspapers).  
Avoid using patterns or pictures for background. Break up the text using sections.  
Give structural roles: Role: Navigation, Role: Search etc.



## Navigation

Use Simple, Easy to use and Consistent Navigation.



## Others Elements

Avoid moving text, multimedia that plays automatically such as videos or audios.  
Provide users enough time to read and use content.



## Screen Reader Compatibility

Follow WAI-ARIA guidelines and test website frequently using screen reader.  
Images must have meaningful alt text.



## Semantic HTML and WAI-ARIA

Use Semantic HTML and WAI ARIA for better Screen Reader Experience

Figure 4.2: Major Groups of Accessibility Guidelines

#### **4.4.1 Font**

- Use Sans-serifs fonts (such as Arial, Verdana, Comic Sans, Open Scans Calibri) and avoid Serifs (such as Times New Roman, Palatino, Georgia and Garamond). Sans-serif fonts are simple, evenly spaced and letters appears less crowded. Therefore, Sans-serif fonts are preferred and recommended typefaces by BDA and other researchers because they increase readability.
- Avoid italic and underline text because these can make text crowded and impact negatively on readability. Instead, to emphasis text use bold.
- Highlight important information by using colors, boxes, borders etc. so that it could be found easily.
- Avoid using all uppercase letters because dyslexic people find them harder to read (TEXT IN CAPITALS IS MUCH HARDER TO READ).
- Use readable enough font size. Use at least 12 points as suggested by BDA.
- Use enough letter and word spacing to increase readability. Less or excessive spacing between words and letters can reduce readability. For many font families below -1 px is unreadable.

#### **4.4.2 Paragraph**

- Align paragraphs to left. Although justifying paragraphs creates clean paragraph look but avoid using it because it adds extra spaces between words that can make reading difficult for dyslexic people.
- To separate paragraphs from each other, include extra spaces before and after paragraphs and headings etc.
- Avoid too dense and long paragraphs. Keep paragraphs short.
- Per paragraph try to explain about any one idea.
- Use enough line spacing (1.5 line spacing is recommended by BDA).

#### **4.4.3 Color**

- Avoid using pure white background color because it is not preferred by dyslexic people. White color look too dazzling because of glare (BDA). Use any other light or dark colour

background. Also avoid too bright colors.

- Carefully choose the color scheme for every website elements (text, background, buttons, links, links hover, visited links, navigation etc.).
- Make sure that there is a good contrast between the background and text color as well as for other elements. The minimum preferred contrast ratio is 4.5:1 (WCAG). Online contrast checkers can be used to check the contrast ratio. Check this ratio for every website element i.e. for visited links, unvisited links, hover, buttons, focus etc.
- Use single color background and avoid background having patterns, textures or pictures.

#### **4.4.4 Writing**

Some guidelines regarding the writing style and headings are discussed below:

##### ***4.4.4.1 Writing Style***

- Provide information clearly in an easy and interesting way. Explain information in a way that is easy to understand and manage i.e. Use meaningful headings and explain single idea in single paragraph. Divide information into chunks that are easy to digest i.e.be concise and explain one point in one sentence.
- Break long sentences in to short sentences. Long sentences and multi clause sentences are often complex and create problems such as losing the focus, difficult to process and understand the information.
- Use graphics to explain the text i.e. use flowcharts to explain procedure.
- Use common words and avoid unusual words because they are difficult to decode.
- Use lists, graphics and tables instead of the continuous prose of text to lower cognitive overload and to improve understanding.
- For long web page articles, provide the table of contents at the beginning and set links. It is helpful for dyslexic people to quickly narrow and find the topic of interest. Also indicate those pages that have been accessed.
- Provide summary or key points at the end of long articles.
- Use active voice sentence.
- Do not use double negatives. When two negative words are used in a single sentence it is called double negatives. Avoid it because they are considered as bad practice and they can

make text confusing.

- Avoid abbreviations and if they are used then provide full form of abbreviations while using them for the first time. Provide a glossary defining all technical terms.

#### **4.4.4.2 Headings**

- Provide enough headings and sub heading in a way that clearly describe the topic. It helps users to digest information easily and find required section quickly.
- When the user get distracted due to some reason then headings can help to orientate and to restore the context.
- Rules about using headings can also help those people who do not have enough time to read complete information and they just want to scan webpage headings to get an overview of entire information. These writing best practices keep a balance between the beauty and accessibility of information.
- Use heading tags rather than font tag with larger font size. Also, use heading tags logically in semantic order. To explain the importance of correct use of heading tags, an html code example is provided in next section.

#### **4.4.5 Layout**

- Use common, consistent and familiar layout design that is easy to understand and use.
- Structure the website properly by creating various sections. Any area that has a landmark role is known as region. Typically, the page structure contains a logo, navigation and search at top, followed by main content and a footer area at bottom, and sometimes sidebars are used to provide related information.
- Assign structural roles to the website regions i.e. use role attribute equals to Navigation, Search, Banner, Main, Article, List, List item, Form, Content info.
- Well separate all sections or regions using borders, colors, white spaces etc. so that they can be visually differentiated.
- Use div tags for making various sections instead of using table layout.
- Avoid using multiple as well as narrow columns to provide information such as used in the printed newspapers. Also avoid horizontal scrolling.

## **4.4.6 Navigation**

Guidelines regarding the navigation elements such as links, menus, dropdowns etc. are discussed below:

### ***4.4.6.1 General***

- Provide easy, clear and consistent navigation. Providing a site map is also helpful.
- Help users in navigation so that they can easily find the desired content.
- Provide little navigation to reach the desired and important web pages.
- Important links should be visible all the time so that users can visit those important or frequently used pages easily.
- Provide short menus and clearly provide labels.
- Provide easy ways to navigate back or forward (step-by-step).
- Show the progress clearly and provide appropriate help in case if any error occur.
- Use familiar graphic, icons etc. as navigation aids such as indicate step by step progress for completing tasks of an online payment process.
- Enable keyboard navigation and focus because it a good practice and with screen reader people prefer using keyboard navigation. Use logical focus order for access via key board tab key.

### ***4.4.6.2 Links***

- Provide sufficient text describing the links purpose so that users can accurately predict where the link will take them.
- Logically arrange links within a webpage or website.
- Use clearly noticeable links that look different from the regular text.
- Clearly indicate those pages that have been accessed. Displaying visited state of links will help those dyslexic users who have problem of short term memory loss.
- Avoid link that does not clearly explain its purpose such as: read more, click here etc. Write link name as “read more about topic name”. It helps in understanding the context when the users use key board navigation. Also, some screen readers show a list of all available links to users so use a link name that clearly explain its purpose.
- Provide all links such that they are reachable in a logical manner using the keyboard Tab

key when users use website via keyboard navigation. Keyboard navigation is very important because many dyslexic people use screen readers and keyboard navigation is preferred with screen readers.

- Provide visual indicator for those links that will open in new tab or new window (i.e. use text: open in new tab). Allow screen reader to announce such links either using the link text (open in new tab) or use hidden text or title attribute.
- Use a “skip to main content” link for simplification. This link removes extraneous website content and transfer the control to main content so that dyslexic users can maintain the focus and quickly access important information. Otherwise, it will be time consuming and may also distract the user. Screen reader users prefer avoid hearing dozens of navigation links, graphics, heading, etc. that usually exist on every web page. Screen reader users prefer to use skip link to hear main content before all these elements are spoken. Users who use keyboard can also easily reach to main content by using skip link with fewer keystrokes. Otherwise, they have to make loads of keystrokes to reach the main content of the webpage.

#### **4.4.6.3 Icons**

- Use icons to help users in navigation. For icons, there are no specific guidelines because icon tag not exists. Icons are usually used as indicators or links. Use universally recognizable icons that are easy to interpret.
- Tag icons according to their purpose. Use role = presentation for those icons that are used only for decoration purpose.

#### **4.4.6.4 Menus**

- Use menus that can be interpret via screen readers, and allow navigation via keyboard arrow keys.
- Use “NAV” tag or use a “role” attribute on top element which contains all links. Use role equals navigation or menu or menubar (depending upon the menu type).
- Include role= menuitem with links that comprise menu items.
- Allow users to use key board Tab key to navigate next element, and Shift+Tab key



(together) to navigate back to the previous element. Also provide a clearly identifiable focus outline.

- Allow users to navigate across menu bar by using keyboard left and right arrow keys. When user reach at the end of menu, allow users to use the forward arrow key to loop navigation back to first item.

#### ***4.4.6.5 Dropdowns***

- Allow dropdowns to open with Enter key.
- Allow dropdowns to open when user focuses on the menu item.
- Allow navigation within the dropdowns using the arrow keys and the focus must be visible enough.
- Allow users to close dropdown using escape key and move the focus back to the root menu item of the currently selected dropdown item.

#### ***4.4.6.6 Search***

- Provide search option to search within the webpage or website. Provide a search that is capable to tolerate misspellings and typos. It will be a great help for dyslexic people.

#### ***4.4.6.7 Breadcrumbs***

- Items such as breadcrumbs can help users to focus. If users are lost it allows them to restore the context. Allow users undoing mistakes by providing clickable breadcrumbs. Dyslexic people may lose attention so breadcrumbs are helpful for restoring context.

### **4.4.7 Screen Reader Compatibility**

Dyslexic people are slower and bad at reading therefore they commonly used screen readers. Content writers need to keep in view screen readers guidelines while writing because they can write text in a better way that is also understandable when screen reader convert that text to audio. Some examples for preparing website material that support screen readers are explained below:

- Avoid using symbols and characters that cannot be clearly converted into audio i.e. avoid using dashes. Write 1 to 5 instead of writing 1-5. Avoid symbols where possible such as avoid using only “\*” in place of required fields because it will be spoken as “asterisk” or “star”. Use symbols only when they are necessary to use because they are spoken.
- Avoid using short form of words i.e. instead of writing Jan write full form January and instead of writing 'No.' write “number”.
- Use punctuation marks i.e. full stops, comma, semicolons etc. so that screen reader will give pause while reading.
- Use full stop after heading and bullets etc. where pause is required (Developers may use same color shade for full stop and background so that dots appears visually hidden).
- Avoid using abbreviations and avoid using capital text in middle of line because it may be read as single letters.
- Chunk or break apart phone numbers to avoid reading as hundreds, thousands or millions.

Developers can easily know how the content is read by screen reader when they themselves use screen readers and devote their time on screen reader testing. Developers need to be serious about screen reader testing and they should frequently test the website with screen readers to further know how the content sounds and which part or information is not announced correctly. Developers also need to follow semantic HTML and WAI-ARIA guidelines to build screen reader compatible websites.

#### **4.4.8 Others**

Guidelines for some other basic website elements such as forms, buttons, images etc. are discussed below:

##### **4.4.8.1 Forms**

- Use forms that clearly describe field labels, validations, errors, success messages etc. both visually accessible as well as via screen readers all form elements should be clearly announce able.
- Include label tag with all fields and connect it to the field by using attributes such as id, aria-label and“for” attributes.

- Use label that is clearly visible. Provide correct formatting instructions in clear textual form outside the placeholder text. Do not rely only on placeholder text because it may introduce accessibility issues. Its color is often light (grey) so users may find it difficult to read due to low contrast it is less visible. It disappears when field is selected so users may forget what they were supposed to type and due to short term memory they may also forget the correct input format if provided only in placeholder text such as dashes are required with mobile number or not. Such form without cannot be rechecked before final submission. Usually, screen readers don't detect and read placeholder. Also, screen readers usually skip placeholder text so it cannot be used as a substitute for label. It is best to avoid, however, it is okay if placeholder is used occasionally along with label but avoid providing essential information inside it.
- For required form fields, include both visual cues with fields such as \*(Asterix) with text and include attribute "aria-required=true" so that screen reader could announce it.
- Include aria-invalid attribute with fields to tell screen readers about the field status i.e. valid or invalid currently. According to the validation criteria this attribute should change dynamically. For example: If the name field is empty the aria-invalid should be equal to true to indicate this is invalid validation and when the user fills this field it should be change into aria-invalid = false.
- In case of presence of errors when the user submit the form move focus to first invalid field and explain user about the issue using visual hints and error announcement via screen reader to support screen reader users.

