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Web Accessibility and the problem of exclusively relying on development tools to achieve it.

A case study into web development with content management systems and how their design can impact the end result for users with accessibility needs in the wake of the european accessibility act.

Master's thesis in Computer science and engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Gothenburg, Sweden 2025

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Abstract

Web accessibility remains poorly implemented despite decades of established guidelines, with studies showing that the vast majority of websites fail to meet basic accessibility standards. This research examines the gap between accessibility requirements and implementation practice by investigating what needs developers have on their tools when complying with the Web Content Accessibility Guidelines (WCAG).

Through interviews with content management system developers, users, and individuals with accessibility needs, combined with prototype testing of alternative interface designs, this study reveals that accessibility implementation suffers from a fundamental invisibility problem. Unlike visual design elements that provide immediate feedback, accessibility features operate in a realm largely invisible to content creators, leading to implementations that appear correct but fail real users.

Through the formulation of a prototype that tests alternative ways of implementing alt text in a content management system, guidelines emerged that aid users both identify and solve accessibility issues. These guidelines answer the research question by helping developers of content management systems address issues of cognitive load, as well as issues of evaluation and execution to significantly improve implementation accuracy among their users. These are meant to be applied in a meta sense relative to the WCAG, guiding tool designers how to aid their users in adhering to the WCAG by addressing the needs the WCAG puts on its adherers.

The study concludes by highlighting limitations of using automated tools when assessing the accessibility of the web, leading to false positives and skewed targets in the development stage. The inclusion of actual users with accessibility needs in throughout the design process being crucial, stressing the complimentary role evaluation tools have as opposed to a sufficient standalone method.

Keywords: Accessibility, Computer, science, computer science, engineering, project, thesis, Web.

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I'd like to thank those that volunteered for interviews during this project, especially those that allowed me into their homes and shared vulnerable experiences. I'd also like to extend a huge thanks toward my supervisor that supported me through the arduous revision process of this messy report throughout the project.

Oliver Andersson, Gothenburg, 2025-06-27

Contents

Below are the acronyms used in this thesis listed in alphabetical order

1. API - Application Programming Interface
2. ARIA - Accessible Rich Internet Applications
3. B2B - Business to Business
4. B2G - Business to government
5. CMS - Content Management Systems
6. CRPD - UN Convention on the Rights of Persons with Disabilities
7. CSS - Cascading Style Sheets
8. CVD - Color Vision Deficiency
9. EAA - European Accessibility Act
10. G3ict - The Global Initiative for Inclusive Information and Communication Technologies
11. GDPR - General Data Protection Regulation
12. GPT - Generative Pre-trained Transformer (referring to ChatGPT/AI models)
13. HCI - Human-Computer Interaction
14. HTML - HyperText Markup Language
15. IxD - Interaction Design
16. JAWS - Job Access With Speech (screen reader)
17. JIT - Just-in-Time
18. JiTT - Just-in-Time Teaching
19. NVDA - NonVisual Desktop Access (screen reader)
20. SEO - Search Engine Optimization
21. SME - Subject Matter Experts
22. TAM - Technology Acceptance Model
23. UI - User Interface
24. UN - United Nations
25. W3C - World Wide Web Consortium
26. WCAG - Web Content Accessibility Guidelines
27. WebAIM - Web Accessibility In Mind

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1

Introduction

There is a multitude of peoples that navigate the web every day with a wide range of disabilities. It can be in the form of sensory, cognitive, or physical disabilities that make interacting with the web difficult in a myriad of ways. There exists accessibility standards that aim to address some of the more common disabilities and provide a baseline upon which third party tools are able to be developed that help alleviate these problems such as machine readers etc. The web content accessibility guidelines (WCAG)[1] being the most popular in use today when evaluating accessibility. However, several studies point to the fact that the vast majority of websites do not comply with these standards. Contemporary legislation exists to compel website owners to comply with these standards, but that only solves the motivation part of the problem. The developers need to have access to tools that aid them in this endeavor.

The vast majority of websites are created using tools called "content management systems" (CMS) that abstract the underlying structure and provide a more desirable UI to the developers. This also allows for the tools to help the designers make their design accessible by making their interface either implicitly or explicitly coerce the designer to comply with these standards. Webbhuset i Sverige AB is a company based in Gothenburg, Sweden that develops one of these systems and will be working in tandem on this project. They will be able to provide experience and resources related to the subject area of web design. They predict they will see a higher demand on accessibility functionality in their tool in the near future with the impending legislature. I'm a Civil Engineer student at Chalmers University of Technology and will be the sole researcher throughout this study with aid from Webbhuset i Sverige AB. My goal is to figure out what needs this legislature puts on the web developers tools. Trying to find guidelines for developers of these tools. Something that is of interest to both parties involved. The research question is thus:

How can the design of Content Management Systems aid their users in complying to the Web Content Accessibility Guidelines?

This was the initial goal of the study, but as interesting findings from the people involved came to light, another question became just as relevant:

What are the limitations of this tool-centered approach to achieving web accessibility?

In the end, guidelines are provided that answer the primary research question, as

well as a showcase of some discovered limitations of relying exclusively on automated accessibility auditors to catch accessibility flaws.

2

Background

This project, like all others exist in a context. This chapter delves into the areas of accessibility and guidelines. Touching on the current development environment with third party tools and the legislative forces driving the near future evolution of these.

2.1 Interaction Design

Interaction design (IxD) is a discipline focused on creating interfaces that facilitate effective communication between users and digital products, environments, systems, or services. It emphasizes designing interactive experiences that are intuitive, efficient, and responsive to user needs. At its core, interaction design involves crafting the behaviors and actions that occur when a user interacts with a system. This includes understanding user goals, context, and the tasks they aim to accomplish. As noted by the Interaction Design Foundation, "it (Interaction Design) is the design of the interaction between users and products."[2]

The roots of interaction design can be traced back to the early developments in human-computer interaction (HCI) during the mid 1900s. As computers transitioned from large, inaccessible machines to personal devices, the need for user-friendly interfaces became larger. This evolution led to the emergence of interaction design as a distinct field, focusing on the nuances of user behavior and the design of interactive systems.

2.2 Stakeholders

Accessibility implementation involves multiple stakeholders with diverse priorities and perspectives. This sec the educational institution overseeing this work, the company providing technical resources, and the researcher to the ultimate beneficiaries: users with accessibility needs. Understanding these stakeholders and their sometimes competing interests is essential for understanding the challenges when producing accessible designs.

2.2.1 Chalmers University of Technology

Chalmers University of Technology, as the university at which this thesis is written, has an interest in the work and will be affected by the result. The main consideration

for Chalmers is that the thesis contributes some research of value and is produced in an academically honest way and do a work within a well defined scope.

As for me, my name is Oliver and I'm the researcher for this project. I've got a bachelor in information technology and are at the last stages of a masters in Interaction Design (IxD). I have an interest in making and keeping the findings as general as possible to increase my marketability in the job market after my studies are completed. Calling it the consultant's dilemma, where delivering too much makes you redundant and delivering too little makes you not worth the investment.

2.2.2 Webbhuset

Webbhuset i Sverige AB is a company based in Gothenburg, Sweden that develops and maintains a content management system (CMS). They mainly markets their services towards companies looking to establish an online shop or otherwise wanting to display a series of products. They want to make sure that their CMS is equipped to handle the new demands on accessibility from their customers and as such are cooperating in this study. They have a vested interest in the research on this subject as their needs coincide with mine in the search of how developers can be aided in conforming to accesssibility guidelines.

A Content Management System (CMS) is a software application that allows users to create, manage, and modify digital content on a website without requiring specialized technical knowledge. It provides a user-friendly interface for building websites and managing their content, making it accessible to non-technical users. The main advantage of using a CMS is that it separates content management from website design and development, allowing content creators to focus on creating and publishing content without worrying about the technical aspects of web development.

2.2.3 Users with accessibility needs

The end users and main concern. This will entail users who through a variety of reasons make use of accessibility aids and/or have certain impaired functions that require websites to present their content in specific ways. The grid of enlightened self interest as presented by Michael Heron[3] and seen in figure 2.1 demonstrates the possibility of how to increase the standard of living for everyone by designing for those with chronic accessibility needs. As a person without chronic accessibility needs, I've on several occasions utilized accessibility functions such as speech to text, text to speech, and appreciated the high margin button layouts. these accessibility tools have still allowed me to operate my phone in conditions I otherwise would not have been able to. Reading transcripts of video/audio while in a loud place and my headphone batteries die, or using my phone while carrying groceries. There are many ways designing for people with extraordinary needs become beneficial for ordinary people in extraordinary conditions.

	Colour Blindness	Visual	Cognitive	Physical	Socioeconomic	Emotional	Communication
Permanent Always relevant, will probably never go away although severity may modulate	Protanopia Deuteranopia Tritanopia Monochromacy Aging	Blindness Short sightedness	Dementia Alzheimer	Loss of a limb	Social classification Under representation	An emotional control disorder	Deaf / HoH Mutism
Temporary Short term, will eventually go away	Concussion	Eye infection Wearing an eyepatch Wrong prescription	Being drunk Bad night's sleep	Broken arm Sprained ankle	Unemployment A lost wallet Being in 'the wrong neighbourhood'	Received some bad news	Broken jaw A noisy bar
Situational Intermittent, will phase in and out of relevance	Bad lighting Wearing sunglasses	Bright sunshine in your eyes	Being distracted Being in an open plan office	Carrying something heavy On a juddery train	Contactless payments not working	Irritation at a loud conversation in the background	With a group of mixed-language friends

Figure 2.1: The grid of enlightened self interest. Contains examples for each combination of temporal scope and type of ability/capability

While specific numbers for each impairment is lacking, roughly 1.1 million people in Sweden live with some sort of impairment where about 42% deem their impairment to be detrimental to their ability to work[4].

While many of the users the legislature fit in the permanent row, it is not hard to see the downstream benefits of these accommodations. As previously mentioned, there are problems with only strictly abiding by the standards as there will still be legal ways to design websites that are inaccessible to many of the people the legislature attempts to aid. As such, they have a stake in the project and are incentivize to provide as much information as possible to cover the gaps left in the guidelines to ensure that new industry standards will be closer aligned with their needs.

2.2.3.1 Visual Impairments

Visual impairment is a wide umbrella that encapsulates some of the ways in which visual information gets distorted or intercepted. However you see it, it either limits or distorts visual information for those that live with it. As depicted by the National association of the visually impaired [5] there is a plethora of ways and needs for people. This can range from needing additional contrast between elements or fewer elements on screen at once, to complete replacement to vision all-together. While not considered a visual impairment by the state [6] [7], color vision deficiency (CVD) is also worth mentioning as it does affect and potentially impair the way people interpret visual information.

2.2.3.2 Cognitive Impairments

People with cognitive impairments include a variety of people that have additional accessibility needs in often some but not all of the tasks that require the user to take actions or make decisions based on presented information [8]. Dyslexia is a commonly known diagnosis that entails difficulties decoding written language. Dementia is

another condition that might make navigation difficult and put extra needs on clarity on layout and navigation to mitigate the person becoming disoriented [9].

2.2.3.3 Mobility Impairments

From large scale mobility impairments such as missing the function of limbs to finer scale dexterity problems that impede fine motor skills, people with mobility impairments have wildly different experiences. While a study in Sweden shows that people with mobility impairments are significantly more likely to have a lower quality of life on both the social and economic dimension [10].

2.2.3.4 Auditory Impairments

Impaired hearing is a condition over a million swedes live with as per 2012 [11]. While the majority of the cases are age-related damage to the ear, the amount of people under 20 that suffer from hearing impairment almost doubled between the years 2002-2012 [11]. It is also reported that almost half of the people that would benefit from some sort of hearing aid do not have access to it [11]. These are the people that are the silent majority of people that would benefit the most from audio being implemented better on the web.

2.3 Special Needs Legislation

Going into effect June 28 2025, the European Accessibility Act (EAA) [12] goes into effect in Sweden and the rest of the European Union, requiring that all Business to Business (B2B) and Business to government (B2G) webistes comply to the Web Content Accessibility Guidelines (WCAG) 2.1 [1] at all AA level criteria. These are criteria meant to address the most common problems people living with accessibility needs found listed at section 2.2.3.

2.3.1 Delayed compliance with regulation

There are several occasions where companies intentionally delay conforming to regulation until enforcement of said regulation is conducted. Some worth mentioning in the field of the internet would be the 2018 mandate of GDPR, where insufficient enforcement might have influenced the slow adoption of the regulation by companies [13]. Though instances of explicit admission are lacking. It is undoubtable that some organizations see refactoring existing content to comply with accessibility guidelines to be a short term cost with no clear benefit. Combining that with weak enforcement might lead to the cost/benefit analysis working in favor of postponing adoption as far as possible.

2.3.2 Current State

The EAA was signed in 2019, stating that the requirements would go into effect 28th June 2025, giving a 6 year notice and time to adapt to these standards. WebAIM

[14] did an analysis of the state of the top million homepages in 2023 and compiled the most common failures of success criteria for WCAG 2.X. These can be seen in figure 2.2. The slow adoption might suggest that there are benefits of complying are not deemed to outweigh the problems faced by such an endeavor.