#### **4.4.8.2 Buttons**

- To enable operation using keyboard identify tags that are created to use as buttons such as text, link or div that works like buttons.
- Use button tag for buttons. An alternate way is to include a "role=button" attribute.
- Include text, aria-label and title with buttons.

#### **4.4.8.3 Images**

- Include accurate and descriptive alt text with images. It helps those users who rely on screen readers.

#### ***4.4.8.4 Popups***

- Tag popups for screen readers and allow users to close popups using Escape key. After dismissing popup the focus should go back to the element that was focused before the appearance of popup.
- Include attribute “role=dialog” with popups.
- Include attribute “aria-modal=true”.

#### ***4.4.8.5 Time***

- Provide sufficient time for time based activities. For example while designing online tests, provide enough time so that dyslexic people can also complete the test. Also provide sufficient time for session time out because the dyslexic people write slowly due to writing and spelling difficulties and they need to recheck the information due to which more time is required by these people. So avoid data loss due to insufficient timeout.

#### ***4.4.8.6 Ease and Help***

- Help users to understand the website and provide ease for using it. It can be done by using things that are familiar and clearly understood. Avoid using new symbols or terms because it may become difficult to learn. Use familiar design, icons etc. so that no learning is required to learn new ones.
- Use of common approaches is also helpful i.e. use blue underline convention for links and use purple color for visited links because these are standard conventions and are familiar ones.
- Provide ease and help. i.e. use within website search, skip to main content link, auto fill option and clear description for filling forms because of writing difficulties, use some alternative and easy way for complex security mechanisms and avoid CAPTCHA.
- Provide keyboard navigation support because it is a good practice and keyboard navigation is often used with screen readers.
- Use hyperlinks for ease of navigation such as while listing webpage contents use internal or external hyperlinks.
- Provide a consistent look throughout website i.e. provide uniformity in web pages,

navigational elements etc.

- Use a good, simple, easy and familiar website design that makes errors less likely to occur.
- Prevent users from doing mistakes and in case when mistake occur, guide the user and make it easy for them to correct it. Also, help users to avoid mistakes by clearly explaining input formats for form fields.

#### ***4.4.8.7 Distracting Elements (Moving text, Advertisements, Multimedia, Popup)***

- Avoid use of distracting elements in websites surroundings because they divert the attention of these users. Avoid moving text, advertisements, popups, multimedia such as video, audio or background music that plays automatically. These elements may distract dyslexic people. Therefore, do not set music or advertisements to play automatically unless the users turn them on. However, skipping distracting elements such as advertisement may be undesirable option for some websites that rely on the advertisement revenue. Hence, if distracting elements such as advertisements are used then they should be easy to close.

#### ***4.4.8.8 Authentication and Security***

- Minimize the cognitive load of dyslexic people by providing easy security and authentication mechanisms. For example, provide some alternative security mechanism for CAPTCHA because they are difficult to understand by dyslexic people.
- Minimize the cognitive load by using limited the number of steps.

#### ***4.4.8.9 Overlays***

- If overlays are used for personalization, then make sure they are easy to use and close. Overlays can improve accessibility because they provide users a way to choose their own settings according to their comfort level.

### **4.4.9 Semantic HTML and WAI-ARIA**

Semantic HTML means to use the right HTML elements for the right purpose. While writing HTML, use correct semantic as much as possible because it gives context to assistive

technologies like screen readers and thus assist users to navigate, interact, understand and use the website in a good way. For example, write descriptive title element because it is announced by screen readers when the webpage is loaded for the first time. It is also very important to use proper alt attribute while adding images because screen reader announce it while reading images.

W3C has developed Web Accessibility Initiative's Accessible Rich Internet Applications (WAI-ARIA) accessibility guidelines to further add meaning to HTML elements and to support adaptation via extensions, add-on, assistive technologies etc [72]. WCAG standards are more popular while the WAI-ARIA accessibility guidelines are not well known. Particularly, WAI-ARIA attributes convey the website elements in much better way to screen readers. For example, it identifies page landmarks sections that support rapid navigation and conveying region name such as search, banner, navigation, main content etc. It also explains forms in better way i.e. auto complete available, field is required etc [72].

Two complete WAI-ARIA versions are recommended so far. The first version of WAI-ARIA named as WAI-ARIA 1.0 was published in 2014 as a recommendation [71]. The next version was WAI-ARIA 1.1 that was published in 2017 with more advanced accessibility recommendations [72]. The WAI-ARIA 1.2 is currently under development according to W3C website and it may include further additional features.

W3C has published Graphic Module of WAI in 2018 that support accessibility of structured graphics like maps, charts, diagrams etc. In this study, we have only focused on the accessibility of key website elements. Depending upon the website requirements, developers need to search accessibility resources and implement relevant accessibility technique accordingly.

#### **4.5 Examples of Guidelines with code (Semantic HTML and WAI-ARIA)**

Accessibility problems are caused when the website is coded poorly. This section provides numerous examples to guide developers how they can practically incorporate WAI-ARIA and semantic HTML in websites development projects to dramatically enhance the accessibility. There exist so many HTML and WAI-ARIA elements therefore we have explained the importance of semantic HTML and WAI-ARIA using only few fundamental examples.

### 4.5.1 Declare Document Language

Always use language attribute inside HTML tag to declare webpage language. It facilitates screen readers and search engines. Every language has own set of pronunciation rules that's why screen reader needs to know the language of the webpage. It also assists in automatic translation of webpage content. The following code specifies webpage having English language:

```
<!DOCTYPE html>  
<html lang="en">  
<head>...</head>  
<body>...</body>  
</html>
```

Also use `<meta charset="UTF-8">` inside `<head>` tag for proper interpretation and indexing by search engine.

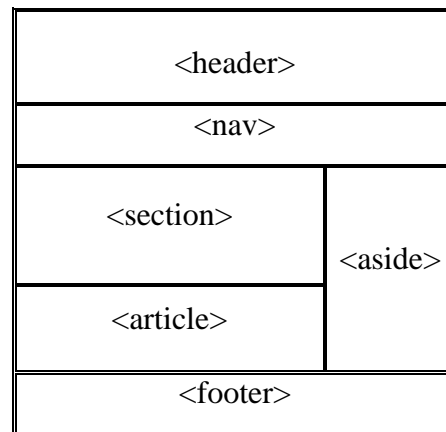
### 4.5.2 Layout Elements (Page Regions & Landmark Roles)

In old days, developers create layouts with HTML tables by using different table elements for partitioning the header, footer, sidebar, main content, footer section etc. It was a bad approach because it was incompatible with screen readers. Screen readers gave confusing readouts, especially when the layout is complex and created using multiple nested tables.

Modern layout structures provide website organization in a way that provide it easy to identify various sections and is compatible with screen readers. Its code size is also reduced and thus it is much easier to understand and maintain. Use HTML5 semantic elements while creating website because it provide content sectioning. It is appropriate to use sectioning elements such as main navigation (`<nav>`), footer (`<footer>`) etc. These section or layout elements provide semantics to screen readers and other assistive tools. Website sections assist screen reader users by giving additional cues while using or navigating the website.

Landmarks are used to define the sections of a webpage. In HTML, several semantic elements are used to define important parts of a web page. Common semantic layout elements are

`<header>`, `<nav>`, `<main>`, `<aside>`, `<section>`, `<footer>` and the area they cover is represented in Figure 4.3.



**Figure 4.3:** *Layout*

Screen reader announces website regions so that users can easily navigate within different areas of website. The same functionality can also be achieved by using ARIA landmark roles. The terms "region" and "landmark" are used as synonyms. A `<header>` tag contains built in role of banner. It means that use `<header>` tag or `<header role="banner">` or `<div role="banner">` because these are semantically equivalent. Create navigation section with `<nav>` element. We can also use div tags with `role="navigation"` but much appropriate way is to use `<nav>`. For main area, either use `<main>` or use `role="main"`. For footer section, use `<footer>` with its `role="contentinfo"`.

Apply `<nav>` region to the primary website navigation and for those websites that have deep content, secondary navigation can also be used by using `aria-label` to differentiate both navigation. For example, use `<nav aria-label="Primary Navigation">`.

Each landmark element has a corresponding role. Roles are used to define the significant regions of web page and are inherited from landmark:

- **banner:** Equivalent to `<header>` and usually contains website logo, name, main navigation and search.
- **navigation:** Equivalent to `<nav>` and contains website navigation links.
- **main:** Equivalent to `<main>` and contains website central or main contents



- **complementary:** Equivalent to <aside> and contains supporting website content usually using side bar.
- **contentinfo:** Equivalent to <footer> and contains footnotes of website such as privacy policy, copyright or contact information etc.
- **search:** No equivalent element in HTML and contains website search function. Use <form role="search">.

Avoid using bad conventional page layouts that are created using table because they do not give appropriate readout with screen reader. An example of inaccessible layout is:

```
<table width="1200">
***Header with Main Heading***
    <tr id="heading">
        <td colspan="8"> <h1 align="center"> Provide Header Here </h1> </td> </tr>
***Navigation Row***
    <tr id="nav" bgcolor="#ffgggg"> <td width="195"> <a href="..." align="center"> Home
    </a> </td> {Use same way for creating all Navigation Pages i.e. Products and Contact.
***Search Form***
    <form width="200"><input type="search" name="q" placeholder="Search"
width="300">
    </form>
    <td width="110"> <button width="100">Go!</button> </td></tr>
***Spacer Row***
    <tr id="spacer" height="15"> </tr>
***Main Content***
    <tr id="main">
        <td id="content" colspan="7" bgcolor="#ffgggg"> Provide Main Content </td>
***Aside Content***
    <td id="aside" colspan="2" bgcolor="#ff80ff" valign="top"> <h2>Related</h2> </td>
***Spacer Row***
    <tr id="spacer" height="15"> ... </tr>
***Footer***
```

```
<tr id="footer" bgcolor="#ffggg"><td colspan="7"><p> Copyright....</p></td> /tr>
</table>
```

Good and accessible way is to use various section tags (header, navigation, main, article, aside, footer etc.). An example describing the correct method to create layout is explained below:

```
<header> <h1> Provide Website Header Here </h1></header>
<nav role="navigation"> Provide Website Main Navigation Here
    <form role="search"> Search Form </form>
</nav>
<main> Provide Web Page Main Contents Here
    <article> Provide Article Headings and Contents </article>
    <aside> Provide Related Aside Contents </aside>
</main>
<footer> Provide Footer Contents Here that will use across all pages. </footer>
```

Many websites contains HTML code having <div> tags for indicating navigation, header, and footer area such as developers use <div id="nav"> , <div class="header">, <div id="footer">. This method not works efficiently with screen readers. The example is explained below:

```
<div role="article">
    <h3>Heading Name </h3>
    <p> First Paragraph. </p> <p> Second Paragraph. </p>
</div>
<div role="article"> ... </div>
```

Instead of using a <div> with the role="article" it is appropriate to use the <article> element in the case when the native element exists such as:

```
<article>
    <h3>Heading Name </h3>
    <p> First Paragraph.</p> <p> Second Paragraph.</p>
</article>
```

### 4.5.3 Headings

HTML provides six levels (<h1> to <h6>) for headings. Use these heading tags to properly structure all webpage content under headings and sub headings. Assistive technologies like screen readers could not identify those headings that are created without using heading tags such as by using merely large text, bold, or emphasized. Therefore, heading tags are important because screen readers rely on it and could not interpret headings unless the heading tags are used. Many screen readers also readout the heading level. Headings are also important because some screen readers allow users to jump among various headings such as move to next and previous heading. Some screen readers (such as Voice Over) identifies all headings and bring a list of headings as a table of contents and allow users to use these headings to easily move to the desired content. Developer may avoid using <h1> because it looks ridiculously large or <h5> <h6> or may avoid <h5> or <h6> as they look absurdly small. It is very important to use headings in semantically correct way and they can change headings size using CSS (Cascading Style Sheet). Always use <h1> for main heading, followed by <h2> and so on. Use the hierarchy correctly in order and do not skip any level such as from <h3> to <h5>. Correct way of using headings is explain below:

H1: Recipes

H2: Quick Recipes

H3: Burger

H4: Chicken Burger

H4: Beef Burger

H3: Spaghetti

H4: Chicken Spaghetti

H4: Vegetable Spaghetti

H2: Time Taking Recipes

H3: Lasagna

H4: Chicken Lasagna

H4: Vegetable Lasagna

Also, avoid using heading tags for other purpose such as for making text bigger, highlighting or emphasizing text, because visually it will work well but for screen readers they gave inappropriate results. Therefore, following the HTML semantic is very important.

The correct way of creating headings is to use heading tags:

```
<h1> Heading 1 </h1>  
<p> Paragraph </p>  
<h2> Sub Heading </h2>
```

The incorrect way is by using font tag with size attribute such as:

```
<font size="8"> Heading 1 </font>  
<font size="6"> Sub Heading </font>
```

Use role attribute equals to presentation or none where it is required to remove actual semantic. For example in case of headings if it is written `<h3 role="presentation"> Accessibility is essential </h3>` then it will removes the actual semantic of heading and make it equivalent to `<div> Accessibility is essential </div>`. The heading role semantics are removed, but the content itself will still available.

#### **4.5.4 Images**

In HTML, the alt attribute is used to provide an alternate text for images. Mostly developers agreed that this tag provide information about image when due to some reason the image could not load (such as slow connection, invalid image name etc). This concept is not widely understood by developers that screen readers readout alt attribute and thus many website images does not have either this attribute or does not have proper alt attribute. Many screen readers such as voice over read image name in case if alt attribute is missing such as it will read file name“img\_islamabad.jpg” and sometimes file name does not provide any context. Therefore, alt attribute is very important and it should clearly describe the images and those images as well that contains text or used for decoration purpose.

```

```

Another alternate mechanism is to use `aria-labelledby` to add the extra semantic to improve image accessibility via screen reader.

```
  
<p id="icon-label">The Description of Image... </p>
```

In above example, instead of using `alt` attribute an `id` is used to refer and screen reader will read the referred paragraph as `alt` attribute. This method is suitable especially when same description is required for multiple images.

Use empty `alt` (`alt=""`) attribute for images that have no meaning such as icons etc. which are used for visual decoration. Screen readers will ignore such images and does not describe the images with empty `alt` or sometimes it may readout “image”.

```
<h2>  Accessibility </h2>
```

The reason to provide an empty `alt` (`alt=""`) attribute instead of skipping `alt` is that many screen readers announce the whole URL for images if no `alt` is present. Another alternative way is to use the `aria role` attribute equals to `presentation` or `none`. It will also restrict the screen reader from announcing images.

```

```

#### 4.5.5 Buttons

Do not use the `<div>` tag for creating buttons because it does not tell about context. Use the `<button>` tag because screen reader identifies it as button and can be focused, clickable and by default have suitable styling. A button is also accessible via keyboard (using tab key) because buttons have built in accessibility via keyboard.

Semantic: `<button> Report Error </button>`

Non Semantic: `<div> Report Error </div>`

Both button and div tag works different with assistive technologies. The correct use of tag is very important to tell about context to assistive technologies.

## 4.5.6 Links

Some examples of creating accessible links are given below:

### 4.5.6.1 Clear Purpose

Create links with descriptive text that clearly explain the link purpose. Link should clearly explain what information the user will get by clicking on the link. It is important because with screen readers the users use key board navigation and while navigating using tab key links are focused. Some screen readers also provide a list of all links to help users move directly on relevant part. In such case, links with bad names does not provide any meaningful information such as "read more", "click here". Instead developers can use “read more about topic name”.

Example of good link name is: "Read more about Accessibility". Sometimes the topic may be big so in situation if developers want to use non descriptive links like "read more" there is another way to improve link accessibility that is to use aria-label attribute. Example to describe link purpose by using aria-label attribute is given below:

```
<h2> Digital Accessibility </h2>
<p> Accessibility means that...<p>
<a href="accessibility.html" aria-label="Read more about the Accessibility"> [Read
more...] </a>
```

Another way that can also be used to provide clear description about link is given below:

```
<h3 id="news_headline">Digital Accessibility is important </h3>
<p>.....</p>
<a id="p13" href="news.html" aria-labelledby="p13 news_headline"> Read more </a>
</p>
```

In above example, screen readers will readout the link as: Read more Digital Accessibility is important. The reading order will base on the order in which they are specified.

#### 4.5.6.2 Skip Link

The idea of skip link is to provide a link at the top of webpage to help users jump directly to the main content. People who navigate using keyboard and assistive technologies such as screen reader often use this link to directly reach the main content in much faster and easier way instead of passing through so many navigation links. Many developers think that visible skip link is unattractive because it is not used by many people. As this link may confuse people so mostly this link is created as a hidden link and it remains invisible until it receives focus. Provide this link in <header> with an id refer to <main>.

```
<header>
  <a href="#main_content" class="skip_link"> Skip To Main Content</a>...
</header> ...
<main id="main_content">
```

Multiple skip links are mostly unnecessary and not required but for complex websites we can use multiple skip links. This is very helpful method for reaching important parts of webpage.

#### 4.5.6.3 Navigation

WAI-ARIA is basically used to express the semantics to assistive technologies. The role value equal to presentation declares that the element is used for decoration purpose so actual semantic of that element are not applied. Role equals none can also be used for the same purpose. Actually, the role equals none or presentation both serves as synonyms. An example describing role equals to presentation is given below:

```
<ul role="presentation">
  <li> <a href="#"> First Link Name </a> </li>
  <li> <a href="#"> Second Link Name </a> </li>
  <li> <a href="#"> Third Link Name </a> </li>
</ul>
```

In above example presentation role is applied to an unordered list. Each child list item inherits the role equals presentation so it will not expose like a list to screen readers. This way should be used to create links such as table of contents links etc. Similarly, it is allowed to use role equal to

presentation with table, headings etc. For example `<h3 role="presentation"> Accessibility Matters </h3>` will remove the `<h3>` heading semantics and will behave like `<div>Accessibility Matters </div>`.

Another way that is the accessible is to use `<nav>` region element for primary navigation such as:

```
<nav>
  <ul>
    <li><a href="#">Home</a></li>
    <li><a href="#">Our Team</a></li>
    <li><a href="#">Projects</a></li>
    <li><a href="#">Contact</a></li>
  </ul>
</nav>
```

For distinguishing two navigation landmarks, the following technique is useful to provide a label for assistive technologies such as when screen readers readout the object, they readout `aria-label` text to explain users about what is it.

```
<div role="navigation" aria-label="Primary">
  <ul> <li>...Provide list of Primary links here ...</li> </ul> </div>
<div role="navigation" aria-label="Secondary">
  <ul><li>...Provide list of Secondary links here ...</li> </ul></div>
```

#### **4.5.6.4 External link**

External links are those links that will either opens in a new tab or opens in a new window. Dyslexic people may become confused and distracted by these links and such links may distract users from actual website. Therefore, it is a good practice to alert users about such links both visually and via reading aloud for those who use screen readers. Let users know about such links in advance. Use `target="_blank"` and provide hint in the link name to indicate that the link is an external link such as:

```
<a target="_blank" href="https://www.w3.org/"> World Wide Web Consortium (opens in a new tab) </a>
```



### 4.5.7 Keyboard Navigation

Keyboard navigation support is very important feature of an accessible website. It is used and preferred by many people such as people having motor disabilities, blind people who use screen readers or other screen reader users, people who cannot use mouse due to imprecise muscle control and even some non disable users depend on keyboard navigation as it is easier and faster.

Screen reader users often prefer to use keyboard for navigation. Some of the HTML elements provide built-in keyboard accessibility. Non keyboard focusable HTML elements can also be focused by using WAI-ARIA tabindex attribute. It allows developers to customize tab order and provide users to navigate easily via keyboard tab key. It means that tab sequence can be arranged in logically correct way according to the website. It will allow focusing on important webpage elements such as links, headings, forms, buttons etc and tabindex attribute can be used with all HTML elements.

It also allows focus to those elements that are not focused by default such as fake <div> buttons. This fake button can also be tabbed via keyboard tab key by using tabindex attribute. Set tabindex equals to zero (tabindex="0") or any greater value. Basically, this attribute allows developer to set a custom specified tab order (positive increasing numerical order).

```
<div tabindex="1">Dyslexia</div><br>  
<div tabindex="3">Symptoms</div><br>  
<div tabindex="2">Assistive Tools</div>  
<div> Not tab-able because no tabindex is used. </div>
```

In above example, these elements became tab-able due to using tabindex. If it is not specified, it uses 0 as a default value and tabindex="0" means to focus the element in default sequence with keyboard navigation.

If the website internal search field contains tabindex=1, it means it will be focused first using the tab key. Many developers follow this even though it should not be given the first order because it is not often used initially when the user visits the webpage. So, logically set tabindex value to focus all the main links and content in appropriate order according to preference.

If multiple elements have given identical values of tabindex then they are navigated according the order they appear. This method is less error prone as compared to giving multiple different values. If developers use different numbers for tabindex then those website that are frequently updating may become difficult to maintain. For example to add some new links in between existing links, developer needs to change multiple tabindex values. By using identical tabindex developers can easily modify, rearrange and add new elements in existing webpage. For example:

```
<a href="#" tabindex = "1"> Tabbed on First number</a>  
<a href="#" tabindex = "1"> Tabbed on Second number </a>  
<a href="#" tabindex = "1"> Tabbed on Third but added after a Long Time</a>  
<a href="#" tabindex = "1"> Now tabbed on fourth number but previously it was tabbed  
on Third number</a>
```

If tabindex is not included then keyboard navigation may not be supported in logically correct order. Instead, the default tabbing order will be followed that will not work efficiently because it will focus according to the order as the object appear in source code. Therefore, developers need to enhance the keyboard accessibility as it is very crucial aspect of accessibility.

#### **4.5.8 Forms**

Make forms accessible via key board navigation as well as via screen reader. Some of the best practices for creating forms are:

##### **4.5.8.1 Labels**

Use form landmark for creating from region. Use appropriate labels with forms controls to correctly describe the purpose. Labels give hint to screen reader users about what is needed to enter so labels are important for every form element.

One method for creating form is given below:

```
<form>  
    Enter Name <input type="text" id="name" name="name">  
</form>
```

By using above method visually the form looks well, however, this is a bad way of creating form because if it is accessed with screen readers, it give inappropriate description along with edit text. So, better way to create forms is to use label tags such as:

```
<form>
    <label for="name">Enter Name: </label>
    <input type="text" id="name" name="name">
</form>
```

When the above method is used, the label will clearly associate with the input so screen reader describes it correctly. The value of “for” attribute of <label> tag and the “id” attribute of <input> should be equal in order to bind these elements together. The <label> element is very useful for screen-reader, because it will read the label when the user focuses on the input field. Also, do not rely alone on placeholder text because it is not a substitute of label. Use placeholder with appropriate label because screen readers usually skip placeholder and do not read it.