Home pages with most common WCAG 2 failures

WCAG Failure Type	% of home pages in 2023	% of home pages in 2022	% of home pages in 2021	% of home pages in 2020	% of home pages in 2019
Low contrast text	83.6%	83.9%	86.4%	86.3%	85.3%
Missing alternative text for images	58.2%	55.4%	60.6%	66.0%	68.0%
Empty links	50.1%	49.7%	51.3%	59.9%	58.1%
Missing form input labels	45.9%	46.1%	54.4%	53.8%	52.8%
Empty buttons	27.5%	27.2%	26.9%	28.7%	25.0%
Missing document language	18.6%	22.3%	28.9%	28.0%	33.1%

96.1% of all errors detected fall into these six categories. These most common errors have been the same for the last 5 years. **Addressing just these few types of issues would significantly improve accessibility across the web.**

Figure 2.2: A report from WebAIM about the state of the top million homepages 2023

2.4 Web Accessibility Organizations

The World Wide Web Consortium is the main international standards organization for the World Wide Web. And while they are the authors of the Web Content Accessibility Guidelines that are adopted in legislation, there are also some other relevant actors in the realm of web accessibility. These all work to provide resources and information with the ultimate goals being to make the web accessible to all. Let's start with the aforementioned World Wide Web Consortium:

2.4.1 World Wide Web Consortium (W3C)

The creators and maintainers of the WCAG, the World Wide Web Consortium (W3C) have become the defacto authority on the subject as more and more people deem them as the authority through popular vote[15]. The fact that many legislative bodies adapt their work further solidifies this as with the most publicized and relevant one:

the European Accessibility Act[12]. Further list of legislation directly mentioning can be found on their website with laws going so far back as 1992[16].

2.4.2 The Global Initiative for Inclusive Information and Communication Technologies (G3ict)

G3ict[17] is a global advocacy initiative dedicated to promoting digital accessibility and inclusion for people with disabilities. It was launched in 2006 as a collaboration between the United Nations (UN) and the International Telecommunication Union (ITU) following the adoption of the UN Convention on the Rights of Persons with Disabilities (CRPD)[18]. G3ict's mission is to aid the implementation of digital accessibility policies and standards.

2.4.3 Web Accessibility In Mind (WebAIM)

Taken from their own webpage, WebAIM describes themselves as: "one of the leading providers of web accessibility expertise internationally"[14]. They are a non-profit service center at Utah State University that provide instructions and data with the aim of promoting web accessibility and it's adoption. They also provide the WAVE automated accessibility checker, one of the more popular third party accessibility tools[19]. It will be used to aid some of the accessibility checking in the study.

2.5 Content Management Systems

The majority of websites created today are done so with the aid of Content Management Systems (CMS). Upwards of 70% as of February 2025[20]. The implications of this are that developers sit with an additional interface above the source code they produce. These often include several interfaces that provide designed and deliberate facades to the underlying structure.

The benefit of this is that the appropriate options and tools can be curated to the context the developer is in, presenting them only with the relevant options and allowing for display of the exhaustive list of options for the specific task with as little cluttering as possible, ideally speeding up development.

In these CMS's there are often separate sections in the interface which provide the user with all the additional information that can be added to increase the accessibility of the content based on some set of standard or guidelines. Though these interfaces are commonplace in the current day, their usage is lackluster at best as indicated by figure 2.2. This indicates that the way these are integrated today are not sufficient to make developers utilize them enough.

It is also worth noting that many developers of websites are beholden to managers or reviewers that have the ultimate say in how accessibility should be regarded. The responsibility of indubitably is shared between several actors. Assigning responsibility to actor groups will not be further discussed in this paper. This will simply see

to which extent the tool in question can aid the user in it's goal of succeeding the criteria of WCAG 2.1 and what potential existing patterns hinder this.

2.6 Hinders to Web Accessibility

There has been some studies that tackle the problem of creating accessible design artifacts, and they point to a similar problem. Hayfa et al[21] Conducted a study in 2016 and found several reasons for the low adherance to the WCAG 2. They enforce the idea that the problem lies in lack of experience and expertize during the design phases and difficulties evaluating their designs with tools that were inappropriately applied or user tests where lack of access to users with which to test with were a problem. Summarizing the problem as a result of lack of motivation and expertize, advocating for legislature to address the former and education for the latter.

Krupal Maheta et al[22] conducted as study on developers in India that found that 69,9% of developers reported wanting extra education in accessibility in order to be able to comply with the WCAG as they deemed their current experience insufficient to complete the task.

The challenges identified in contemporary research, from lack of expertise to difficulties with evaluation to fundamental problems in how accessibility knowledge is acquired, retained, and applied in real-world content creation workflows. To address these implementation gaps, we must examine the underlying cognitive and learning processes that influence how developers interact with accessibility requirements.

The following chapter establishes the theoretical frameworks that inform our understanding of why accessibility implementation remains challenging despite decades of guidelines and tools, and how interface design principles might bridge this persistent gap.

3

Theory

Creating accessible websites remains challenging despite decades of guidelines and tools. This chapter lays the theoretical groundwork for understanding this persistent gap. We start by exploring what accessibility means in the digital world, examining established principles and standards while acknowledging their limitations. We then delve into cognitive load theory to explain why implementing accessibility features often overwhelms content creators, leading to poor execution or complete avoidance. Finally, we present just-in-time learning as a promising approach for interface design that could bridge this gap by providing guidance exactly when content creators need it. By weaving together these three theoretical frameworks, we create a foundation for rethinking how accessibility tools should work to better support content creators in delivering truly accessible experiences.

3.1 Accessibility

The concept of accessibility provides the foundation for this research. By examining accessibility on the web alongside their standardization in the Web Content Accessibility Guidelines, we establish critical criteria for evaluating both current CMS tools and potential improvements. This section also addresses common criticisms of accessibility standards to provide a more nuanced understanding of implementation challenges.

"Accessibility is the design of products, devices, services, vehicles, or environments so as to be usable by people with disabilities."[23].

In the context of the web however it makes sense to focus on accessibility of the web, a subdomain of accessibility. The four principles of which described as the four principles of accessibility by the World Wide Web Consortium (W3C)[15]:

- **Perceivable** - Information and user interface components must be presentable to users in ways they can perceive.
- **Operable** - User interface components and navigation must be operable.
- **Understandable** - Information and the operation of user interface must be understandable.
- **Robust** - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

When talking about how accessible something is, this will be the dimensions on which it is measured. These are unspecific in terms of implementation as accessible only relates to the humans that try to access it as the specifics differ depending on context, they are as such open to interpretation.

3.1.1 Web Content Accessibility Guidelines (WCAG)

The increasingly accepted authority on accessibility is the W3C[15] whose guidelines, the WCAG[1]; are being increasingly adopted by lawmakers as standards to test against when implementing wide-sweeping policies. They are a collection of guidelines touching different areas of interactions the web can offer. They provide different success criteria for each one in increasing order of complexity: A, AA, AAA. A certain criteria might be deemed basic enough that no AAA level for it exists and vice versa and as such each guideline has a subset of these. For a guideline to considered to be met at a AA level, all instances of the affected guideline have to meet or exceed the AA criteria (if one such exist).

3.1.1.1 Criticism against WCAG

There are several detractors to the WCAG that profess its shortcomings and highlight the areas in which its implementation can be problematic. Karl Groves[24] argues that the nature of language necessitated when writing a standard such as this makes applying it difficult on a personal level as parsing the guidelines can be difficult. Further support to this claim is an experiment run på Alonso et al.[25] in which designers were instructed to grade a set of websites on a subset of the guidelines and the results showed an alarming rate of deviance in the results.

The standard being seemingly designed for automated testing yet requiring manual review is also seen as a problem as stated by Giacomo Petri and Christian Federici[26], as 70% of success criteria needed manual supplementory review to be used. This combined with the previously exemplified ambiguity in interpreting the guidelines by novices forms a strong critique of current methods of application.

"Nothing about us without us" is a slogan meant to convey the idea that policy regarding a disenfranchised group should not be decided upon without the direct participation and endorsement of the affected group[27]. In the context of web accessibility, the criticism is often levied towards the people responsible for implementing accessibility aids as they often lack the perspective of their users[28]. There are designs that meet criteria yet lack usability due to nuances the developer is unaware of. These are often hard to exhaustively encapsulate with guidelines or standards as they are emergent and context dependent in nature. The inclusion and utilization of disabled user in development and evaluation is instead promoted as it forces the developers to direct their design towards them rather than the guidelines.

Automated checkers are also subject to false positives and negatives as they rarely account for nuances. They might simply check wether an image has a desired attribute rather than checking if the information is useful. An automated tool would

be susceptible to pass a website with automated random generated strings as alt-text simply due to the criteria "all images has alt text" being met without regard for the content. The opposite also happens, where all images are marked as decorative by the CMS, bypassing the automated checker all-together[28].

3.1.2 False positives in automated accessibility testing

In a binary classification process, when testing data for a condition, a common problem arises where both groups contain false classifications[29]. The set of data deemed to all have met the condition might contain data that do not, and data that met the requirement will be falsely rejected. This is often because we are only able to measure indicators or proxies of the condition we want to test for, and in those cases the populations will make up of overlapping distributions.

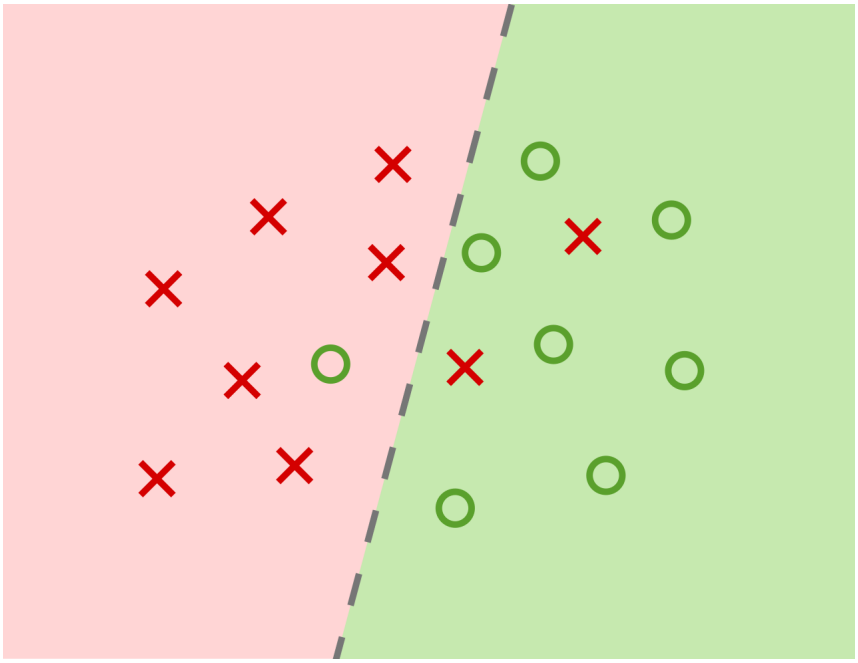


Figure 3.1: A representation of an arbitrary data set of crosses and circles where no straight line cleanly separates the 2 sets without excluding all circles and including all crosses. Produced by wikipedia user: Waldyrious under the CC BY-SA 4.0 licence.

The problem of testing then becomes when able determining the cutoff-point where the optimal number of true cases are correctly labeled while keeping the false. These rates vary depending on the problem. The reasons for why this happens can vary greatly depending on the thing being measured, from unreliable measuring equipment, to the things being measurable only working as proxies for the underlying condition we want to test for[29].

When it comes to automated accessibility checkers, or tests. Nuances of user experience are often condensed into meeting certain technical and measurable criteria, such as formatting data correctly, calculated contrast exceeding an arbitrary threshold

etc [30]. This makes them prone to false positives and negatives as it can only measure if content exists or not, not verify the quality of it [31].

3.1.3 Assistive Technologies

Assistive technologies are technologies that help users with alternative functions of both perceiving data and providing input by working as an adapter between the user and the original system. The way these systems often interpret the data on the web is dissimilar to the normative way, providing alternate navigation methods and data flow. In many ways, they restrict users to only being able to perceive one thing at a time, or only navigate in 1 dimension at a time. Though alternative and to some seemingly restrictive, these technologies work to expand the capabilities of their users.

3.1.3.1 Screen Readers

Screen readers are a set of assistive technologies meant to complement a range of visual impairment, from total blindness to blurry vision by reading the focused elements on screen. This can include metadata in the case of the web is such data exist and help identify the context of the text read. According to a study on 1539 screen users by WebAIM [32], three different screen readers make up 90% of the market [33]. These are the JAWS and NVDA for windows desktop as well as Voiceover for mac os and IOS. Around 40 % of the users reported that they used different screen readers[14] and further anecdote[34] support that they each have their strengths depending on the context of use. These work in various ways, but the standard approach is to flatten html which is a tree structure into a one-dimensional list representation of that tree and providing methods to skip to headers, links, inputs etc. During the navigation, the tool also reads out and explains the content it is focused on, calling headers headers, links links, and buttons buttons etc. before reading out the contents of said element.

3.1.3.2 Alternative Keyboards

There are several technologies that fall under the umbrella of keyboard adapters that provide an alternate interface for the same Application Programming Interface (API) as a conventional keyboard. This is similar to how a majority of accessibility aids in gaming adapts the controls of a standardized controller and provides alternate interfaces for users to provide the same set of inputs. The implication of this is that as long as the website in question is navigable by keyboard, it will then be navigable through these aids as well, providing the developers for one inclusive target that is not dependent on the specifics of the assistive technology of the individual users.

3.1.3.3 Accessible Rich Internet Applications

Accessible Rich Internet Applications (ARIA) provide a set of supplementary settings and attributes to html that allows it to convey additional semantic meaning to assistive technologies. Such as communicating that an element is able to be expanded

with user input or that an otherwise active user input element is disabled. The regular html components provide some semantic meaning like this, but ARIA attributes allows developers to convey even more meaning using a composition approach, using a superset of commonly found web components such as menus or progress bars [35]. This allows developers to make custom components yet still communicate to the assistive technologies about the types of input or data the component provides[36].

3.2 Cognitive Load Theory

Cognitive Load Theory, introduced by John Sweller in the late 1980s, provides a framework for understanding how mental effort affects learning and information processing [37]. The premise of Cognitive Load Theory is that working memory has a limited capacity that can process only a few elements simultaneously [38]. In contrast, long-term memory possesses significantly larger storage capacity in the form of schemas, cognitive constructs that organize multiple elements into single units of meaning.

Cognitive load refers to the total mental effort being used in working memory. The theory differentiates between three types of cognitive load, each with distinct implications for learning and task performance:

Intrinsic cognitive load stems from the inherent complexity of the material being processed. This type of load depends on the number of elements that must be processed simultaneously and the interactivity between these elements [39]. Intrinsic load cannot be reduced without altering the task or building expertise that allows for more efficient processing.