#### ***4.5.8.2 Required Fields***

Labels that contains asteric "\*" or use word "required" for indicating that the field is mandatory. These methods are fine according to visual look but "asteric" will not sound good with a screen reader (it may sound like "Enter your name star, edit text"). Therefore, it is recommended to use the aria-required="true" and "required" with fields that are required. This attribute give clue to screen reader that the field is required to be filled.

```
<input type="text" name="name" id="name" aria-required="true" required>
```

#### ***4.5.8.3 Search Form***

There is an option to use "aria-label" where visual labels are not needed. Search fields often have no label but have a placeholder. A placeholder is not considered as a valid or accessible name and many screen readers don't read it. When the input field of form is focused then screen reader read out the term enclosed in aria label attribute. So, as a solution we need to add aria-label attribute so that screen reader could read it such as:

```
<input placeholder="Enter Term" aria-label="Enter Term ">
```

Search landmark can also be used such as:

```
<form role="search">
  <label for="search"> Enter Term </label>
  <input id="search" type="text" size="20">...
</form>
```

If image buttons are used then must provide an equivalent alternative (alt) text. Otherwise, screen reader will just readout "button", without indicating the purpose of button.

#### ***4.5.8.4 Auto complete***

Browsers often stores user details so provide auto complete options for forms. It will be a great aid for dyslexic people because along with reading difficulties they also face writing difficulties. So the best way to allow filling forms is to use auto complete such as:

```
<input id="email" autocomplete="email" name="email" aria-required="true" >
```

#### ***4.5.8.5 Password***

When it is needed to associate descriptive information with a form input then use aria-describedby so that screen reader will readout description as well. For example a password field with correct format details may look like:

Enter Password

The password must have at least 10 characters and must include number, capital and small letters.

In above example a form contains a password field with some rules where the rules are written in the next line or after the field. In such cases, when focus is on text field then screen readers cannot announce the next elements. Thus, screen reader may not announce rules timely. Screen reader typically read descriptions in order where they are written, sometimes after labels and sometimes after input fields as the very last information. However, for screen reader users, descriptions are much useful while focusing form input fields. So the better way to make descriptions read by screen reader is to use aria-describedby such as:

```
<label for="password">Enter Password</label>
<input type="password" id="password" aria-describedby="passwordnote"><br>
<p id="passwordnote"> The new password must have at least 10 characters in length and
must include number, capital and small letters.</span>
```

Use aria-describedby to describe form elements where longer description is required. Typically screen readers readout the label initially, then it readout input type such as checkbox etc then it readout additional properties if exists such as field is required and finally it will read out the description if it exist.

A screen reader friendly example of password with requirement that suggest password must contain at least 10 characters is given below:

```
<label for="pwd"> Enter Password:</label>
<input type="password" name="pwd" id="pwd" pattern=".{10,}" aria-
describedby="password-length-error" aria-invalid="true" title="Ten or more characters
are required">
<p id="password-length-error" role="alert"> Ten or more characters are required </p>
<input type="submit">
```

Role equals alert is assigned to error so that screen reader read content even though this is not focused. This error message is not just associated with this field. The aria-invalid equals true till announce via screen reader about the current state of password whether valid or invalid (means it needs to be corrected) according to the given format. According to the input its value changed dynamically.

#### **4.5.8.6 Check box**

For a checkbox, the following method can be used to provide accessible name to screen reader:

```
<span role="checkbox" aria-checked="false" aria-labelledby="terms_conditions"></span>
<span id="terms_conditions">I agree with the Terms and Conditions. </span>
```

### 4.5.9 Semantic Elements

It is very important to use correct semantics for screen readers to readout properly. Avoid changing the actual semantic of HTML because the default semantic works best with assistive tools. Use headings tags for creating headings and create buttons using button tag. The semantically correct way of using list is to use the list tag and the incorrect way is to make list as given below:

1. Apple <br><br>
2. Mango <br><br>
3. Orange <br><br>

Screen readers will not give proper readout for this list which is created without using list tag. So, it is very important to use the correct semantic element always to improve accessibility because assistive technologies rely on semantic and understand the code correctly when correct semantic are used. Semantic HTML itself is a great aid for screen readers to screen readers to understand website contents. Screen reader readout tag through the website contents to notify users about what is being read i.e. heading, list etc.

Widgets that are used on web pages are also created with accessibility barriers and are unrecognizable through assistive technologies. WAI-ARIA guidelines also make widgets accessible by screen readers. Some common examples of widgets are: Sliders, Breadcrumbs, Carousels, Checkboxes, Date pickers, Tooltips, Dialog windows, Alerts, and Drop down menus.

The above mentioned code examples seem reasonable enough to guide developers how they can improve accessibility by doing few changes in HTML code to make it screen reader friendly as well. Developers need to conform to these guidelines while developing websites in order to make accessible websites for dyslexic people.

## 4.6 Benefits of Guidelines

It is very important to build better websites in terms of accessibility. The suggested guidelines, WAI-ARIA and semantically meaningful HTML collectively allow dyslexic users including those who use screen reader to better understand and use the website. If developers follow these

practices then the developed website will also work well with screen readers and thus improves website accessibility and quality by clearly explaining websites to users.

These key guidelines are important because they would facilitate developers to understand dyslexic people needs and create website that dyslexic people can easily use and also benefit many other individuals and society. The guidelines can be used as an inspiration by different team members in different ways. For example, teams can incorporate these guidelines in:

- Requirement specification
- Design
- Implementation
- Testing
- Maintenance

Furthermore, these guidelines will give awareness of key issues and are beneficial for all stakeholders that are involved in website development projects. Every stakeholder including developer, designer, tester and content writers can use these guidelines to play their role to enhance website accessibility.

#### **4.7 Brief Summary of Guidelines**

This chapter has provided the basic website accessibility guidelines that are helpful for making friendly websites for dyslexic people. The major accessibility barriers for dyslexic people along with the guidelines to fix those barriers are summarized in Table 4.1.

**Table 4.1:** Summary of Major Accessibility Barriers and Guidelines for Fixing

<b>S.No</b>	<b>Major Barriers</b>	<b>Guidelines to fix Barriers</b>
1.	Poorly Presented Information	Use short paragraphs, headings, bold, diagrams, lists, examples etc. to convey message in a meaningful and interactive way. Expert opinion could be taken regarding the organization and simplicity of all written material. Use simple and easy words while writing.
2.	Complex Layout	Avoid using too many columns and complex website layout. Keep it simple, familiar and easy.
3.	Inappropriate Text Size, Spacing and Color Contrast	Use readable enough font size, spacing and color contrast as recommended by WCAG standard. Check the contrast ratio using online color contrast checkers.
4.	Inaccessible Navigation	Use simple and clear navigation. Make navigation accessible via screen readers and keyboard by using WAI-ARIA elements. Use a skip link that move user to main content especially for those pages that contains a lot of information.
5.	Inaccessible forms	Use WAI-ARIA guidelines for every form element to make it accessible via screen reader. Use labels for fields. Provide input assistance such as provide auto fill option, provide clear hints for accurate field format and display clear error message.
6.	Inaccessible images	Provide "alt" tag with images explaining complete description about the image. For images that are links provide alt text. Tag all icons for screen readers.
7.	Not much support for screen readers	Use the best practices to write Semantic HTML and WAI-ARIA elements to develop screen reader friendly website.
8.	Others	Avoid using popups, advertisements, moving text and multimedia that plays automatically. Provide enough time and control time outs of sessions. Also give accessibility trainings to developers.



# **PROPOSED FRAMEWORK**

## **5.1 Overview**

In this chapter, the need of an approach and the steps of proposed approach to provide accessibility solution framework is discussed. Developers can practically adopt this approach to enhance website accessibility. The benefits of the proposed approach are also discussed in this chapter.

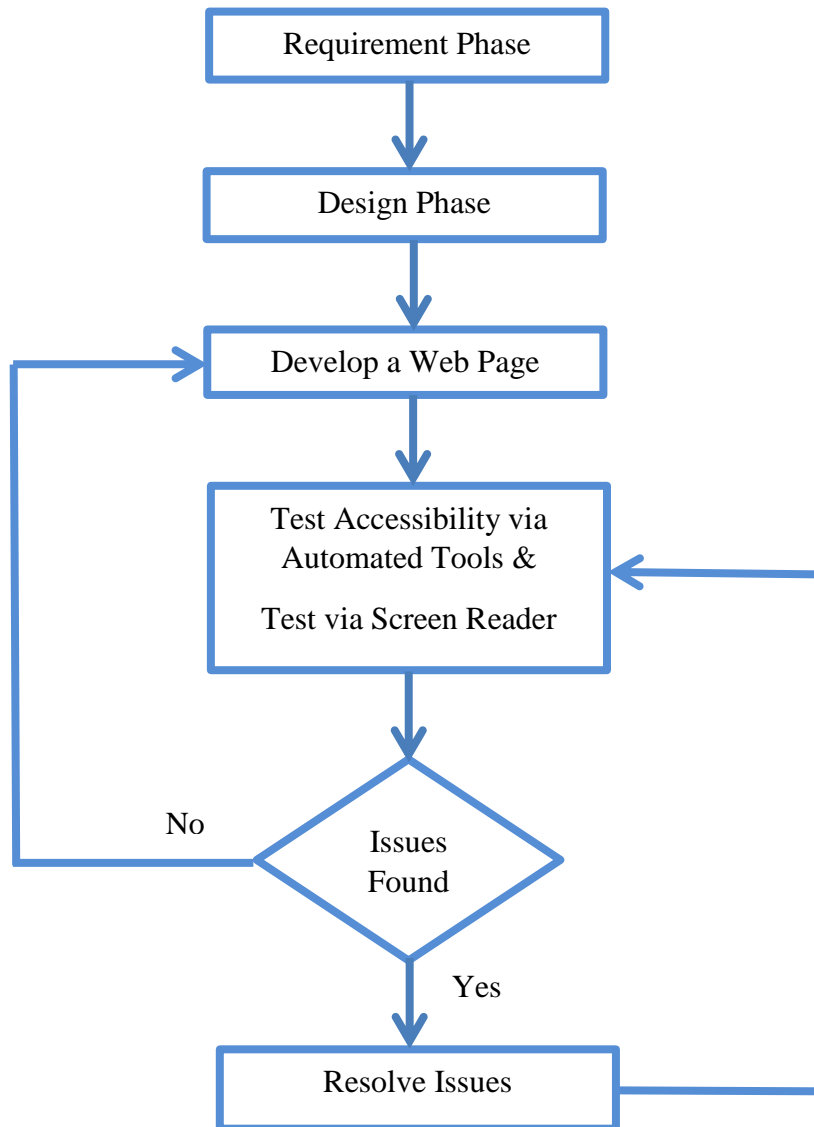
## **5.2 Need of an Framework**

Although, awareness about the topic of web accessibility is increasing, but this study identified that lack of knowledge exist that guide developer how they can implement accessibility in website development projects. The proposed approach work on improving website accessibility and can be easily put into practice by developers.

To know whether a website is accessible or not it needs some evaluation. Website accessibility evaluation main methods include manual testing by experts, automated testing and testing by users. Automated testing methodologies can save time, efforts and cost and can easily be done frequently by developers throughout the development. While user testing and experts testing methodologies can be expensive, tiring and slow and cannot be easily put into practice throughout the development. Therefore, the proposed solution suggests adopting the automated accessibility testing tools and screen reader testing approach from early stages. The approach suggests prioritizing accessibility from beginning as it easy to resolve the issues from the beginning. Moreover, the proposed approach gives a practical way that can help developers to create more accessible websites.

### 5.3 Proposed Approach

The steps involved in the proposed methodology are shown Figure 5.1. The development procedure starts with requirement phase and after performing a series of steps developers can finally built accessible website for dyslexic people.



**Figure 5.1:** *Proposed Framework*

Plan and prioritize accessibility from the requirement phase and keep focusing on it till the maintenance of website. Write requirements and prioritize accessibility as other requirements. Develop accessible design keeping in mind the accessibility guidelines. Then during implementation, frequently test for accessibility and fix identified issues. Continue testing until

the issues are resolved and until the complete website is developed. During maintenance, whenever changes are requested then again follow same steps including test for accessibility (automated and screen reader). Findings and lessons learned from both the testing types can also be noted. This report can be shared with other stakeholders to further train them to resolve potential accessibility problems. The testing tasks can be assigned to testing team from the beginning.

To ensure quality and accessibility, test the web pages with automated accessibility evaluation tools and with screen readers regularly across the entire development of website. If the website developers do not plan for accessibility thoroughly then they will ultimately end up ruining the website accessibility with every update they made and it will become difficult to resolve all issues if discovered at the end. Therefore, we need to test and fix the website early, repeatedly and thoroughly for accessibility in same way as we perform other testing (mobile browser view or desktop browser view).

Making an existing website accessible could be difficult using this approach but works well as an initial step towards accessibility. Developers can start accessibility improvements from high priority or more popular web pages. By following suggested steps, the development team can develop accessible websites using limited available resources.

## **5.4 Benefits of the Proposed Approach**

The propose approach incorporates the benefits of accessibility testing, screen reader testing as well as combined benefits of both. Screen reader testing could also play some of the role of user testing.

### **5.4.1 Benefits of Automated Accessibility Testing**

Some benefits of automated accessibility evaluation tools are:

- These tools are free and easy to use.
- They are cheap in terms of effort, time and cost.
- They provide fast way of detecting accessibility critical problems such as forms without labels, missing alt, colour contrast errors, font readability errors. The evaluation report is

generated in short time period. The errors are located with code snapshot so can be traced easily and these types of error are very important to remove.

- Developer can easily fix the errors by using hints provided to resolve errors.
- Inexperienced developers can easily use these tools to evaluate and work on website accessibility.

#### **5.4.2 Benefits of Screen Reader Accessibility Testing**

Some benefits to test for screen reader compatibility are:

- It helps to understand how the website works for those people who use screen readers. Many of the digital accessibility lawsuits were filed by screen reader users who get frustrated because they could not complete desired task using screen readers either on a website or mobile app [66]. Therefore, screen readers can help to identify existing barriers and motivate developer to develop screen reader friendly websites.
- Many screen readers are free and easy to use.

#### **5.4.3 Benefits of the Combined Approach**

For better results, one should use both testing types. Such a combined testing approach provides an effective way that leads towards higher levels of accessibility. Some of the benefits of using combined testing approach are:

- Website accessibility problems of dyslexic people are also related to no support for screen readers. Therefore, screen reader testing can overcome some of the limitations of automated testing such as automated testing can detect the absence or presence of alt text in images while the screen reader testing could depict that alt text is meaningful or not.
- Automated tools alone does not provide complete solution, so, for effective results human judgement is required and thus, screen reader testing can be considered as an accessibility best practice. Testing using accessibility evaluation tools is a great initial step but testing with screen reader will give much closer view of how screen reader users experience the website.
- This approach has potential to encourage even those development teams that neither have

the knowledge required to produce accessible content nor can afford the cost to hire accessibility experts from outside to examine and correct the source code by applying their knowledge.

## **5.5 Summary**

An accessible website development framework is presented in this chapter that will assist developers to create accessible websites for dyslexic people by using limited resources. The approach focuses on the automated accessibility testing and screen reader testing that is often ignored by developers. This approach is easy to follow because both testing tools are free of cost.

# EVALUATION RESULTS

## 6.1 Overview

In this chapter, a prototype of website is developed using recommended guidelines and framework. The website is evaluated for accessibility and evaluation results showed that the proposed website is accessible.

## 6.2 Tools Used For Evaluation

Two tools are used for the evaluation process.

1. **AccessScan:** It evaluates website accessibility against WCAG 2.1. This tool scans full website and needs website link for scanning.
2. **Screen Reader:** It gives an idea about the website look and feel for those users who use such tools i.e. dyslexic people. The Screen Reader extension was added from chrome web store as shown in Figure 6.1.

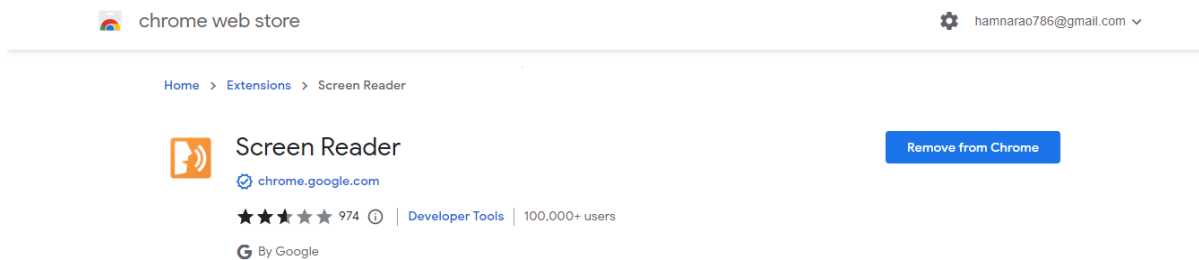


Figure 6.1: Screen Reader used for Testing Website

## 6.3 Website Prototype

The website is developed using the proposed guidelines and methodology. The website is tested frequently for accessibility and via screen reader during development phase. The detected accessibility issues are removed frequently throughout the development. Figure 6.2 show the

website development phase, Figure 6.3 represent home page, Figure 6.4 represent categories, Figure 6.5 represent the products and Figure 6.6 represent contact page of website.