Extraneous cognitive load results from poorly designed instructions or interfaces that require mental resources but do not contribute to learning or task completion [40]. This type of load can be minimized through improved design of learning materials or interfaces, freeing cognitive resources for more productive mental activities.

Germane cognitive load represents the mental effort dedicated to constructing and automating schemas. This productive form of cognitive load contributes directly to learning and skill development [41]. Effective instruction aims to maximize germane load within the constraints of total working memory capacity.

These three types of cognitive load are additive, and their total must remain within working memory capacity for effective learning to occur. When cognitive load exceeds working memory capacity, learning is impaired as the cognitive system becomes overwhelmed [42].

As learners develop expertise, they construct increasingly sophisticated schemas that allow them to process complex information more efficiently, reducing cognitive load for familiar tasks. This explains why experts can perform complex tasks with apparent ease while novices struggle with the same activities [43].

Cognitive Load Theory has significant implications for instructional design, suggesting various techniques to manage cognitive load effectively. These include using

worked examples for novices, gradually increasing problem complexity, and presenting information in integrated formats to reduce split attention [44].

3.3 Mental Models

Mental models, as conceptualized by Johnson-Laird [45], represent internal cognitive frameworks that individuals use to understand and interact with external systems. In accessibility implementation, the mental models held by content creators and developers and the misalignment of which might compromise the quality of implementation.

Mental model misalignment

When users' mental models diverge from designers' intentions, it creates a fundamental barrier to effective task completion and learning [45]. These misalignments manifest in several ways: users may attempt interactions that the system doesn't support, misinterpret feedback from the system, or develop workarounds that bypass intended functionality. The persistence of incorrect mental models can lead to systematic errors and inefficient workflows, as users continue to apply flawed understanding even when presented with better approaches [46].

In interface design contexts, mental model conflicts often occur when technical system requirements clash with users' domain-specific understanding of their tasks. This creates a cognitive burden where users must simultaneously manage their primary work objectives while translating them into system-compatible actions—a process that increases cognitive load and reduces task performance quality.

Mental models of visually impaired screen reader users

Based on previous research, visually impaired users' mental models function by integration of tactile and auditory information processing. Touch sensation plays an important role in improving the representation of a computer application to them [47], creating a foundation where users combine physical feedback from keyboards or touchscreens with audio output from screen readers to construct their understanding of digital interfaces.

They build their understanding step-by-step with reinforcement rather than through immediate visual comprehension. This creates a systematic approach where users develop reliable sequences of actions that they can replicate across different applications and contexts [48]. Blind users construct spatial representations without visual input. The two-dimensional mental model created by the visually impaired people when they are using touch screen with audio feedback [49] demonstrates their ability to build internal maps of interface layouts, understanding where elements are positioned relative to each other through navigation patterns and audio cues alone. They are thus heavily sensitive to disruptions in function, such as switching tools [48] as old knowledge needs to be replaced rather than built from scratch.

3.4 Just-in-Time Learning

Just-in-Time (JIT) learning is an educational approach that delivers knowledge and skill development precisely when it is needed, rather than through pre-scheduled, comprehensive training sessions. This theory has particular relevance for understanding how CMS users approach accessibility implementation and how interfaces can better support their learning needs at the point of decision-making.

Theoretical Foundations

Just-in-Time learning emerged from manufacturing principles developed by Toyota in the 1970s, where inventory was supplied precisely when needed in the production process, reducing waste and improving efficiency [50]. In educational contexts, this concept was adapted by Novak and colleagues as "Just-in-Time Teaching" (JiTT), focusing on providing learners with information immediately before they need to apply it [50]. The theoretical foundation of JIT learning draws on constructivist learning theories, particularly the idea that knowledge is most effectively built when learners can immediately apply new information to solve real problems [51]. This approach aligns with cognitive load theory in that it delivers information in focused, manageable chunks at the moment of relevance, reducing extraneous cognitive load that might otherwise interfere with learning [52].

Principles of JIT Learning

The principles that make up JIT learning are that information should be provided within the context where it should be applied, that it is easy to digest and only pertinent to the task at hand and tied to said task. These principles stand in contrast to traditional learning where comprehensive information is provided far in advance of its application, requiring learners to retain and recall it when needed.

Applications in Interface Design

In the context of CMS accessibility implementation, JIT learning principles can significantly impact user success. Effective JIT learning interfaces for accessibility might include contextual help that appears when users interact with specific accessibility fields, or examples of appropriate implementations specific to the current task.

The effectiveness of JIT learning in CMS interfaces is supported by research showing that adult learners are more receptive to information that addresses an immediate need [53]. For CMS users implementing accessibility features, the immediate need arises at the moment of content creation or editing—precisely when JIT learning interventions can be most effective.

Empirical Support

Research across educational contexts has demonstrated the effectiveness of JIT approaches. Studies in higher education have shown that JIT teaching methods can improve student engagement and knowledge retention compared to traditional lecture formats [54]. In workplace learning contexts, JIT approaches have been associated with improved performance, higher satisfaction, and better knowledge transfer [55].

Particularly relevant to accessibility implementation, research by Watkins and Mazur found that JIT approaches can help learners identify and address misconceptions more effectively than traditional instruction [56]. This finding has direct implications for addressing common misunderstandings about accessibility requirements among CMS users.

Implications for CMS Accessibility Interfaces

The JIT learning framework suggests several design implications for improving accessibility implementation in CMS interfaces [41]: Instead of separating accessibility documentation from implementation interfaces, embed guidance directly within the context where decisions are made. Layer information so that basic guidance is immediately available, with more detailed information accessible when needed. Tailor guidance to the specific accessibility task at hand rather than providing general accessibility principles. Provide concrete examples that demonstrate proper implementation for the specific content type being edited. Offer real-time validation and suggestions to reinforce correct implementation patterns.

These solutions might benefit users that lack any education on accessibility and yet are posed with the task of creating accessible web content through a series of informed decisions [37].

Limitations and Considerations While JIT learning offers significant advantages for addressing immediate accessibility implementation needs, there are some limitations that should be considered: JIT approaches may not develop deep theoretical understanding without supplemental education [55]. Leading to a permanent surface understanding that is only applicable in that scenario. They should also not be used superfluously as to not introduce extra cognitive load during the task at hand [42]. These limitations suggest that JIT learning should be viewed as one component of a broader learning strategy rather than a complete replacement for more comprehensive accessibility education.

3.5 The gulf of Execution and Evaluation

The Gulf of Execution and Evaluation Donald Norman's concept of the "Gulf of Execution" and "Gulf of Evaluation" provides a fundamental framework for understanding the challenges users face when interacting with systems, particularly relevant to accessibility implementation in content management systems [46].

The Gulf of Execution represents the gap between a user's goals and the actions required by the system to achieve those goals [57]. This gulf encompasses the difficulty users experience in figuring out how to operate a system. In the context of accessibility implementation, the Gulf of Execution manifests when content creators understand they need to make their content accessible but struggle to translate this goal into specific actions within their system.

The Gulf of Evaluation represents the difficulty users face in determining whether their actions have successfully achieved their intended goals [57]. This gulf concerns the system's ability to provide feedback that allows users to evaluate the results of

their actions against their original intentions. In accessibility implementation, the Gulf of Evaluation is particularly problematic because the effects of accessibility decisions are often invisible to content creators using standard interfaces. A content creator may implement what they believe is proper, but without access to screen readers or other assistive technologies, they cannot easily evaluate whether their implementation truly serves its intended purpose [57].

Bridging the Gulfs

Norman suggests that well-designed systems minimize both gulfs through clear affordances, feedback mechanisms, and conceptual models that align with user mental models [58]. In the context of accessibility tools, this translates to interfaces that make accessibility requirements understandable (reducing the Gulf of Execution) and provide meaningful feedback about implementation quality (reducing the Gulf of Evaluation).

3.6 Recognition over Recall

The principle of "Recognition over Recall" is a fundamental concept in cognitive psychology and interface design that describes the difference between recognizing information when presented with cues versus retrieving information from memory without external prompts [59]. Recognition tasks require users to identify previously encountered information when presented with it again, while recall tasks demand that users retrieve information from memory without external assistance. Recognition is almost always easier than recall because it provides contextual cues that trigger memory activation, reducing the cognitive burden on working memory [38]. This difference has implications for Cognitive Load Theory, as recognition tasks impose lower intrinsic cognitive load than recall tasks [37]. When users can recognize rather than recall information, more cognitive resources remain available for processing new information and making complex decisions [41].

4

Methodology

Some relevant design processes will be discussed in this chapter. The ones that will be lifted as relevant in this chapter are the "Goal-directed Design" found in the book "About face"[60], the "Double Diamond" described and popularized by the British design council[61], "Design Thinking" described by Tim Brown[62] and "Participatory Design" by Douglas Schuler and Aki Namioka[63]. In addition to these more complete design processes, some relevant alternative steps in these processes will be presented as well.

4.1 Quantitative Research

A set of quantitative research methods relevant to and used in one or more of the processes. According to Cooper[60], quantitative research should be primarily used to guide further qualitative research and do not provide any basis for answering questions of how.

4.1.1 Market Research

Market research consists of analyzing demographic data, purchasing behaviors, and trends[64]. It focuses on collecting quantitative information to define user segments and assess market viability. When surveys are used, the surveys often consists of numerical rating questions where the surveyed answer on a scale. Questions where the surveyed are able to answer freely are also valid as there are ways to quantitatively analyze those answers.

Sentiment analysis is a method of sorting the answers based on the perceived attitude, commonly positive, negative and neutral to provide some insight into the general attitude towards the subject[65]. Alternatively topic classification can be done by sorting the answers into topics and then measuring the size of each category to gain an overview into which topics are frequent or not[66]. This attempts to provide the researcher with an overview into which topics that are being discussed and how big the discussions are comparatively.

Word frequency analysis is a common method where no reading of the responses is used at all. The words in the responses are aggregated and counted, pairing each word with the frequency of occurrence[67]. This can be useful if you are looking for specific keywords or jargon that have meaning in the context of the survey or

can be used to spot loaded words that might in the other analyses fall into several categories and thus not become visible through those methods.

4.1.2 Experimentation

Outside of surveys there are other valid methods such as A/B testing, where subjects are presented 2 different comparable products and quantifiable data i measured in the use of both. The data gathered is then able to be used to compare the measured areas in the products with each other, such as time spent in the comments of a post when A/B testing social media applications.

4.1.3 Analytics

When researching already existing digital applications, there is often the opportunity to measure certain values from the users passively. This is referred to as web analytics and can include figures such as click-though rate which is the proportion of people proceeding from one site to another, time spent on the site, mouse movement. It can even chart the paths most people take to get to a certain domain if several paths are possible. Such as how many people land on a page through the search feature rather than navigating trees or other means. If it the application is something more interactive, those means of interaction are also often measurable. Social media platforms often openly display those figures to the users themselves in the forms of likes, shares and comments.

(names) conducted a study in 2012[68] into how to best apply these analytics and found that there are some limitations on the context in which they suit themselves. Their primary findings being that they suit themselves as part of a diverse and complex analysis and can serve as complementary to other methods, similar to surveys.

4.2 Qualitative Research

Goal-directed design makes great use of qualitative research[60]. relying on it to let the researcher immerse themselves in the field of study to understand the variety of perspectives and opinions people in the field hold. The aim of this is to help the designers make informed decisions on a visceral level as the qualitative parts build a narrative around the goals people in the field have and the problems faced. To achieve this they rely on a mix of interviews and observations, similar to ethnographic studies[69]. A literature review on ethics in qualitative research by Stella R. Taquette et al was conducted in 2022[70]. "The main conflicts were related to confidentiality breach, disregard of autonomy, potential damages, confusion about the roles of researcher/therapist/friend, and impasses in the Research Ethics Committees." They also argue that many of these can be addressed by some methods that were based on "self-awareness, reflexivity, continuous consent, and ethical mindfulness.". Dennis Wilke et al.[71] still claim that the benefits of inclusion of personal perspectives of

the ones affected outweigh the risks in the case of research conducted with cancer patients.

4.2.1 Literature Review

But before asking and observing people, it can be useful to read up on the existing literature surrounding the subject to get aquatinted with terminology and some common jargon in the field. This can include internal documents from organizations already involved in the field. This can be technical specifications and white papers to recorded customer support data. Anything that already talks about the subject from the perspectives of experts and/or users. This can stretch to social media or internet forums, leaving the commercial sphere and absorbing discussions about the subject in a less clinical environment. These combined with the quantitative research should provide you with some knowledge in the area and provide you with the basis for conducting interviews and asking meaningful questions. Cooper[60] claims that the domain knowledge gained should also lessen the friction during interviews as the interviewee does not have to spend as much time describing domain language to the interviewer(s). There are those that claim that even this stage can stand to gain from being guided by stakeholders as it's usually hard for the uninitiated researcher to determine which information is worth looking for[72]. As both conducting interviews before and after literature review seems to have benefits, the ordering of these could be an impactful decision in the early stages for both procedures.

4.2.2 Interviews

There are several types of interviews utilized for the purpose of gaining a better understanding of the goals, requirements and problems of the different groups or stakeholders that will be interfacing or relate with the design artifact in some way. Cooper [60] differentiate between 4 different sets of interviews that all fulfill different goals, these being:

- **Stakeholder Interviews**
- **Subject Matter Experts (SME) Interviews**
- **User Interviews**
- **Customer Interviews**

These all need to be described in further detail, and will be done so by answering some questions for each interview: Which people are the target for this interview? What information is to be gathered from this interview? In what context should the interview take place? And Are there any considerations needed to be taken?