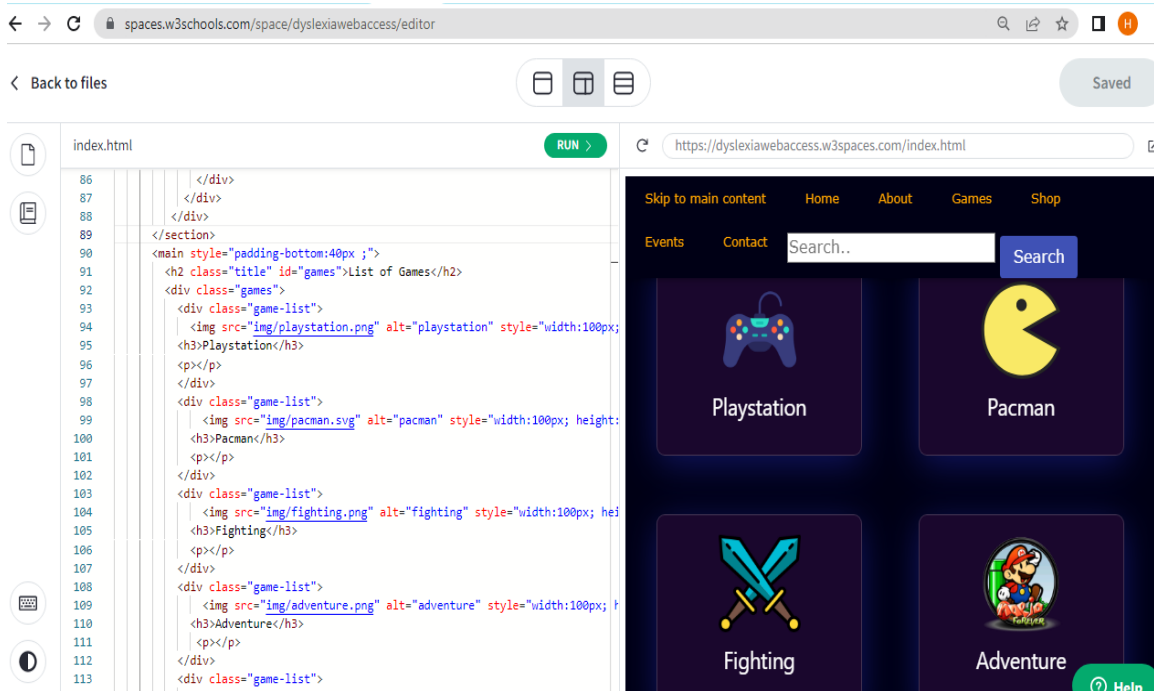


Figure 6.2: Website Development Phase

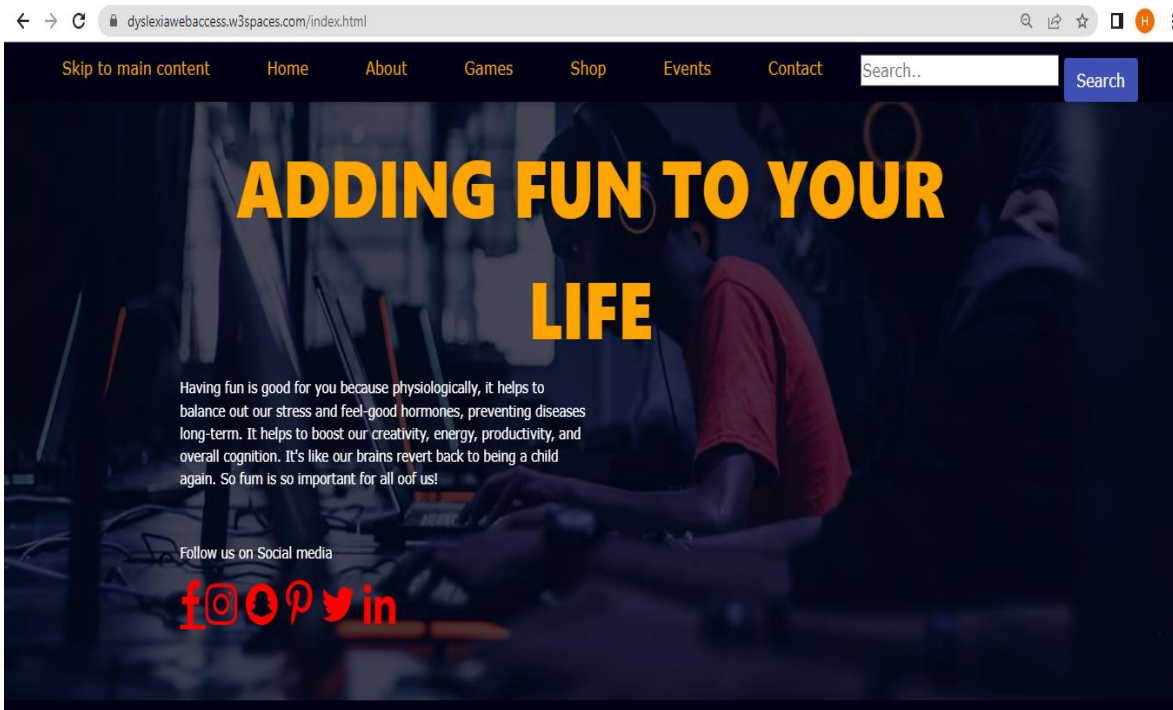


Figure 6.3: Home Page of Website

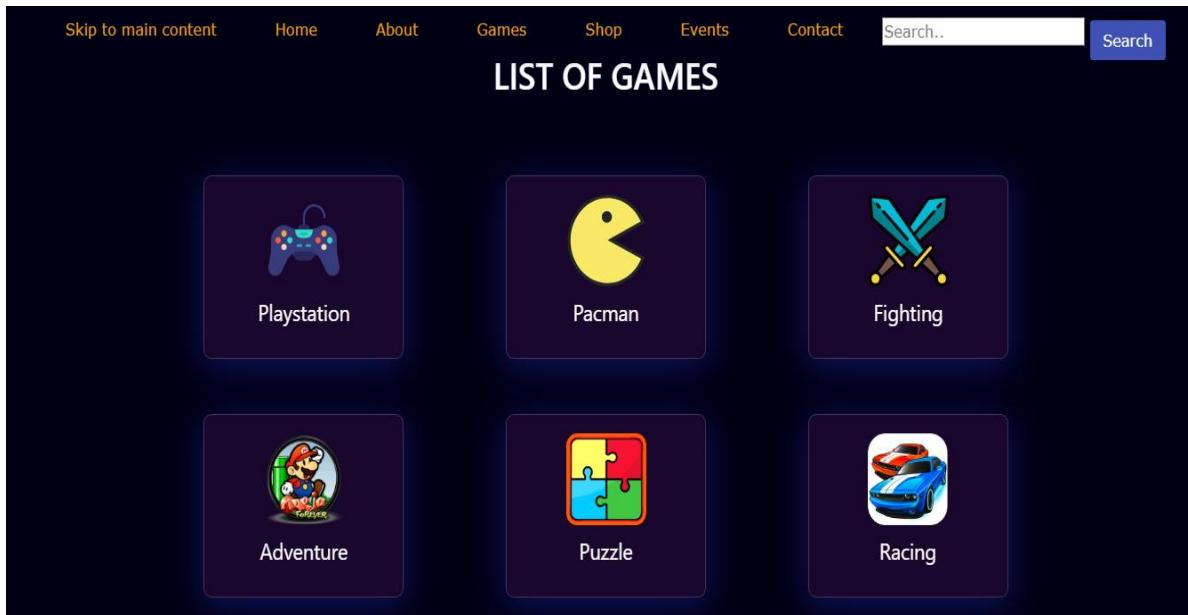


Figure 6.4: Game Categories Page of Website

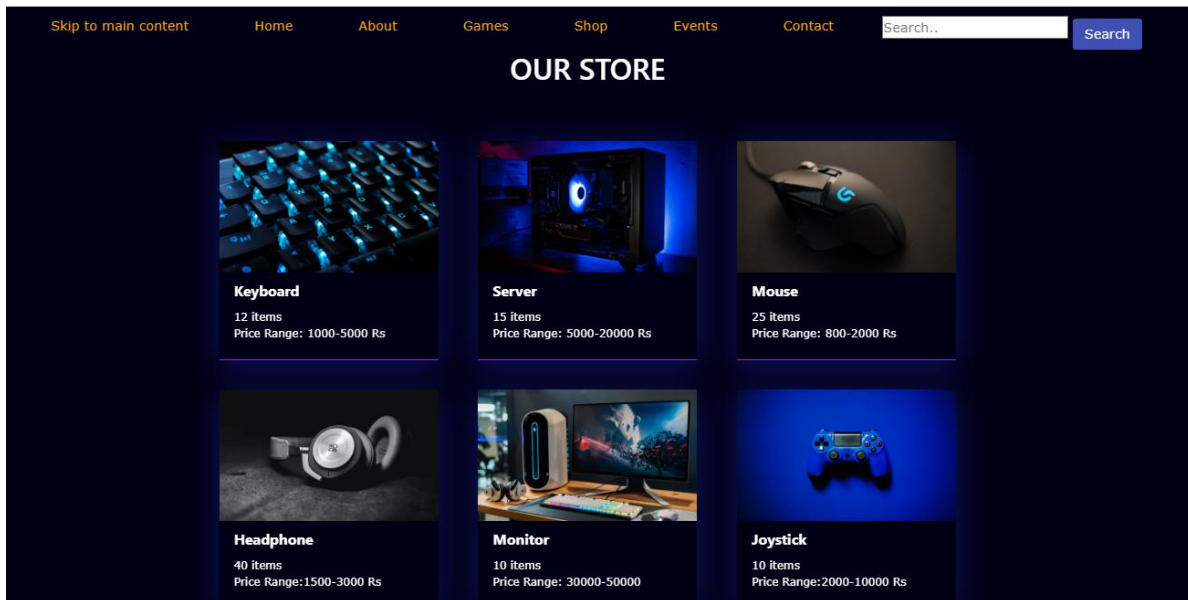


Figure 6.5: Products Page of Website

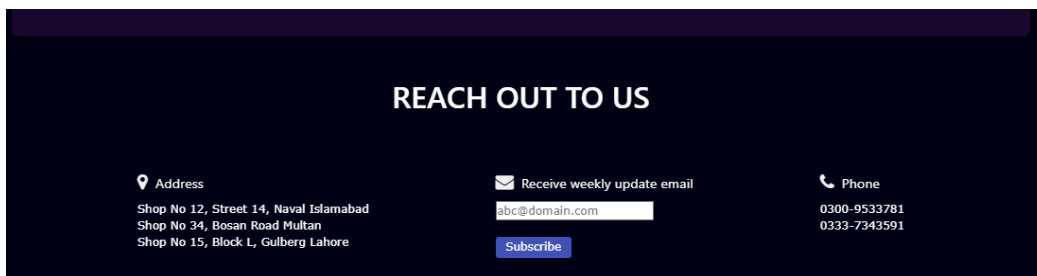
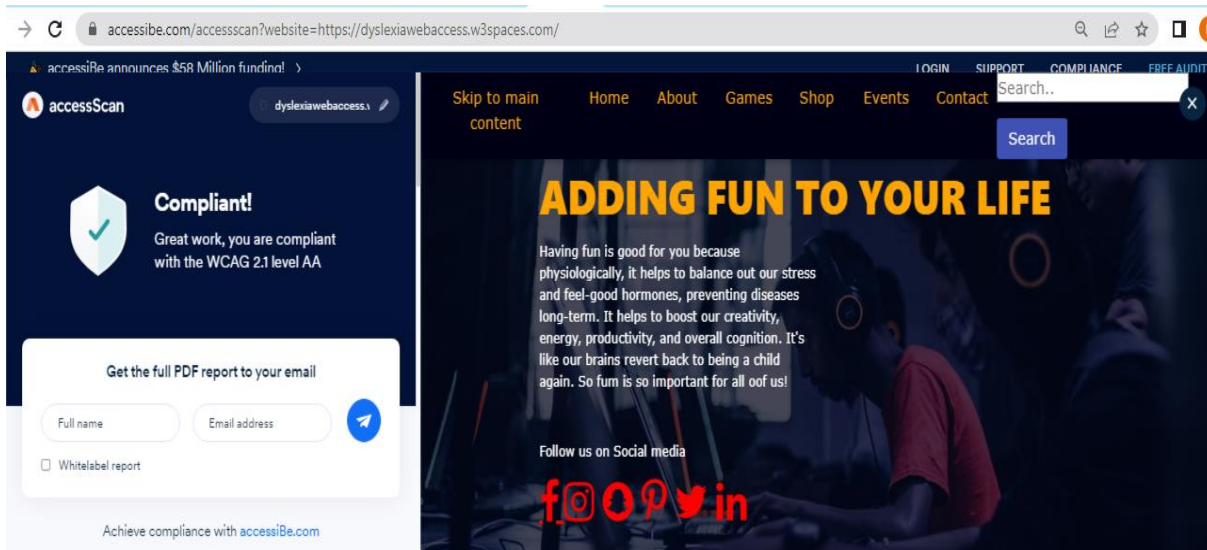


Figure 6.6: Contact Us Page of Website

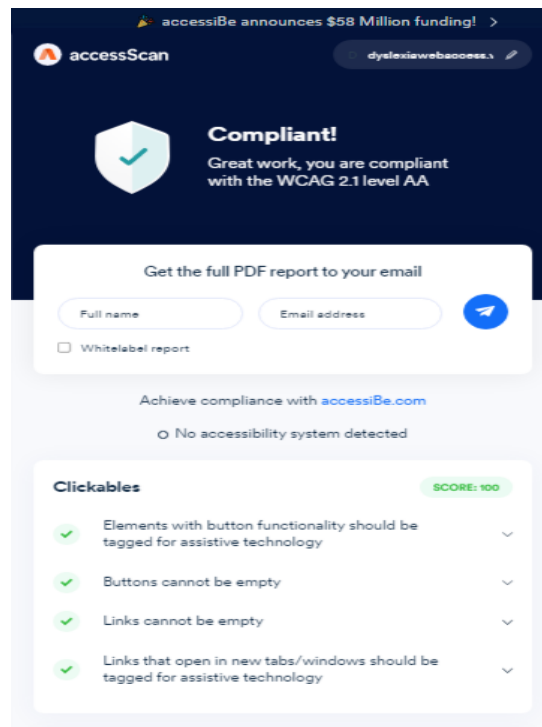


## 6.4 Results

The website is evaluated using the "AccessScan" tool and evaluation results show the website is Compliant according to WCAG 2.1 Level AA. Accessibility evaluation results and remarks are shown in Figure 6.7 and Figure 6.8.

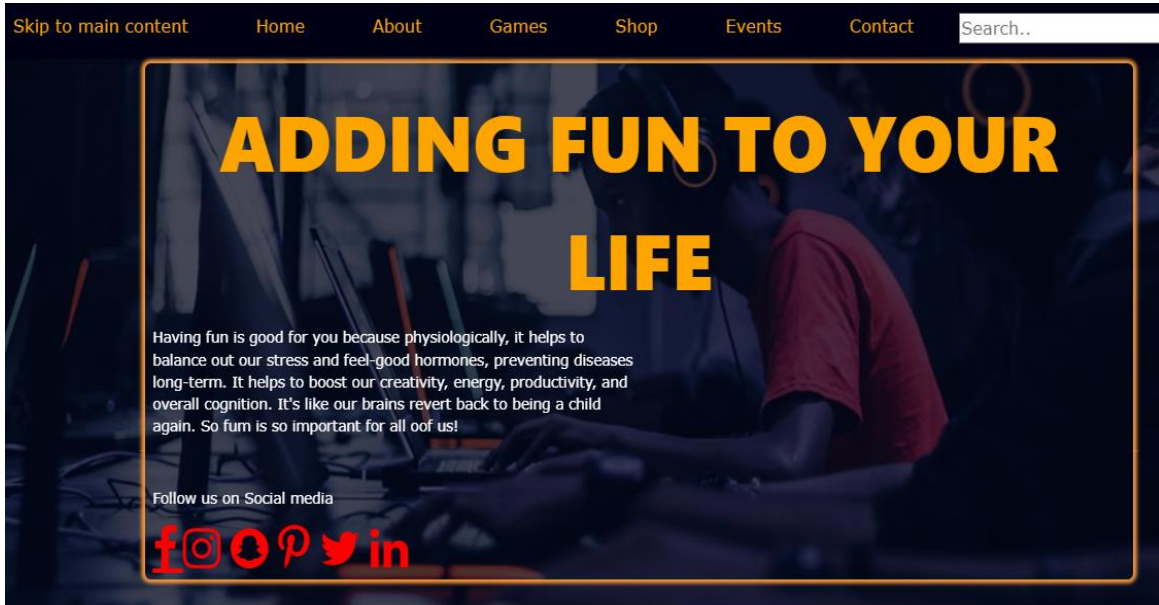


**Figure 6.7:** Evaluation Results of Proposed Website Using "AccessScan" Accessibility Evaluation Tool

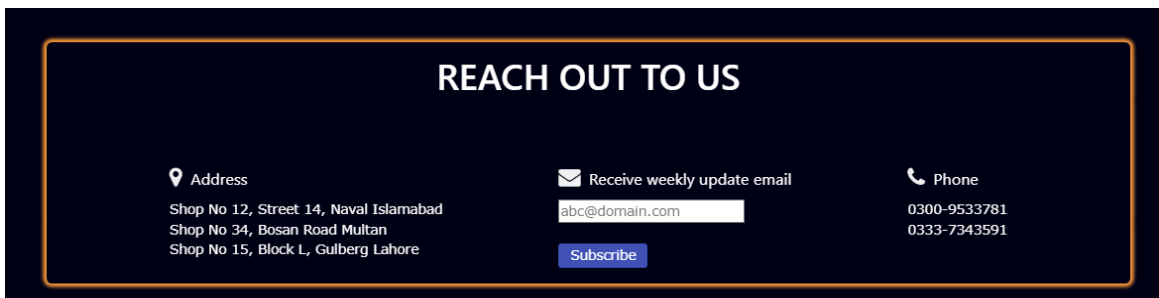


**Figure 6.8:** Proposed Website Compliant according to WCAG 2.1 Level AA

The screen reader testing is done by using chrome extension and the results have shown that website works well with screen reader. The screen reader testing process is shown in Figure 6.9 and Figure 6.10.