Starting with the **Stakeholder interview**. As described by Cooper[60], stakeholders are people with authority or responsibility over the product being designed. They might include other people as representatives for the development team or other departments at the company/institution. They are able to provide the initial product

vision, of what the design should accomplish. It is not uncommon for the different stakeholders to have slightly or even significantly different opinions in this matter, and this should give the designer a range of perspectives to take into account. They should also be able to provide more rigid constraints such as budget and schedule to the extent those come into effect depending on the task. They should also ideally provide their perception of their users (both current and prospective), in both what constitutes them as well as their needs. This information is most useful in the early stages, as they both are useful as guides for user research in terms of demographics and behaviors.

Moving on to **Subject Matter Experts (SME) Interviews**. Cooper[60] describes subject matter experts as those with deep expertise in a specific field, such as healthcare specialists, financial analysts, or engineers. These people are often expert users of the current system and can provide bountiful knowledge about that perspective. There are some overlap with stakeholder interviews in this regard, but these are crucially not responsible for the product or system being analyzed. These can be useful to conduct throughout the entirety of the interview process as they usually have the technical answers to the questions that arise during the other interviews, as well as provide reality checks during later design phases to ensure that industry standards are being met etc.

Nielsen & Norman[73] are hesitant to lean to heavily on the information gathered in these interviews as they fear that it is prone to "expert blindness" where over-reliance on expert opinions often assume a comparable level of knowledge from their users on the subject. Conducting these interviews in context: in the space the product is being used might mitigate this risk as the interviewer is able to snap up things the expert might take for granted or ignore as not important. Such as external tools or other environmental impacts that they are ignorant to.

As for **User Interviews**. Users are the people that will be directly interfacing with the design artifact to complete goals, which notably exclude most that would fall into the category of stakeholder. If current users exist in the case of redesigning, they should be included as this as well.

Cooper [60] claims that users are often equipped to answer questions regarding the context of use of the product, questions of "when", "why" and "how". Having a variance of domain experience of the users will hopefully provide a more nuanced view to the SME interview and ideally there should be some overlap. The users are also really helpful at helping identify problems with current solutions. As the userbase will be diverse, so will hopefully the problems they experience be, and should help to give you a good idea of where problem areas exist. Users are also able to provide their mental models of how their tasks and activities work and in what ways the product connects to the other tools they use and how they imagine them working. Information that is invaluable for later stages of development. For these

reasons, they also benefit greatly from being conducted in the context of use.

Finally, **Customer Interviews**. As Cooper [60] describes In many cases of consumer products, the customer and user are the same person and no distinction is needed. However, in many industrial settings, the person deciding on software to be used or development systems that are to be used are often managers, tech leads, or otherwise representatives for a group that makes that decision on their behalf. These often have different needs and expectations than the users themselves and it is important to keep their needs in mind. These often answer similar questions to the stakeholder interview but from the perspective of the customer instead. These give insights into what attributes make products attractive to their situation/context and as the gatekeepers into the product being used their perspective needs consideration as well.

Patton[74] differentiates between structured and semi-structured interviews. With structured interviews allowing for more direct comparisons between interviewees. However, they are prone to bad questions as these take place so early in the process and the questions are often formulated with some ignorance into the users. A semi-structured interview with rather areas of exploration allow the interviewer to be more open to unexpected insight that they were previously ignorant to through no fault of their own. Cooper[60] agrees with this perspective and advocates in general for the use of ethnographic interviews where possible for the sake of immersion for the researcher as it provides the full picture rather than relying on the filter of the interviewee and their potential to lie, misremember or disregard important information.

4.2.3 Observations

As mentioned, many of the previous interviews benefit from being conducted in the context of use with the interviewee. Expanding on this, observations are a perfect way to complement an interview. Many users have difficulties assessing their own behaviors when removed from the context in which they are performed[75]. Therefore it can be beneficial to instead have them act out the interaction and observe their actions instead, allowing their ingrained behavior show. This paired with the occasional clarifying question might give a more complete picture of their behavior than an "either or" approach. Having the ability to ask clarifying questions about a context at it is happening allows for the observer to infer intent and saving the nuanced explanations for where they are needed, lessening the burden of the observed and allowing them mental space to proceed as natural.

Video and/or audio recording equipment can be utilized for the purpose of recording outside of notes. The necessity of this equipment might differ depending on the amount of available researchers, as it is often too high a workload to conduct the

interview while taking notes at the same time. When employing these technologies, having them concealed or at least out of sight will help greatly to reduce the anxiety that comes with being observed, even though the participant and willing and acknowledge that their actions are being recorded. If the equipment is too intrusive the observed might alter their behavior in ways that might contaminate the data gathered.

Beyer and Holtzblatt[76] describe the method **Contextual inquiry** that falls under observation. A short synopsis of it would be:

- **Context** — The observation should take place in the users' normal environment, posing questions when necessary.
- **Partnership** — Establishing that the observer and observed are undergoing a collaborative is important and stresses setting the tone early. The assumption is that the observation should last a day, thus rapport is needed.
- **Interpretation** — The researcher should make assumption to the behaviors of the observed but are required to verify these assumptions before noting them down as data. Doing this without leading questions is notably difficult. Teams of observers are used to try to catch out extreme assumptions.
- **Focus** — The observer should steer both the interaction and conversation towards the area they are studying rather than allowing the observed to "wander free" or use a set questionnaire.

Cooper[60] proposes some alterations to the method in order to suit their process better. Mainly: shortening the interview process to roughly an hour instead of the proposed day, opting for a larger quantity of observations. Having the same team do the observations in sequence, ensuring that the researchers get to see every subject and removing the overhead of coordinating with other teams of researchers. And focusing on more overarching goals instead of trying to identify a discrete set of tasks, letting the tasks come downstream instead. The main benefits of these alterations are the saving of time and resources needed to conduct the research, a trade-off of time for depth and immersion which he would argue is superfluous.

Another commonly known method is the so called **Fly-on-the-wall** method as described by Hanington [77]. Instead opting for having the researcher physically present but prohibited from acting or asking questions. This notably puts some requirements on both the researcher as well as the observed. As the equipment needed to record has to be able to capture everything without the observed having to intervene or without the researcher being seen interacting with it. The trade-off for this method is that it allows for the user to be as authentic as possible, minimizing intrusion and allowing for their unfiltered behavior to be recorded. Interpreting the data might become difficult as the researcher then lacks insight into the though process and has to make inferences from the data to describe anything of value that is not directly observable. Follow-up interviews are a great way to mitigate this but can be hard to achieve depending on the context.

4.3 Modeling

Understanding the needs and behaviors of the users allows for the creation of models that can be used to predict, test and verify different design ideas for further use.

4.3.1 Personas

Personas are a user-centered design methodology introduced by Cooper[60] and work as a means of creating more effective and empathetic digital products. A persona is a fictional, yet data-driven representation of an archetypal user, based on qualitative and quantitative research. These personas encapsulate key characteristics such as demographics, behaviors, goals, motivations, and pain points, providing designers and developers with a clear and humanized target for their design decisions.

4.3.2 Work Flow

Otherwise known as sequence models. These capture model data flow and decision-making processes. These can be represented as directed graphs that model the work to be done. They are discussed by Beyer and Holtzblatt[76] in their book.

While useful for describing complex interactions on a detail level, Cooper argues that they often leave out the humanity behind them. More akin to an uml class diagram from programming. It leaves little room for the "whys" while being really efficient at capturing the "what" when describing behavior. Though sometimes insufficient on their own, personas often incorporate subsets of these work flows into their

4.4 Prototyping and Evaluation

The prototyping will be heavily shaped by the results of the research and potentially modeling stages. Leaving this undefined will allow the picking of a method best suited for the data. It is however worth noting that the proximity to the development team of a CMS, the option of a process similar to the one described as participatory design[63] might be convenient. Either way, as this step of the process will likely be suffering from a lack of time, it will probably focus on low fidelity prototypes with the purpose of simply having designs ready to evaluate. If this is not the case, a smaller set of higher fidelity prototypes will instead be the goal as to be able to test interactions in a as closely to reality simulated environment.

Similar to how the appropriate prototyping method will be down-stream from the gathered data during the research step, the evaluation method will be down-stream from the prototypes that exist. If the access to users becomes a problem, supplementary personas will be used as stand-ins for evaluation instead. They would in this case already be integrated during the prototyping step, similar to the process described in chapter 4 of about face[60] when setting the requirements for the design.

4.4.1 Usability Testing

Goals or tasks can be given to users, letting them navigate the prototype and completing tasks and getting to interact with the design artifact. This lets the users stumble into problems not previously thought off and get a feeling for more visceral experiences that only occur upon interaction. Certain sensory stimuli has to be experienced in order to evaluate if it was a good experience, and in these cases Usability testing might come in handy[60]. This also lets the facilitator witness "real" behavior among the testers as Kate puts it[78].

4.4.2 User Feedback

It might also be more relevant to simply talk through the prototypes and explain their intended use step by step. This might be good at catching errors in thinking similar to the purpose of SME interviews. The nuance lost in not having the user actually test the design might be a worthy trade-off for the proportionally shorter time spent evaluating. However, to catch less obvious shortcomings, the usability testing might be preferable.

4.4.3 Participatory Design

The concept of participatory design as described by Schuler[63] consists of having the users be part of the prototyping stage along with the designers. This also tends to blur the line between prototyping and evaluation as the team tends to swap between them, though this will depend on the prototyping style used. A collaborative story-building exercise will have different demands and produce different results than a Crazy 8 style prototyping supplemented by having the ideas passed around and refined. The main benefit of both is that they give the users a large direct influence at setting the goal of the design early and already discovering potential problems early on.

4.4.4 Tinkering as a Design Method

Tinkering represents a valuable approach to understanding and improving digital tools through exploratory interaction and iterative experimentation. As described by Jacobsson [79], tinkering involves hands on exploration that allows practitioners to develop intuitive understanding through direct manipulation and observation of system responses. In the context of digital tool development, this approach emphasizes learning through doing rather than following predetermined specifications.

The tinkering approach aligns with the iterative nature of accessibility implementation, where solutions often emerge through experimentation with different interface configurations and user guidance strategies. Rather than assuming optimal solutions can be designed in advance, tinkering acknowledges that effective accessibility tools develop through continuous refinement based on actual use patterns and user feedback.

4.4.5 First-Person Methods

First-person methods are qualitative research approaches that position the researcher as the primary subject of inquiry, utilizing their own firsthand experience as the starting point for knowledge production [80]. Unlike traditional research paradigms that emphasize objectivity and distance, first-person methods explicitly embrace subjectivity and the researcher's influence on the research process.

These methods achieve rigor through triangulation between participant observation, reflective writing, interviewing, and gathering documents and artifacts [80]. Rather than aiming for repeatability and objectivity, first-person research focuses on relevance and rich descriptions that resonate with readers jones2012inproceedings.

5

Process

This chapter documents the empirical investigation undertaken to understand how developers and content creators experience accessibility implementation within content management systems. The research process was designed to address the central question: What needs do developers have on their tools in aiding them with complying with the Web Content Accessibility Guidelines?

The investigation employed an approach that combined stakeholder analysis, technical evaluation, and user-centered design methods. Beginning with an assessment of the current state of web accessibility among existing websites of the company's clients, the process moved through interviews with three distinct stakeholder groups: CMS developers, CMS users, and individuals with accessibility needs. The resulting understanding drove the development of a prototype CMS interface that were subsequently tested.

CMS developers comprise of those that are tasked with designing and creating a CMS. CMS users are those tasked with using the CMS created by CMS developers to create content for the web. Individuals with accessibility needs are the users that will interact with the content created by the CMS user.

The methodology draws heavily from Goal-Directed Design principles outlined by Cooper et al., emphasizing the importance of understanding user goals, contexts, and mental models before proposing solutions. The research process was necessarily iterative, with findings from each phase informing the subsequent phases. This adaptive methodology proved essential given the complexity of accessibility implementation and the lack of initial understanding of the subject along with the diverse perspectives of stakeholders involved.

Each phase of the process served a specific purpose in building toward actionable design recommendations. The problematization phase established baseline understanding and identified key challenges. The analysis phase deepened this understanding through systematic evaluation of both technical systems and user experiences. The prototyping phase translated insights into concrete design proposals, while user testing validated the effectiveness of these interventions.

The following sections detail each phase of this investigation, providing both the rationale for methodological choices and the specific findings that emerged from each stage of the research.

5.1 Problematization

To understand the problem of implementing accessibility, some insight into the problem was gathered. This was done through a mix of litterature analysis, testing of tools and interviews with different stakeholders. This section outlines that process and the different information that was gathered during this step of the process.

5.1.1 Current state

Before talking to the stakeholders, some familiarization with the context seemed appropriate. Getting an understanding of what problems their clients currently faced could help identify problem areas in their current context. As such, evaluating their clients homepages to the WCAG 2.1 was deemed appropriate.

Being provided with the stats of the current state of the web accessibility 2.2. I started evaluating the company's clients on those metrics. This was initially done manually by inspecting the web page with the help of the browser provided developer tools (usually accessible through f12 or at the bottom of the context menu provided when right clicking a webpage). The critera that were checked where:

1. Text color contrast. If all text has a contrast value of 3 or higher.
2. Alt-text coverage. If all meaningful non-text content had a text alternative.
3. Empty links. If all links have text describing the link destination.
4. Missing form input labels. If every form input field has an associated label that describes it.
5. Empty buttons. If all buttons have text that describes their function.
6. Missing doc language. If the page begins by declaring the language used in the text.

This was done by manually opening the inspector panel on my web browser and highlighting images, buttons, links, and any text whose contrast seemed borderline passing on the homepage to see if they met the standards [1] If a single element did not meet the criteria, it was marked as failed and the evaluation continued on another critera. This way, no data of the scale of the problem for each criteria was recorded, simply a binary yes or no.

This was a faulty way of conducting this evaluation due to the authors limited understanding of the web framework The author had a limited understanding of structures of web content, which led to erroneously categorization of content by way of not properly checking the correct things on the site. This realization prompted a second evaluation. Learning from the errors in the first evaluation, another evaluation was conducted. This time, the use of the automated accessibility analysis tool "lighthouse" was utilized in conjunction with the WCAG. This time the tool was utilized to produce accessibility reports like the one found in figure 5.1 but otherwise followed the same process as previously but with the earlier misconceptions resolved.