**Figure 6.9:** Testing with Screen Reader



**Figure 6.10:** Testing with Screen Reader

## 6.5 Summary

The evaluation results provided in this chapter have shown that the developed website according to proposed guidelines and development approach has significantly improved the website accessibility for dyslexic people.

# LIMITATIONS

## 7.1 Limitations

Some of the limitations are mentioned below:

- There are multiple methods for accessibility evaluation. In this research, two methods are used in combination to assess the website accessibility. First method include an automated tool to evaluate accessibility and the second method includes examining the website for screen reader compatibility. Other evaluation methods such as expert based manual checking can also be used for this purpose. Dyslexic people can also be involved to evaluate usability of website and their involvement could further describe how well their needs are met.
- Due to the diversity of the topic and time constraint, only key guidelines are discussed. This work has focused only on some common website elements while there are so many other elements available for websites such as multimedia (videos, audios), tables, live chat, shopping cart etc. Accessibility of carousels, tables, deleted texts (used to show previous price), fast moving text, fast moving video, audios, videos, breadcrumbs, moving or blinking content, advertisements, reviews and ratings etc., are not discussed in this study. Therefore, depending upon the type of element that developer is going to use on website, it is recommended that developer should learn and implement relevant accessibility concerns.
- The proposed website prototype is tested using single accessibility evaluation tool and screen reader software. Multiple accessibility evaluation tools and multiple screen readers can be used for achieving much better results as more tools can give more valuable feedback.
- This research has discussed about accessibility basics and highlighted only the importance of semantic HTML and WAI-ARIA guidelines to achieve accessibility. This study has not discussed other practices such as CSS and JavaScript accessibility practices.

- Passing through automated accessibility testing tools does not guarantee that the website is fully accessible. Automated testing tools can be a good starting point to quickly find key issues on the website, but automated testing alone is not enough and there is always a need for humans to manually review each item or review using screen reader to assure that website is fully accessible. Few examples to describe that sole dependence on tools is risky because there are some limitations of tools:
  - Tools cannot test that the content is easy to read and is in logical flow.
  - Tools can only tell about presence or absence of “alt” text. They cannot verify that texts written in alternatives are meaningful.
  - Tools cannot ensure that the navigation order is logical using tab key from keyboard and desired path is followed.
- To summarize, each testing type has its own importance. Some issues are only identified by expert analysis. Also, user testing is important because users can reveal those issues that may be overlooked by automated testing and experts testing. Finally, to fully provide better accessibility, a combination of all these approaches is required.

# **CONCLUSION & FUTURE WORK**

## **8.1 Conclusion**

The main goal of any website is to reach as many customers as it can. A fully accessible website according to WCAG is one that is easy to use by everyone including people with various disabilities. By following WCAG properly, we can develop perfect websites but enough time, effort and dedication is required to make the website fully accessible for all disabilities. Also, be practical because the concept of 100 percent accessibility is an unattainable target. Therefore, developers should make websites accessible as much as they can. Although, WCAG exists for the past 20 years, dyslexic people still struggle to use websites.

Despite the fact that nearly 15 to 20 percent of the population is dyslexic [7], accessibility is rarely a consideration for website developers. Mostly the websites are developed without giving attention to accessibility. Generally, dyslexic people are affected by website inaccessibility because when they use websites, they often experience discrimination and receive poor quality services. Discrimination means that these people are treated less favorably due to their disability. This discourages them from using websites. This discrimination may occur as a result of a lack of awareness of key website accessibility issues and best practices to overcome those issues.

This research has presented a high level overview of website accessibility, highlighted its benefits and importance, presented statistics of increasing number of lawsuits and exposed the current accessibility evaluation results. Additionally, key accessibility guidelines and a framework is provided to help developers to quickly and easily identify and fix the accessibility obstacles faced by dyslexic people.

Previous facts and figures and our accessibility evaluation results have shown that dyslexic people are unable to fully utilize the website offerings. They usually use assistive technologies and mostly screen readers are used by these people. Despite the fact that screen readers can help

dyslexic people to understand website content, barriers to access still exist. Accessibility will remain an issue unless the content is created in a way that can be understood by the screen readers. Therefore, testing alone for accessibility is not enough and in order to achieve higher levels of accessibility we suggest that it is necessary to test websites with screen reader for checking screen reader compatibility. This research has also highlighted the importance of both accessibility testing and screen reader testing.

In this research, key guidelines and framework are proposed for making websites accessible for dyslexic people to encourage their participation and to open up opportunities for them. Selection, design and adaptation of material according to guidelines from the beginning is very crucial to keep the websites dyslexic friendly. We have suggested that testing of website for accessibility should be prioritized from the beginning to minimize the efforts and costs of fixing it later. Testing for accessibility early and regularly using automated tools is ideally a good initial step towards accessibility. It helps to easily and quickly find out the programmatically detectable HTML and WAI-ARIA issues such as missing alt text (alternative text) from images or links with bad text such as “click here”, “see more”, missing labels from form controls, contrast errors etc. Semantic HTML and WAI-ARIA guidelines are a good basis for addressing main accessibility issues.

A website prototype is developed using suggested guidelines and framework and by using frequent testing approach. From evaluation results, it is observed that the proposed website model has considerably lessened the key issues. Accessibility is an important part of the website and should be given importance from the start and need to be focused throughout the development so that we do not have to go back and redo all the work to become accessible. Naturally, website accessibility seems like a big task but considering accessibility throughout is a vital part of building and maintaining a successful website. It is often overlooked due to lack of awareness, limited time, limited budget and limited resources but if accessibility related issues are uncovered in the later stages then it will become very costly, time taking and difficult to fix those issues. Accessibility of websites is a much important element to be tested throughout. It should not be considered as an add-on or afterthought but it should be prioritized as an ongoing process and prioritized from the very beginning of development. With the proposed approach, the accessibility obstacles can be easily found and removed in early stages in a cost effective

way. Hence, it is concluded that accessible design is not hard to achieve if it is focused from the beginning of development.

This research will further increase awareness and encourage valuing the needs of dyslexic people as a key component in website development projects. When websites are properly designed, developed and maintained, dyslexic people needs can be accommodated without decreasing the website accessibility for others who are not disable because dyslexia friendly practices makes websites simpler and easier to learn and use by many other users as well. Along with its ethical and financial benefits, there are legal risks as well in some countries that enforce developers to implement accessibility. This research could also become a resource to build capacity among policy makers, businesses owners, professionals and service providers to promote website accessibility. With this view, every stakeholder involved in website development should feel accountable for it and everyone has a role to play to eliminate existing barriers and prevent new ones as much as they can.

The research on accessibility should be given considerable attention on the national and international levels because accessibility is a key challenge that most of the websites are currently facing. Based on the work described in this research, it is recommended that it is a very critical issue and government of every country should either adapt the existing accessibility guidelines or should develop their own guidelines that are appropriate for their context. Government should also set some policy for website accessibility with strict enforcement procedure, i.e., make it a compulsory requirement to create accessible websites and the owner should be sued and accountable for providing inaccessible websites. Giving rewards to those who provide accessible website might also help in promoting accessibility in the environment.

## **8.2 Future Work**

The topic of accessibility is complex because with changing technology the accessibility guidelines are evolving and increasing rapidly. WCAG 3.0 with a wide set of guidelines will be published soon in future. In the world where technology is always developing, this topic needs more attention because websites are of different types and can contain a lot of elements. Keeping in view the limitations of this research work, some future directions relating to this topic are discussed below.

In this research, only one accessibility evaluation tool and one screen reader program is used. It may be worthwhile to look into the results from various accessibility tools for the same website. More tools can be used in order to extract more issues regarding accessibility of websites.

The future research can also include dyslexic people to further evaluate the usability of website. A large sample of websites or country specific websites can also be evaluated for accessibility using automated tools to check the current accessibility status, obstacles and statistics.

This research work has focused only on some common elements that are present in most of the websites such as layout design, forms, links, buttons, headings, images, colors and textual data. There are so many other elements available on websites such as multimedia (videos and audios), tables, live chat, shopping cart, moving text, online tests etc. The proposed guidelines can be extended by adding more accessibility factors, criteria and guidelines.

Dyslexic users face different types of obstacles on different types of websites i.e. educational, entertainment, banking, government, news, e-commerce etc. In this research, only key issues are discussed. Therefore, depending upon the type of website, research can specifically be conducted to identify dyslexia friendly guidelines for a particular type of website such as conduct a study to highlight the obstacles faced on e-commerce websites and suggest guidelines to tackle them.

Until now, most of the studies on dyslexia focused on the English language. Because of this, several problems relating to other languages are not covered yet by current accessibility guidelines. Therefore, the research can also be conducted to identify problems faced by dyslexics in other languages. Also, font is one of the key factors that mostly impact on readability so there is also a need to work on suitable font in other languages such as Urdu, Arabic etc. We can suggest suitable font face, suitable word spacing, letters spacing, line spacing etc. based on empirical results. Also, very limited screen readers support such languages so language specific research also needs attention.

These dyslexia friendly accessibility guidelines can also be used to create mobile or desktop applications for dyslexic people. Furthermore, these guidelines can be used to create augmented reality and virtual reality based applications for dyslexic people.



## REFERENCES

- [1] Berninger, Virginia W. "Understanding the 'lexia' in dyslexia: A multidisciplinary team approach to learning disabilities." *Annals of Dyslexia* 51.1 (2001): 21-48.
- [2] World Wide Web Consortium. "Web Accessibility Initiative (WAI)." <http://www.w3.org/WAI/> (1998).
- [3] Caldwell, Ben, et al. "Web content accessibility guidelines (WCAG) 2.0." *WWW Consortium (W3C)* 290 (2008): 1-34.
- [4] Boas, Micki. *One in Five: How We're Fighting for Our Dyslexic Kids in a System That's Failing Them*. Tiller Press, 2020.
- [5] Innocenti, Clarie C. "Foundations: A Systematic, Research-Based Program to Support Students with Dyslexia through Tier 1 Instruction." (2017).
- [6] United Nations, Department of Economic and Social Affairs, Population Division. "World Population Prospects 2019: Data Booklet (ST/ESA/SER. A/424)." (2019): 1-28.
- [7] International Dyslexia Association. "Frequently Asked Questions; 2022." *View Article* (2022).
- [8] WHO, W. "World report on disability." Geneva: WHO (2011).
- [9] Boldyreff, Cornelia, et al. "The case for the use of plain English to increase Web accessibility." *Proceedings 3rd International Workshop on Web Site Evolution. WSE 2001. IEEE, 2001.*
- [10] Zarach, V. "Ten guidelines for improving accessibility for people with dyslexia, 2012. CETIS University of Wales Bangor."
- [11] McCarthy, Jacob E., and Sarah J. Swierenga. "What we know about dyslexia and web accessibility: a research review." *Universal Access in the Information Society* 9.2 (2010): 147-152.
- [12] Horton, Sarah. "Building an Accessible Digital World." *Computer* 55.1 (2022): 98-102.
- [13] Paul, Trevor. "Is a Website Subject to Title III of the ADA: Why the Text Applies to Only Websites" of "a Place of Public Accommodation." *Tex. A&M J. Prop. L.* 8 (2021): 179.