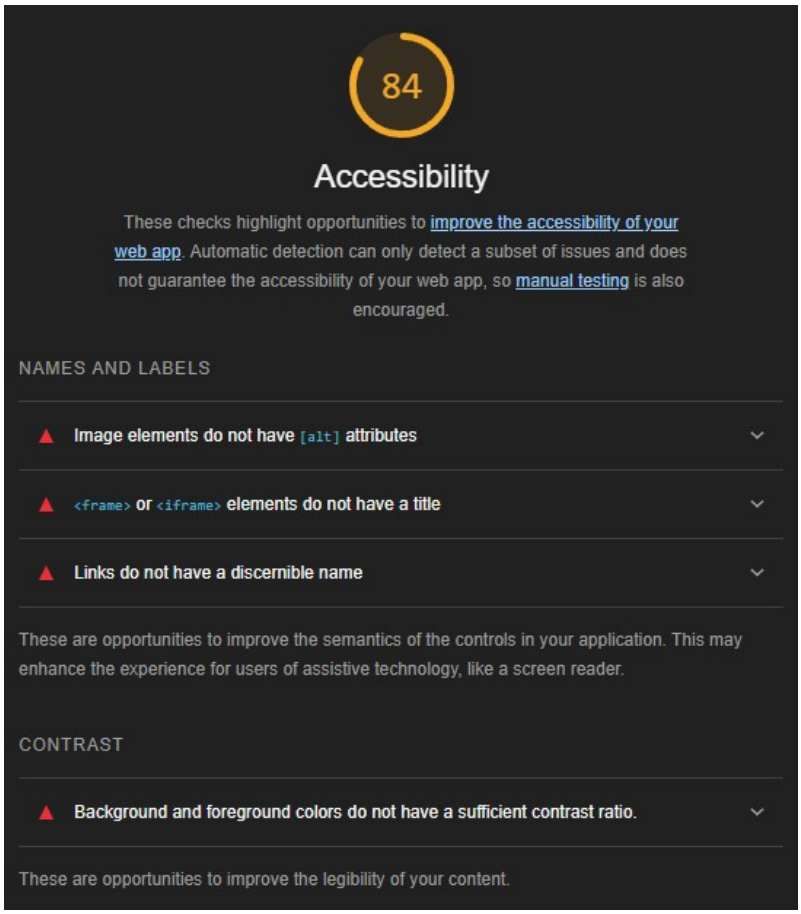


Figure 5.1: An example report from lighthouse.

5.1.2 Client website evaluation

This evaluation showed that in these 6 criteria found in figure 2.2, only the first and second had an above 50% failure rate among the clients, with alt-text having a failure rate of 100%.

Before explaining the following section I need to help clear up a common misconception about what constitutes a button in the domain of web development. While the term colloquially is used to describe any interactive area that is clickable, most of the things described as buttons are actually links. For most people this is not a problem but the difference is significant for assistive technologies for which the distinction matters a lot. In short, buttons do something and links take you somewhere [81]. Many people colloquially call anything styled like a button "buttons," but true buttons in HTML use the <button> tag and have different functionality than links. Links use the <a> tag with an href attribute to navigate between URLs or page sections, while buttons trigger actions on the current page such as submitting forms or opening modals[82]. Additional to different functionality, they are interpreted differently by assistive technologies and thus make for different user experiences while utilizing these assistive technologies. Screen readers handle links and buttons differently buttons can be activated with both Space and Enter keys, while links

only respond to Enter. As for the WCAG, the criterion is simply to make sure all the buttons on the page contain text that explain their behavior [83], I.E "Add item to cart". But as there are few actual buttons on the cite, rather elements styled like them and had added ARIA roles to mark them as buttons for assistive technologies. Oftentimes the search button in the search field on most sites where the only buttons on the landing page.

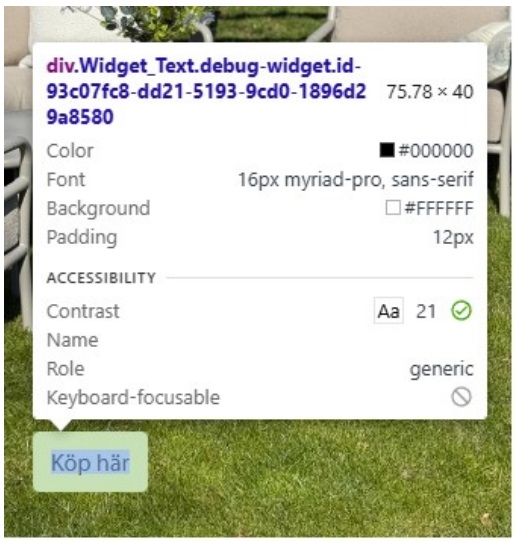


Figure 5.2: Example of a false button that does not even contain any interactive functionality.

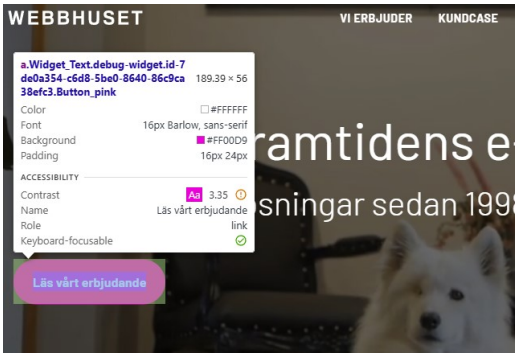


Figure 5.3: Example of a false button that is a decorated link

Another thing I, the author did not know at the time was that an empty but existing alt-tag for an image marks it as invisible to assistive technologies, but for the manual testing these were marked as faulty due to the lack of this knowledge. Essentially contaminating the test results with a large set of false negatives; Incorrectly marking images as erroneous that did in fact meet the guidelines.

After redoing the analysis with the aid of lighthouse, another pattern emerged. Going manually through the resulting analyses the lighthouse tool did, a lot of the images marked as decorative were in fact conveying information. As these are to some extent subjective categorizations done by the CMS user it did not at first seem appropriate to override their ruling of an image as decorative. But it became clear that there were a non-zero amount of images set as decorative that were in fact conveying exclusive relevant information.

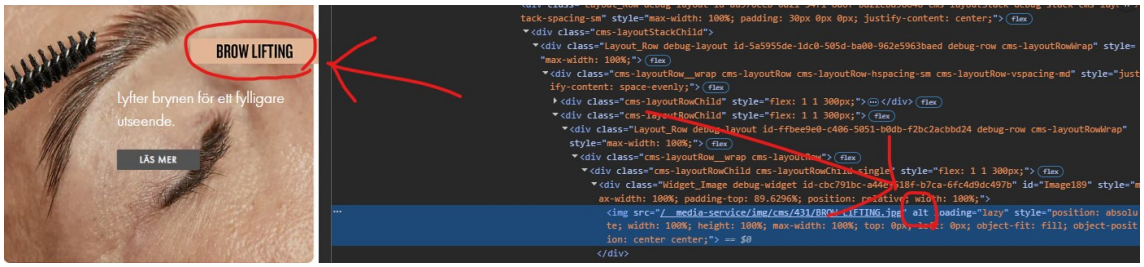


Figure 5.4: An image containing informative text "brow lifting" found nowhere on the page except for in the image itself that is marked as decorative, making the information exclusive to users able to read it on the image.

5.1.3 Tinkering with the CMS

The company provided access to their current iteration of the cms and got the ability to test creating a web page myself using the same interfaces as their clients. The goal was to setup a simple page, showing off two images and include paragraphs of text in a mock-up product display page.

The aim of this was to immerse myself in the CMS to be able to ask more specific questions during the interviews. This was to safeguard against scheduling problems in case the CMS developers were available before the CMS users. It also allowed me to get a sense of the beginner experience with the CMS. This proved to be useful later as the interviewees I got had several of years of experience and had already become adept at their specific workflows with the CMS.

My own inexperience with web development led to this being a really slow process that spanned many of the following chapters. However, this did not lead to much apart from an understanding of common problems that arise as well as familiarity with common industry jargon and frameworks. My frustrations and questions were noted down as my perspective at the time was that of a novice with the tool and without further instruction of how to use it. The assumption was that the problems I'd run into during my tasks were ones that were prone to happen to novice users. I had a setup of 2 monitors with the CMS on one and the live updated web-page on the other during this development, allowing me to test features live to try to deduce how they functioned and how they impacted the site.

5.1.3.1 Learning a screen reader

Parallel to the tinkering with the CMS, I also started using the screen reader NVDA to see how my creations would be experienced with a screen reader.

Findings from CMS analysis

Getting into the accessibility settings was an intimidating experience as they simply consisted of three empty fields with drop-down menus for the 53 aria states and 88 aria roles and 26 aria properties. The first impression was that making something accessible meant comprehending the permutations of these fields and how they interact and modify each other.

Figure 5.5: CMS accessibility settings with selected arbitrary values for aria role and aria properties

A discovery made during this phase was that when I left the alt-text field empty for an image, it still did not trigger any problems with the lighthouse tool. Upon inspection I noticed that the image element tag had and alt attribute even though I did not prompt it. Somewhere in the compilation, one was added without my expressed intent to.

Figure 5.6: CMS view of the image with empty alt field

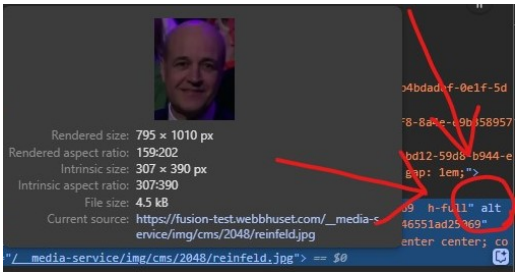


Figure 5.7: Inspector view of the image with highlighted alt attribute

5.1.4 Interviews with stakeholders

There were problems correctly making clean groupings of the people available for interviews since the people available for interviewing often had intersecting roles. The owner of the system was also a developer of it, the developers of it were intermittently also users of it. The customers available for interviews were also users. The lack of knowledge about accessibility in general apart from the people with accessibility needs rendered those the only ones qualified to be subject matter experts, yet those lacked the technical skills to with precision talk about technical details.

A more useful grouping of interviews thus became:

1. Interviews with CMS developers
2. Interviews with CMS users
3. Interviews with accessibility needs users

These were all semi-structured interviews with the exception of observations for the blind people, with aims towards the findings in the previous part of evaluating client websites informing questions for the initial interviews. There were in total 6 interviews and 2 observations done. Supplementary to these there were weekly meetings with the development staff. These were mainly used for insights about problems faced and quotes were gathered from these meetings.

5.1.4.1 Interviews with CMS developers

Three Different interviews were had with the developers of the company's current system. 2 were in person in the company's offices in the natural usage environment and 1 was done remotely. The interviews consisted mainly of understanding their approach to accessibility and assessing their knowledge on the subject. Justifications for choices made in their current system and what their frustrations and challenges faced up until now and how they perceive the incoming enforcement of the WCAG 2.1. Notes were taken when statements of emotion were expressed and other statements that were interesting. These interviews were not recorded in video or audio format as I wanted the interviewees to be as candid as possible without having to worry about policing their language and being able to correct themselves. The goal was to gain an understanding and form some rapport with them as we would be having repeated interactions along this project.

Findings from CMS developers

All described some anxiety over not having enough time and resources, a major influence on the decisions made. Hard to justify fixing something problematic that works "good enough". Due to the current state of affairs, presets or functions in the CMS are not transferrable between projects as each client possesses a modified version of the same base structure. This further de-incentivizes spending time and resources on a particular component in the CMS as it will not be easy to transfer onto other projects. This have led to the interfaces being constructed for professionals to use with high degrees of freedom, leaving much work to the implementer but providing the necessary tools given enough expertise of the user.

On the topic of how come every client has different interfaces in their cms with different components.

> The needs of our clients are too different to make one thing that encapsulates and abstracts all cases while still being viable to develop. We've tried it before and failed.

Discussing navigating "mega menus" (nested menus) with a keyboard and the expected behavior for different inputs. The problem being nested menus where the sub-menu head is also a link itself that is clickable.

> "I've seen all types of implementations for how they should work and I've heard all types of preferences, I don't know if this division exists among screen reader users."

Discussing how they handle collisions with Search Engine Optimization (SEO) and accessibility with clients.

> "They usually come to us with problem specifications from another third party auditor that have their own agenda that we cannot contest."

The high variance in client's needs further de-incentivizes the attempt at making an overarching system able to fit every need, instead lending it to custom made solutions for each individual client.

All stated confusion of the behavior of users of screen readers and how to design for them. Throughout the project there has been an ongoing work among the developers to test out designing menus, lists, navigation hierarchies with screen readers to get an understanding of how the nuances of implementation impact the end user.

5.1.4.2 Interviews with CMS users

The interviewees consisted of two personnel at the company and one external client. These were observations done in person and remotely respectively, where the users would show examples of content created with the CMS and simulate different workflows to show how they would go about solving common problems. Their working environment and hardware were recorded, their aspirations and frustrations with the CMS were recorded, focusing on what they brought them relief from the tool and made them feel smart using it.

Findings from CMS users

The environment setup was different among the users, some preferring the overview a multi-monitor setup provides with the website preview, cms, and asset libraries on separate screens constantly getting instant feedback on every alteration made. Other users preferred the flexibility of only working from a laptop and could fill out an entire page worth of content before checking the result. They noted that this had to do with experience, with taking longer breaks between checking the result depending if what they are doing is something new or if it is similar to existing content. In the former case, the constant back and forth was prone to missing individual items of configuration when those items were invisible, such as configuration or accessibility settings.

None used assistive technologies to validate their designs. Having the visual interface the only thing being manually tested with access to mouse and keyboard, and phone with the mobile interface available in their web browser.

None claimed to have read the guidelines or using them to guide their creation process, rather having an external set of checklist items to check before moving on in the creation process that might be partially influenced by the guidelines (such as checking that items are readable with responsive displays).

All claimed to make great use of the CMS's keyboard shortcuts when duplicating content, heavily "copy pasting" existing pages that are up their standard and later going in to modify the content so that they keep the configurations from the previous page (layout, styling). They felt ambivalent about this as it on the positive side let them reuse content they were satisfied, yet frustrating as it was difficult to go through and update all the settings. Leading to some values left unchanged that should have been without any real way of finding them outside of going through every set of options for each item in the tree.

> "I'm really proud of this page layout, I've reused it about 20 times. I do however find it really tedious having to go through each section and swapping the alternating background colors to match the new content"

During showcasing their workflow, it occurred several times that the order of duplicating and filling out information got mixed up, and in three occasions where the duplicating happened before the filling in of information, alt text got left unfilled for either the mobile or desktop version of the page.

All noted that the work consisted of manually retyping the same information multiple times, a task they reported as tedious and prone to errors if they were interrupted at any point.

Those who stated SEO as a major goal also mentioned actively comparing their creations to competitors, tweaking their designs to try to beat specific competitors on specific keywords after initial design is completed. These retroactive alterations was prone to errors due to missing altering all relevant information in all places when not following a routine procedure.

The client claimed to primarily design for mobile, using their website as a way of attracting customers and optimizing the desktop version of their website for completing sales. To this extent, the initial visual allure of the mobile version is paramount, while the desktop version only has to function as to lead people to completing sales initiated on the mobile version. As such, the only mentioned testing is user testing layouts on mobile and later reusing them when adding new content.

External tools (figma) is used to alter color and contrast for content as is simply transferred into the cms after creation, no testing in the tool takes place. The same is the case for shadow box configuration and other visual effects, to this extent the interface in the CMS is adapted to fit the format those external use as output and not meant for in-tool creation/alteration.

One claimed to make heavy use of a personalized GPT model to produce alt texts according to some standards preset into the model, generating 5 different texts for the image and often picking one of them to paste into the field. This ensured the user that the message would be optimized for SEO purposes and let them continue their work without the doubt inherent in stating what is necessary for all users, offloading that responsibility and stress onto the GPT to let them continue with what they deemed closer to their expertize, such as layout and graphical design. This was a stated risk averse tactic to ensure that in the worst scenario, the screen reader user experience was a bit straineous, but ensured great SEO complience. The

alternative of potentially ruling a meaningful image as decorative could cause a worse user experience along with a guaranteed reduction in SEO.

Those who did validation tests on their websites did so with external tools that give scores on different metrics, with SEO being a major consideration for those that did. Google incentivizes implementing accessibility features by boosting indexed pages that comply to the standards in the search algorithm. Essentially making filling the page with accessibility considerations a viable way of achieving SEO.

5.1.4.3 Interviews with blind users

After contacting and visiting city officials, organizations and social media groups, a mother and adult son with the same genetic condition agreed to let me observe them in their home environment. The use of language regarding people with visually impairments is controversial [84]. These people in particular identified themselves as blind as opposed to "visually impaired people" or "people with visual impairments" and preferred to be referenced as such. The proceeding interview/observation consisted of 3 hours of talking about experiences with websites, tools, workarounds, hardware, life-goals, organization politics etc. Everything that builds a high resolution image of their life and how web accessibility impacts it in nuanced ways and how they adapt to it. Stories and exclamations of emotion were noted down on a digital notepad. They were kept brief as to not break the flow of the observation too much and retroactively filled out with specific information roughly 2 hours after the session.

This came after a long and arduous process of networking. I had severely underestimated how difficult it would be to get in touch with people willing and able to participate in this study, even with the incentive of monetary compensation for their time and expertise. I am so grateful to those who made this possible, and highly value the insight the 3 hours provided.

5.1.4.4 Example findings of accessibility problems

Throughout the observational interview, several examples of problem interactions were recorded. A curated selection that highlights different aspects of web accessibility is included in the following section.

The Willy:s incident

When showcasing how they shop on the web using screen readers on mobile, an interesting incident occurred that showcased how even benign design choices have consequences.

The interviewee navigated to willys (a Swedish grocery store) website. where upon identifying a product, they tried putting their finger on the high contrast window to make it read out the text on the label, upon which "snedstreck kg" (forward-slash kg). After 6 repeated attempts I erroneously interfered and told what the price and product was after what i interpreted as signs of distress. This could have been prevented by the use of aria-labelledby tags on the individual text elements seen

in fig 5.8 to allow each section to read out as the whole price, making for a less confusing user experience with screen readers.

The user in question identifies as a technology enthusiast, someone who actively keeps up with the latest digital developments. Despite her experience and interest, the interaction presented numerous usability pitfalls.

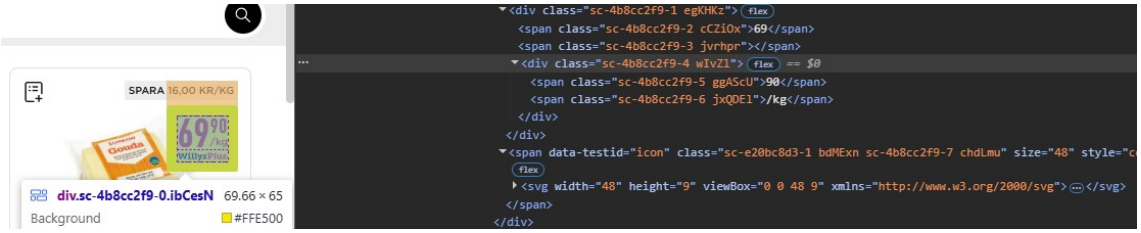


Figure 5.8: Willys price label example with source code showing that the price tag is split up into 3 distinct elements that are separately targetable using a mobile screen reader. Also shows the "willusplus" svg that lacks a text alternative making it invisible to screen readers.

Given that independence in grocery shopping is a critical issue—see services like MatHem or municipal home assistance programs—this serves as a rather embarrassing example of how poor accessibility design can lead to exclusion.

In addition, beyond the unmarked svg bearing the text “Willys Plus,” there is nothing else on the page that distinguishes these products from others—despite the visual cues being clear to sighted users. This fails the criterion of meaningful images having alternative text as per the criteria 1.1.1 [85]. Stating that:

> All non-text content that is presented to the user has a text alternative that serves the equivalent purpose.

Knowing that this is a problem that can be solved in this manner would require the CMS user to know both about this specific problem interaction when using screen readers as well as some knowledge about the functions of specific ARIA attributes. Both of which is lacking according to the studies [21] and [22].

Skip links

In the interviews with two blind users neither was aware of the existence of skip links [86], at least by that name—a common accessibility feature on websites that allows users to bypass repeated navigation elements. It’s possible they were familiar with the concept under another name, but their primary navigation methods did not involve tabbing through content. One of the participants, for instance, uses VoiceOver’s directional navigation, which offers more flexible interaction compared to the linear method provided by tabbing. According to their own account, the Swedish Tax Agency’s website was a frequently visited site, and it employs skip links. Had she navigated via tabbing, this feature might have been more apparent.

Offering options such as skipping navigation and/or bypassing the search function. These links are among the first elements encountered by those navigating via the

tab key. These serve provide some alleviation of conative load of having to parse a set of links if the user knows that they want to proceed to a following section [1].

SEO compromised alt text

Alt text is normally hidden from users that are not utilizing assistive technologies. It is however used by search engines as a way of understanding the contents of the page. This explains the observed phenomena of embedding SEO keywords in alt text rather than conveying the actual content of an image presents a clear accessibility issue. For users who rely on screen readers to understand visual elements, this practice results in content that detracts from the intended message or function of the image [87].

This raises the question of whether accessibility tools can assist not just by suggesting alternative text, but by helping to distinguish between meaningful and meaningless descriptions. Ultimately, however, the responsibility falls on the content creator to provide as much descriptive context as is needed to accurately convey the purpose of the image. Striking this balance is difficult even for humans. A naive solution—generating image descriptions using AI—can lead to wildly inconsistent results depending on how prompts are structured, and the output often struggles to consider the broader page context, crucial for keeping the text relevant [87].

Nevertheless, this is a space worth exploring. Comparing the website of Webbhuset to that of a non-client, Axfood, reveals two superficially similar experiences with contrasting underlying approaches.

For example:

- Webbhuset's alt text: *"Conversation about the future of e-commerce between two people in a modern office environment."*
- Axfood's alt text: *"Employee smiling at the camera, colleagues around the Axfood office."*

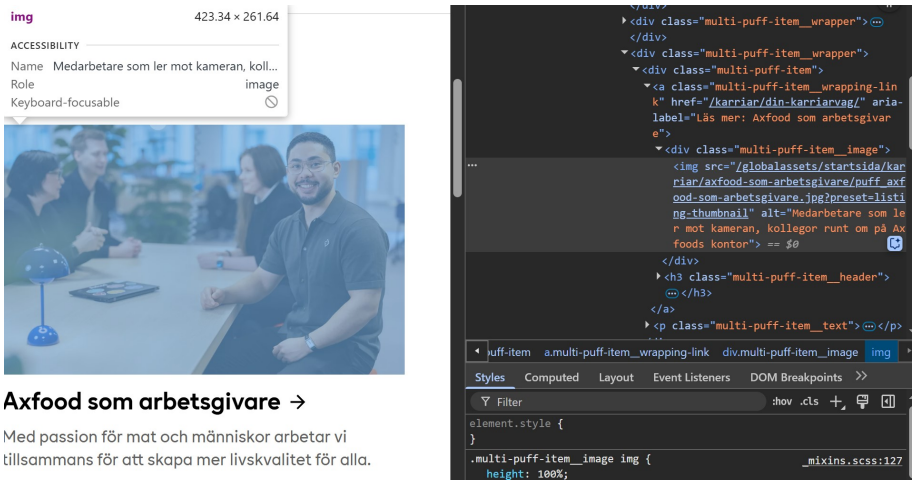


Figure 5.9: Image with the alt text: "Co-worker smiling at the camera, surrounding colleagues at axfood's offices."

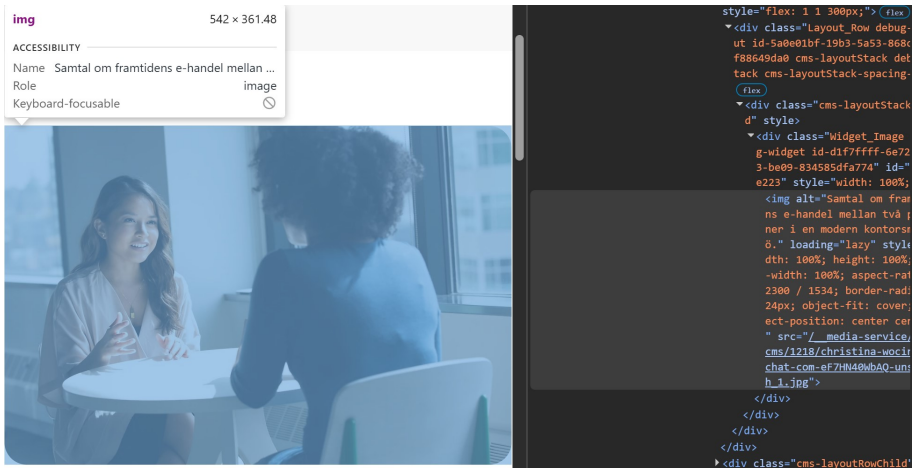


Figure 5.10: Image with the alt text: "Conversation about the future of e-commerce between 2 persons in a modern office environment". Containing information not present on the screen as nothing in the image conveys the contents of their conversation.

In Axfood's case 5.9, the image contains location-based context "at the Axfood office"—that helps users orient themselves in the content. In contrast, Webbhuset repeatedly embeds phrases like "future of e-commerce" into images' descriptions. This is the result of using a GPT model, prompted specifically to tailor text according to a list of SEO-oriented criteria as revealed in the user interviews.

The critical difference lies in the intent and utility: Axfood's descriptions provide contextual information that benefits users, while Webbhuset's appear designed to appeal to search engine algorithms rather than human understanding and breaking the aim of having alt text being succinct [87]. What stands out is that the information included in Webbhuset's alt text 5.10 does not reflect what is visually present in the image nor does it serve the user trying to interpret it. Instead, it primarily serves the interests of stakeholders seeking algorithmic visibility.

Addressing this issue requires more than technical tooling. It demands awareness, responsibility, and education among CMS users. At present, there is no clear solution within the tooling itself to prevent this misuse.

On hover

For users who rely on mouse navigation in combination with a highly zoomed screen, a common practice among individuals with low vision. The dynamic behavior of on-screen content based solely on cursor position can pose significant usability challenges. Specifically, when the layout or visibility of elements changes in response to hover states, it often disrupts the user's ability to perceive and interact with the content.

Even seemingly minor elements like tooltips, which appear when hovering over interactive items, can obstruct important information. This becomes especially problematic when the tooltip itself disappears as soon as the cursor moves away, forcing the user to reposition the mouse and potentially lose both the tooltip and

the underlying content. As a result, users may have to spend additional time and cognitive effort to understand and navigate the page.

> "I'm trying to read the text, but as I move the screen to read it I accidentally overshoot and I have to go searching for the trigger again."

The core issue with hover-based interactions is that they generate a high volume of false positives—interactions that the system interprets as intentional user input but which do not reflect deliberate action. This leads to unpredictable or disruptive interface behavior, particularly for users navigating with fine motor difficulties or visual impairments.

This problem is acknowledged in WCAG 2.1, specifically under Success Criterion 1.4.13 [1] – Content on Hover or Focus (Level AA), which sets requirements to ensure that content triggered by hover or focus can be dismissed without moving the pointer to prevent having to renavigate to the content. To the same goal it should also remain visible while the pointer is on it and be persistent on the screen long enough to hopefully prevent the issue [1].