- [14] Gregor, Peter, and Alan F. Newell. "An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques." Proceedings of the fourth international ACM conference on Assistive technologies. 2000.
- [15] Rello, Luz, and Ricardo Baeza-Yates. "Good fonts for dyslexia." Proceedings of the 15th international ACM SIGACCESS conference on computers and accessibility. 2013.
- [16] West, Thomas G. In the mind's eye: Creative visual thinkers, gifted dyslexics, and the rise of visual technologies. Prometheus books, 2020.
- [17] Miesenberger, Klaus, et al. "Tools and applications for cognitive accessibility." Web Accessibility. Springer, London, 2019. 523-546.
- [18] Al-Wabil, Areej, Panayiotis Zaphiris, and Stephanie Wilson. "Web navigation for individuals with dyslexia: an exploratory study." International Conference on Universal Access in Human-Computer Interaction. Springer, Berlin, Heidelberg, 2007.
- [19] Rello, Luz, and Ricardo Baeza-Yates. "Good fonts for dyslexia." Proceedings of the 15th international ACM SIGACCESS conference on computers and accessibility. 2013.
- [20] Gregor, Peter, and Alan F. Newell. "An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques." Proceedings of the fourth international ACM conference on Assistive technologies. 2000.
- [21] Gregor, Peter, et al. "SeeWord—a personal word processing environment for dyslexic computer users." British Journal of Educational Technology 34.3 (2003): 341-355.
- [22] Dickinson, Anna, Peter Gregor, and Alan F. Newell. "Ongoing investigation of the ways in which some of the problems encountered by some dyslexics can be alleviated using computer techniques." Proceedings of the fifth international ACM conference on Assistive technologies. 2002.
- [23] Kurniawan, Sri, and Gerard Conroy. "Comparing Comprehension Speeds and Accuracy of Online Information in Students with and without Dyslexia." Advances in Universal Web Design and Evaluation: Research, Trends and Opportunities. IGI Global, 2007. 257-270.
- [24] de Santana, Vagner Figueredo, et al. "Firefixia: An accessibility web browser customization toolbar for people with dyslexia." Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility. 2013.

- [25] O'Brien, Beth A., J. Stephen Mansfield, and Gordon E. Legge. "The effect of print size on reading speed in dyslexia." *Journal of Research in Reading* 28.3 (2005): 332-349.
- [26] Zorzi, Marco, et al. "Extra-large letter spacing improves reading in dyslexia." *Proceedings of the National Academy of Sciences* 109.28 (2012): 11455-11459.
- [27] Rello, Luz, Gaurang Kanvinde, and Ricardo Baeza-Yates. "Layout guidelines for web text and a web service to improve accessibility for dyslexics." *Proceedings of the international cross-disciplinary conference on web accessibility*. 2012.
- [28] Topac, V. "The development of a text customization tool for existing web sites." *Text Customization for Readability Symposium*. 2012.
- [29] Kanvinde, Gaurang, Luz Rello, and Ricardo Baeza-Yates. "IDEAL: a dyslexic-friendly ebook reader." *Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility*. 2012.
- [30] Lewis, Clayton. *Using the "thinking-aloud" method in cognitive interface design*. Yorktown Heights, NY: IBM TJ Watson Research Center, 1982.
- [31] Rello, Luz, and Ricardo Baeza-Yates. "How to present more readable text for people with dyslexia." *Universal Access in the Information Society* 16.1 (2017): 29-49.
- [32] McCarthy, Jacob E., and Sarah J. Swierenga. "What we know about dyslexia and web accessibility: a research review." *Universal Access in the Information Society* 9.2 (2010): 147-152.
- [33] Elkind, Jerome. "Computer reading machines for poor readers." *Perspectives* 24.2 (1998): 9-13.
- [34] de Santana, Vagner Figueredo, et al. "Web accessibility and people with dyslexia: a survey on techniques and guidelines." *Proceedings of the international cross-disciplinary conference on web accessibility*. 2012.
- [35] de Avelar, Luis Otávio, Guilherme Camillo Rezende, and André Pimenta Freire. "WebHelpDyslexia: a browser extension to adapt web content for people with dyslexia." *Procedia Computer Science* 67 (2015): 150-159.

- [36] Rello, Luz, Horacio Saggion, and Ricardo Baeza-Yates. "Keyword highlighting improves comprehension for people with dyslexia." Proceedings of the 3rd workshop on predicting and improving text readability for target reader populations (PITR). 2014.
- [37] Freire, André P., Helen Petrie, and Christopher Douglas Power. "Empirical results from an evaluation of the accessibility of websites by dyslexic users." Proceedings of the Workshop on Accessible Design in the Digital World. York, 2011.
- [38] Rello, L. B. S. D. J., and Simone DJ Barbosa. "Do People with Dyslexia Need Special Reading Software?." Workshop on Rethinking Universal Accessibility: A broader approach considering the digital gap, Cape Town, South Africa. 2013.
- [39] Kous, Katja, and Gregor Polančič. "Empirical insights of individual website adjustments for people with dyslexia." Sensors 19.10 (2019): 2235.
- [40] Rello, Luz, and Jeffrey P. Bigham. "Good background colors for readers: A study of people with and without dyslexia." Proceedings of the 19th international ACM SIGACCESS conference on computers and accessibility. 2017.
- [41] Renaud, Karen, Graham Johnson, and Jacques Ophoff. "Dyslexia and password usage: accessibility in authentication design." International Symposium on Human Aspects of Information Security and Assurance. Springer, Cham, 2020.
- [42] Renaud, Karen, Graham Johnson, and Jacques Ophoff. "Accessible authentication: dyslexia and password strategies." Information & Computer Security (2021).
- [43] Berget, Gerd, and Frode Eika Sandnes. "Do autocomplete functions reduce the impact of dyslexia on information-searching behavior? The case of Google." Journal of the Association for Information Science and Technology 67.10 (2016): 2320-2328.
- [44] Wessel, Daniel, Ann-Kathrin Kennecke, and Moreen Heine. "WCAG and dyslexia—Improving the search function of websites for users with dyslexia (without making it worse for everyone else)." Mensch und Computer 2021. 2021. 168-179.
- [45] Miniukovich, Aliaksei, et al. "Design guidelines for web readability." Proceedings of the 2017 Conference on Designing Interactive Systems. 2017.
- [45] Miniukovich, Aliaksei, et al. "Guideline-based evaluation of web readability." Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. 2019.

- [46] Rau, Pei-Luen Patrick, et al. "Evaluation of web accessibility in China: changes from 2009 to 2013." *Universal Access in the Information Society* 15.2 (2016): 297-303.
- [47] Cai, Xudong, Shengli Li, and Gengzhong Feng. "Evaluating the performance of government websites: An automatic assessment system based on the TFN-AHP methodology." *Journal of Information Science* 46.6 (2020): 760-775.
- [48] Paul, Surjit, and Saini Das. "Accessibility and usability analysis of Indian e-government websites." *Universal Access in the Information Society* 19.4 (2020): 949-957.
- [49] Al-Sakran, Hasan O., and Mohammed A. Alsudairi. "Usability and Accessibility Assessment of Saudi Arabia Mobile E-Government Websites." *IEEE Access* 9 (2021): 48254-48275.
- [50] Tashtoush, Yahya M., Darabseh Ala'F, and Huda N. Al-Sarhan. "The Arabian e-government websites accessibility: a case study." 2016 7th International Conference on Information and Communication Systems (ICICS). IEEE, 2016.
- [51] Ansari, Rabab Fatima, et al. "Heuristic, accessibility and usability evaluations of Pakistan's e-government websites." *Electronic Government, an International Journal* 12.1 (2016): 66-85.
- [52] Karaim, Nuha Awlad, and Yavuz Inal. "Usability and accessibility evaluation of Libyan government websites." *Universal Access in the Information Society* 18.1 (2019): 207-216.
- [53] Yazid, Mariam Azwa, et al. "Accessibility design issues with Malaysian news websites: a case study using a checker and WAVE." *Int J Eng Technol* 7.4 (2018): 69-73.
- [54] Máñez-Carvajal, Carlos, Jose Francisco Cervera-Mérida, and Rocío Fernández-Piqueras. "Web accessibility evaluation of top-ranking university Web sites in Spain, Chile and Mexico." *Universal Access in the Information Society* 20.1 (2021): 179-184.
- [55] Frazão, Tânia, and Carlos Duarte. "Comparing accessibility evaluation plug-ins." *Proceedings of the 17th International Web for All Conference*. 2020.
- [56] Abascal, Julio, Myriam Arrue, and Xabier Valencia. "Tools for web accessibility evaluation." *Web Accessibility*. Springer, London, 2019. 479-503.

- [57] Freire, Andre P., Cibele M. Russo, and Renata PM Fortes. "A survey on the accessibility awareness of people involved in web development projects in Brazil." Proceedings of the 2008 international cross-disciplinary conference on Web accessibility (W4A). 2008.
- [58] British Dyslexia Association. "Dyslexia style guide 2018: Creating dyslexia friendly content." Retrieved July 13 (2018): 2018.
- [59] Evett, Lindsay, and David Brown. "Text formats and web design for visually impaired and dyslexic readers—Clear Text for All." *Interacting with computers* 17.4 (2005): 453-472.
- [60] Nielsen, Jakob. "Lower-literacy users." Jakob Nielsen's Alertbox. <http://www.useit.com/alertbox/20050314.html> (2005).
- [61] Horton, Sarah. "Building an Accessible Digital World." *Computer* 55.1 (2022): 98-102.
- [62] Ekerling, S. "We analyzed 10,000,000 pages and here's where most fail with ADA and WCAG 2.1 compliance. AccessiBe." (2019).
- [63] WebAIM (2022) Million Report
- [64] WebAIM (2021) Screen Reader User Survey #9 Results.
- [65] The Wall Street Journal, Hiring More Accessibility Specialist, Article by Ann-Marie Alcantara Sep (2021)
- [66] Kassim, Ahmed J., and Laura Lawless. "THE ADA AND WEBSITE ACCESSIBILITY POST-DOMINO'S: DETANGLING EMPLOYERS'AND BUSINESS OWNERS'WEB AND MOBILE ACCESSIBILITY OBLIGATIONS." *Tort Trial & Insurance Practice Law Journal* 56.1 (2021): 53-65.
- [67] Grant, Shawn. "Lessons from the Pandemic: Congress Must Act to Mandate Digital Accessibility for the Disabled Community." *U. Mich. JL Reform* 55 (2021): 45.
- [68] Egger, Niklas, Gottfried Zimmermann, and Christophe Strobbe. "Overlay tools as a support for accessible websites—possibilities and limitations." *International Conference on Computers Helping People with Special Needs*. Springer, Cham, 2022.
- [69] Kirkpatrick, Andrew, et al. "Web content accessibility guidelines (WCAG) 2.1." Retrieved July 31 (2018): 2018.

[70] Seeman, Lisa, and Michael Cooper. "Cognitive Accessibility Roadmap and Gap Analysis." Retrieved June 27 (2016).

[71] World Wide Web Consortium. "Accessible rich internet applications (WAI-ARIA) 1.0." (2014).

[72] World Wide Web Consortium. "Accessible rich internet applications (wai-aria) 1.1 (W3C Recommendation)." (2017).