Hidden elements

A recurring accessibility issue arises when interactive elements remain focusable even while visually hidden or positioned off-screen. A typical example is a text section containing a "learn more" link, which expands to reveal additional links or interactive components. If these elements are not properly marked as hidden when collapsed, they continue to receive focus. This creates confusion for keyboard users, who may struggle to understand their current position within the page structure [35].

This was something encountered several times when analyzing the client's websites. These are difficult to detect by automatic checkers as they currently are not checking if available content is also visible to the user. See figure 5.11 for an example of a link hidden behind a dropdown section and figure 5.12 for a menu that is open to keyboard navigation without being visually expanded.

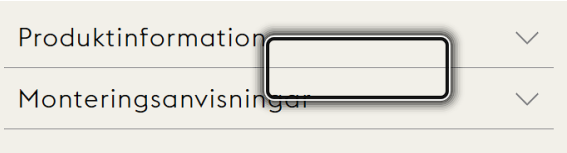


Figure 5.11: Focus on a link that is hidden from view, highlighted with the web browser integrated accessibility settings.

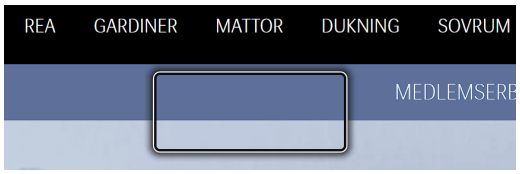


Figure 5.12: Focus on a menu link that is hidden from view, highlighted with the web browser integrated accessibility settings.

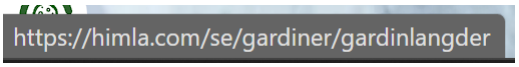


Figure 5.13: The url of the focused hidden link, showing it as a subcategory of curtains while the "curtains" menu is still collapsed.

This problem becomes more pronounced when menus behave similarly, remaining visually collapsed while their child navigation links are still accessible via keyboard navigation. For instance, if a menu section is collapsed but its containing links can still receive focus, users are likely to lose track of both context and content. As they have to navigate through a long list of items that are both invisible and not skippable while the user did not take an action to go through them willingly. The absence of proper focus indicators on parent menu items, often removed via CSS for aesthetic reasons, further degrades the navigability.

Proper handling of such menus involves both semantic HTML and ARIA attributes:

- Use of aria-expanded and aria-controls to indicate the current state of collapsible content.
- Visual hiding of elements through display: none or similar CSS rules to prevent them from being focusable while not in view.

Structuring navigational content as nested lists within a <nav> element can enhance clarity, especially for screen reader users. This approach not only promotes semantic correctness but ensures that assistive technologies can more accurately interpret hierarchical relationships between menu items.

Darkening of background to create a foreground/background

The blind person that preferred to use a combination of screen zoom tools together with a third party dark mode plugin runs into an interesting problem.

First, the third party dark mode plugin is justified by light sensitivity demanding dark mode on their screen. However, the inconsistent implementation of correct dark mode on the web creates the need of another standardized tool. This tool runs a custom set of color conversions to achieve an acceptable set of color combinations to make most places navigable.

The problem occurs when websites programmatically darkens the page by some percentage and overlays it with an area with the original background color to produce a clear foreground/background effect to highlight a certain area of the screen that requires the users attention.

To explain the problem, a simulated replication of it will suffice. Start with an intended user experience consisting of two interfaces that the user has to navigate

through to complete their goal.

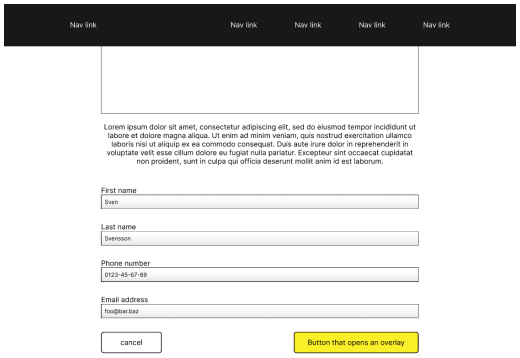


Figure 5.14: Initial State

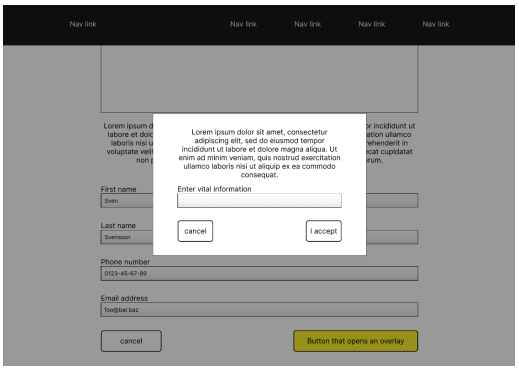


Figure 5.15: After pressing the button

The user is intended to fill out a form, press the yellow button in the bottom right to proceed, being prompted to fill out one additional bit of information and then confirming. In figures 5.14 and 5.15 the two original and intended interfaces are shown. The following will display how this relatively mundane flow gets compromised through the combination of tool use, user behavior, and medical conditions.

First, the effects of both the lack of iris and the dark mode are shown in figure 5.16 and 5.17

Figure 5.16: Initial State from the blind users point of view with the blur simulating eye functionality and the dark mode being applied

Figure 5.17: Pop-up from the blind users point of view with the blur simulating eye functionality and the dark mode being applied

While still enough contrast to make out areas of interest in the first state. The foreground/background effect is severely diminished in this example. In this instance, the text in the pop-up takes a similar position to the text in the background, making it harder to identify as being different than the original.

Figure 5.18: Initial State from the blind users point of view before presing the button. Showing barely anything outside the confines of the button itself. The image being blurry and zoomed to match the user's vision and tool use.

Figure 5.19: The point of view of the blind user after pressing the button. The darkening might be interpreted as an animation to simulate depth. No indication of where to redirect their attention is given. The image being blurry and zoomed to match the user's vision and tool use.

Now, take the zoom tool into account. It can be toggled through keyboard shortcuts to allow the user to switch between reading text by zooming in and finding areas on the the screen zoomed out, relying on contrast and vague shapes to find areas of interest.

As can be seen in figures 5.18 and 5.19, this is the view of the user in the transition between the first and second interface. Here it is not directly apparent that a pop-up has entered the center of the screen, the darkening could for example be interpreted as a pressing animation. The user might switch back to the zoomed out version to try to make sense of what has happened to the page to no avail. The remaining course of action is to scan the page in the zoomed in version, trying to make sense of what has happened.

This presents another problem, mainly that the pop-up is positioned in the middle of the screen. This makes it hard to find due to the disorientating free-floating search when zoomed in due to the difficulty of keeping track where you've already been. Things positioned along the edges are easier to find as the screen border works as a guide to allow you to travel in a straight line as opposed by only requiring general movement in a direction instead of the free floating navigation requiring precise control in two dimensions. This problem of mouse precision in this kind of environment is the same as mentioned in the previous text of on-hover effects.

This problem interaction could be resolved through the use of a screen reader in combination with alerts for pop-ups that are properly implemented. But as this is not the way the user in question decides to navigate the web, it is still a problem for them. In this case it is not a problem of missing accessibility attributes, rather a problematic workflow created by the designer of the form. As such, automatic accessibility checkers would have no way of detecting this as a potential issue, and

the proposed design would pass through lighthouse without raising any flags.

The end user experience in this case is also very far from the intended user experience, and I believe very few designers would foresee this as a potential issue that could arise given the average knowledge about accessibility tools on the web among designers.

5.2 Analyis

The interview notes were not subjected to any formal analysis in-between the recording of data and the construction of neither the personas nor guidelines. Regarding the personas, the justification for this is the already filtered recordings of data to expressions of emotion and explanation of behavior.

Furthering this, there were several overlapping sentiments of doubt or anxiety stemming from their own lack of knowledge on the subject, taking different forms depending on if the interviewee was a developer or cms user.

CMS developers expressed sentiments of not wanting to spend time on something that "does not generate direct value to the customer" and admitted to have only implemented their current accessibility features with ARIA on behalf of an insistent client. They also expressed a want to recruit users that use screen readers to aid their own lack of knowledge which they admitted were a major hindrance towards spending time on something else than what they were good at.

The users I spoke to did not consider accessibility as something else but a means to an end (SEO, meeting external criteria) and spent more focus on the things that made them feel effective and proficient with the tool that were visible to them, such as making nice layouts and designs.

The general lack of data points also discouraged further time spent analyzing the data as it only served to highlight problem areas to the specific design. Further sentiments and problems of creating accessible designs were lifted from outside sources such as W3C [88], Hayfa et al. [21] confirming that the same difficulties are faced by the interviewed CMS users in Sweden, and RQ2 & RQ3 from Maheta et al. [22] that state that education, budget, and improved tools make up for the majority of the requested resources, and that a lack of awareness and proficiency among CMS users as well as the ability to recruit people with disabilities that also possessed technical knowledge were the main barriers to better accessibility on the web.

The gathered stories were instead converted into the personas that highlighted something of interest, such as conflicting SEO needs and the wide range of prior experience among CMS users, and most importantly the lack of validation with screen reader users or other assistive technologies.

For the guidelines that was an oversight on my part and partially a result of time constraints.

5.3 Prototyping

The insights gained from stakeholder interviews and system analysis revealed specific patterns in how different users approach accessibility implementation, along with concrete barriers that prevent effective compliance with WCAG guidelines. These findings provided the basis for the construction of a prototype. The prototyping process was guided by three key principles derived from the interview findings: reducing cognitive load for cms users, providing just-in-time learning opportunities, and making accessibility implementation feedback more immediate and visible. These are elaborated upon in the results chapter.

5.3.1 Justification for delimitation of prototype

This prototype focuses on the experiences of CMS users implementing accessibility features rather than the CMS developers creating those systems. This scope delimitation is strategically necessary for several reasons:

Immediate Impact Potential

CMS users represent the final implementation point for accessibility features—the last step before content reaches end users with disabilities. While improving developer education and frameworks is undoubtedly valuable, such changes would stray too far away from the stated scope of the study and could potentially lead to the project not coming to a close. It would also take too long to validate and would require a set of users to use it over a long period of time to see the downstream effects of those implementations.

By focusing on the user experience of existing CMS platforms, this research targets improvements that can be implemented within current systems without waiting for next-generation development frameworks.

Addressable Knowledge Gap

A substantial body of research already addresses technical accessibility standards implementation at the developer level. The WCAG guidelines [1] themselves are primarily developer-focused, with detailed technical specifications for framework development. In contrast, there is a notable gap in research exploring how non-technical or semi-technical content creators navigate these implementations in daily practice. This research addresses this gap by examining the lived experience of those who work within pre-built frameworks rather than those creating them, a critical dimension of accessibility implementation.

Practical Feasibility Constraints

Accessibility issues arise not merely from flawed technical architectures but from implementation decisions made by content creators working within those architectures. Even with perfectly designed frameworks, content implementers must still:

Write appropriate alternative text, create meaningful link descriptions, maintain proper heading hierarchies and structure content logically. These three make out the

top six reported issues screen readers have according to WebAIMs user survey [33]. The other three were the implementation of Completely Automated Public Turing Test to tell Computers and Humans Apart (CAPTCHA), interactive elements, and unexpected screen changes. All of which fall on the design team to produce and is thus not up to the CMS user to create unless the roles overlap which cannot be guaranteed.

These decisions remain in the hands of CMS users regardless of the framework. Therefore, understanding and improving their experience offers a pragmatic path to immediate accessibility improvements with existing technologies.

Due to the identified conflict with SEO and potential ethical concerns around that, that specific problem was determined to be the first to be tested. The plan was to do it iteratively and implement handling of links and headers as well but due to time restrictions this did not come to be.

5.3.2 Persona development

To guide the prototyping process, three personas were derived from the interview data to represent the different perspectives of a set of potential users.

While directly informed by the interview data, these personas are not direct representations of specific individuals but rather composite archetypes that embody the essential qualities, behaviors, and experiences identified in the research. Each persona had common traits:

- Demographic information (role, experience level, education)
- Technical skill profile
- Workflow characteristics
- Mental models regarding accessibility
- Challenges and pain points specific to their context
- Motivations and priorities that influence their work

I wanted to capture certain things that problematized my own preconceptions, such as having users that rarely use the mouse and thus actual layout for interactive buttons was meaningless, people that saw accessibility as a means to SEO. A common occurrence among both the developers and users of the CMS I interviewed were that they primarily used Linux machines and thus had software limitations that prevented them from using most of the common screen readers on the market. Involving this as an aspect for potential developers tasked with using a CMS further highlights the need of extra considerations from the tool. Other considerations for the design face includes taking into account varying degrees of technical knowledge, the mental bandwidth or cognitive load capacity of the different personas depending on development context, and interoperability with third party tools.

These are useful to help ask yourself how a particular design decision would negatively or positively impact a specific persona. In the case of a keyboard exclusive user,

implementing too many focusable elements make navigating the tool tedious by having to go past too many uninteresting fields. Steps to alleviate this problem then have potential effects for the other personas which begins the analysis anew. In the end it helps to keep a vague sense of balance for the potential users, making sure none are neglected too much without justification.

5.3.2.1 Personas that highlight user needs on their tools when implementing accessible designs

The analysis yielded three distinct CMS user personas that represent different approaches to accessibility implementation: the Marketing-Focused Content Creator, the Experienced Web Manager, and the Technical Developer. Each exhibits distinct characteristics that influence their interaction with accessibility features. While they all have different backgrounds, these should be viewed as people tasked with operating a CMS to create content or to manage existing, allowing for a wide background while still working within the same system.

These work to provide an alternative way of explaining the needs different types of CMS users have on their tools when trying to comply with the Web Content Accessibility Guidelines. As these were really similar to the people interviewed and a four-to-three condensation of users, they were not utilized in the design consistently as much as it became easier too keep track of the real people involved instead of the personas when tying decisions back to user behaviors. As such, they are included in the appendix and available to get a sense of the users interviewed as they are not crucial to the study.

5.3.3 Alternative CMS interface for alt-text

Alt text serves to signal to assistive technologies such as screen readers that the image in question conveys some meaning or information that is relevant to the context in which it is presented and is useful for the user to perceive. To normative users, this is invisible and thus easy to miss when implementing images, leading to screen reader users either missing out on crucial information leading to confusion or in the worst case inability to proceed with their task. Alternatively they are presented with the file name, which in most cases is a jumbled mess of characters yet sometimes useful for determining the content.

The goal was to both tackle the problem of categorizing images correctly into those that are decorative, and those that convey meaning. Additionally it should help users keep track of the meaningful images that lack text to allow the user to return at a later date to finish the implementation. This would also allow for automatic evaluation tools to catch these meaningful images lacking text as opposed to the current state. The categorization and formatting of images in this way is a criteria in the WCAG, ensuring decorative images are marked as such and that all other content has descriptive alt text.

A secondary problem to incorporate was the utilization of shortcuts given the opportunity in prolonged repetitive user scenarios. The aim was to see if the users

would deem these pleasant enough to switch to the flow that required fewer clicks than manually stepping through the tree structure to find the content they're looking for, reducing cognitive load from having to spend too much time navigating.

5.3.4 Prototype creation

The prototyping started directly in figma, using their own UI as inspiration for handling multiple sets of related input fields as can be seen in figure 5.21. Inspiration was also taken from the Godot game engine's UI that can be seen in figure 5.20.

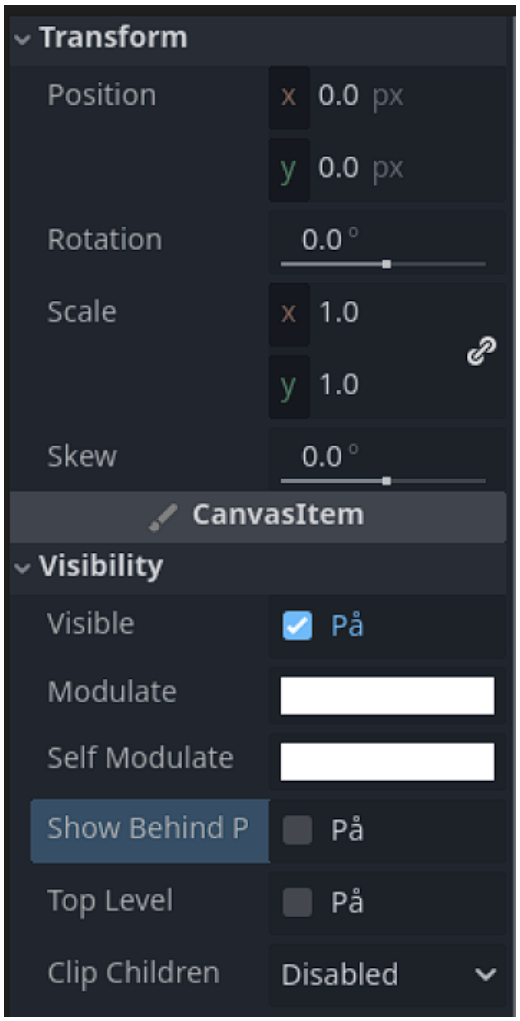


Figure 5.20: Godot game engine user interface for editing a 2-dimensional game object. Presenting a 2-column table layout with labels on the left and values to the right

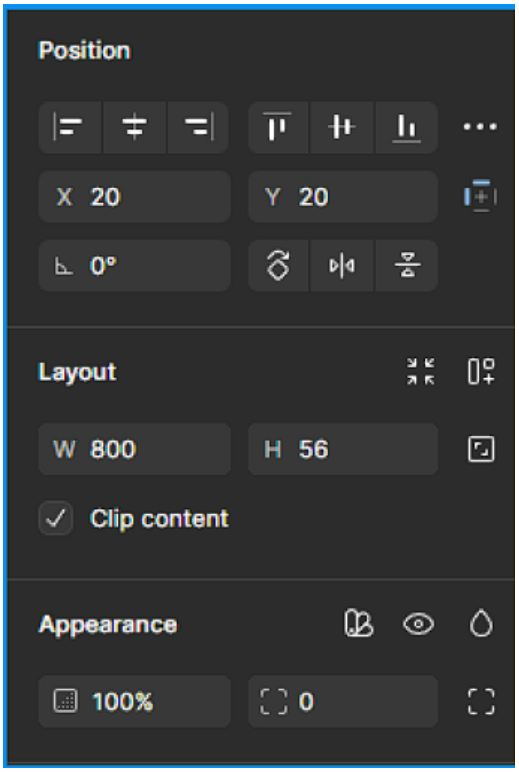


Figure 5.21: Figma user interface for editing a frame container. A visual element containing other visual elements. A 2-column table layout with each table cell containing both label and value with the label usually being an icon or abbreviation of the field name.

These were familiar interfaces that I deemed easy to navigate and wanted to incorporate, mainly how they make good use of grouping to make ascertaining the state of an object relatively easy. Using the dark background also creates a layering effect that I thought would be useful to further separate the navigation from the editing interfaces. Additionally this was already something implemented to the left of the interface and thus seemed like a fitting addition.

To implement error visibility, there was plenty of inspiration to be taken from Integrated Development Environments (IDE) such as Godot's own or more popular ones such as Microsoft's "Visual Studio Code" seen in figure 5.22.

Figure 5.22: Tree file structure view with a propogated error displayed by means of color and additional icon suffixed at the end of the path name. If a dot is present on a file, it is indicative of that file containing a syntax error. If a dot is present on a directory, it is indicative that it contains either a file with a syntax error or a sub-directory that does recursively

The overarching layout of navigation, content, and editor was to be kept as to not include too many deviations from the original, furthermore it was not identified as a problem area during interviews and testing and is a layout commonly found in other products.

The idea behind redoing the buttons for deletion and creation of new content were only intended to have fixed positions to minimize accidental "missclicks" from users that had memorized the relative location of actions. This was something identified in the interviews with blind users but were carried over on the assumption that it would have a negligible positive impact if any to the normative user experience. Making

use of the gestalt principle of grouping to convey similarity in function between the buttons [89].

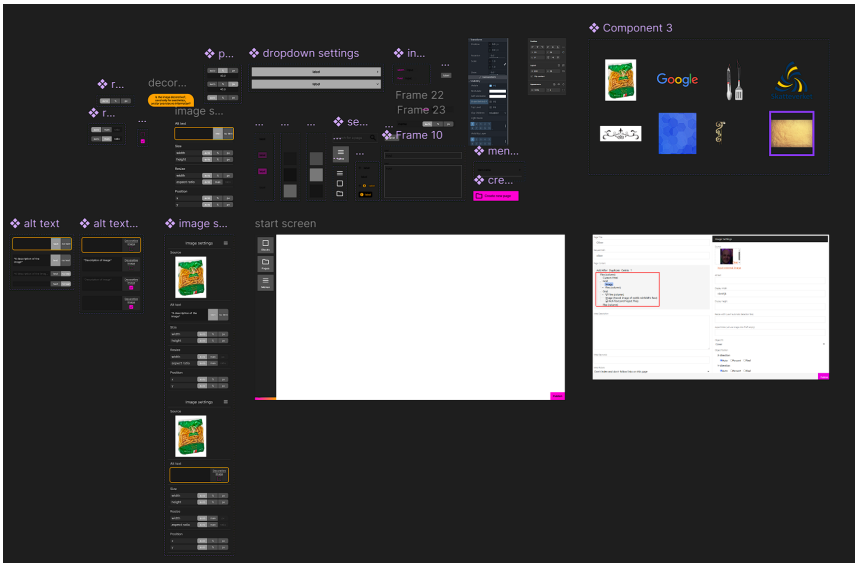


Figure 5.23: An overview of the assets created in figma. Does not contain any user scenarios or flows, only the constituent components of these.

5.4 Resulting Prototype

This section consists of a set of screenshots from the Figma project. The alterations are highlighted and displayed next to the original design.

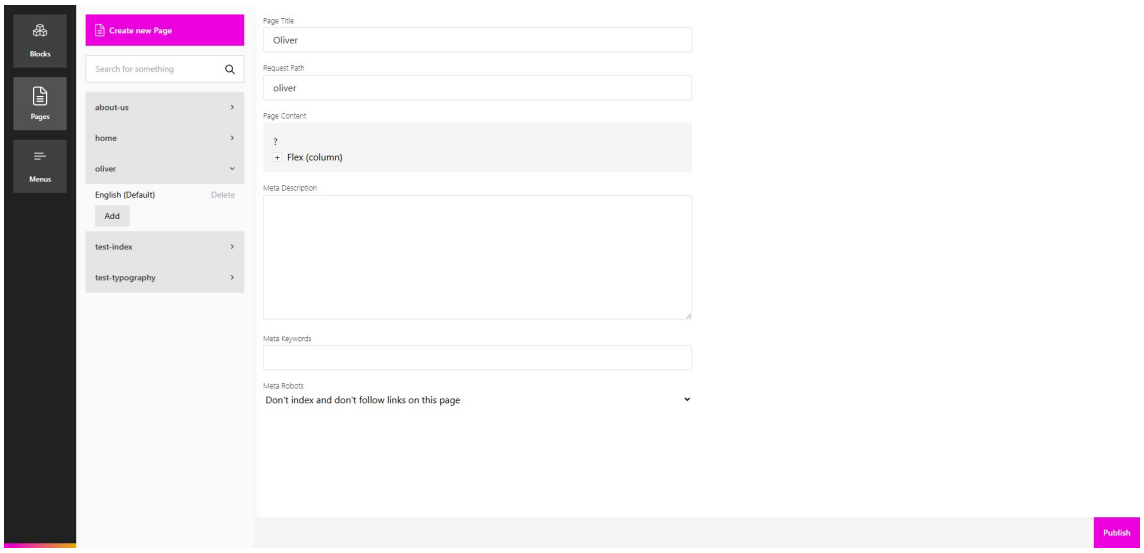


Figure 5.24: Original CMS full view

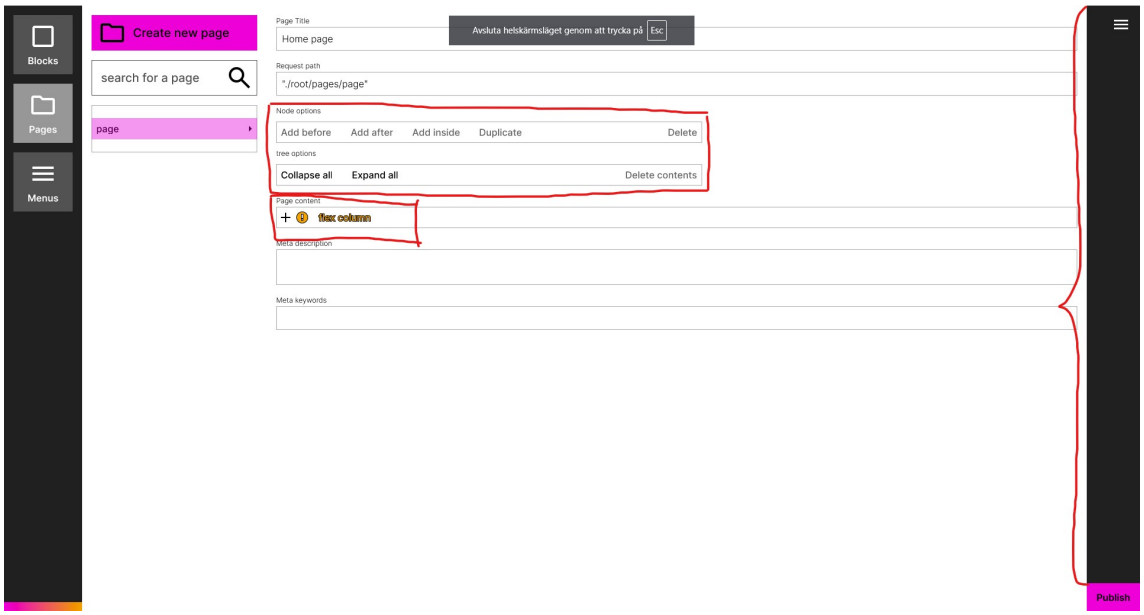


Figure 5.25: Prototype CMS full view, highlighted areas are original and interactable for the user, new buttons for managing the tree content on top, the new tree under said buttons and a new settings view to the right. Flex column is a container that aligns its children content vertically, expanding to fill the available space depending on settings. It is the root node in the content tree.

These are presented for an overview, individual sections will be explained and shown in greater detail. Look to figure 5.27 for a clearer view of the middle portion of figure 5.25.

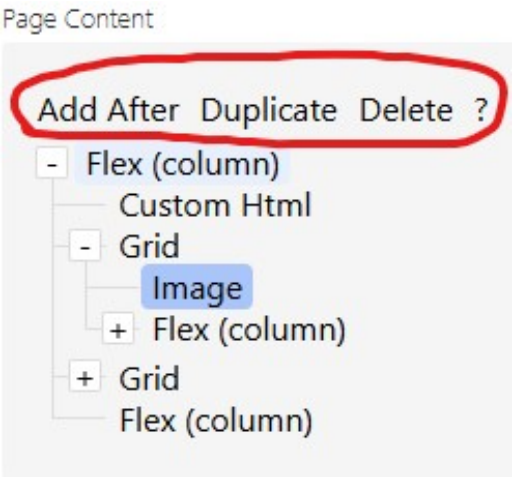


Figure 5.26: Original tree and tree actions. Highlighted are the buttons that interact with the tree to either add additional nodes, duplicate the selected one or delete the selected one respectively, with the "?" providing a legend table. The tree is partially expanded and a third level node is selected called "image". The buttons are not visually distinguished from the tree nodes and are generated in series depending on the node selected.

The options available in figure 5.27 have been semantically grouped and aligned with absolute positions. Nodes on top, trees on bottom, deletion on the right. All buttons pertaining to creation of new content in a row, all buttons related to deletion in a column, tree manipulation on another row.

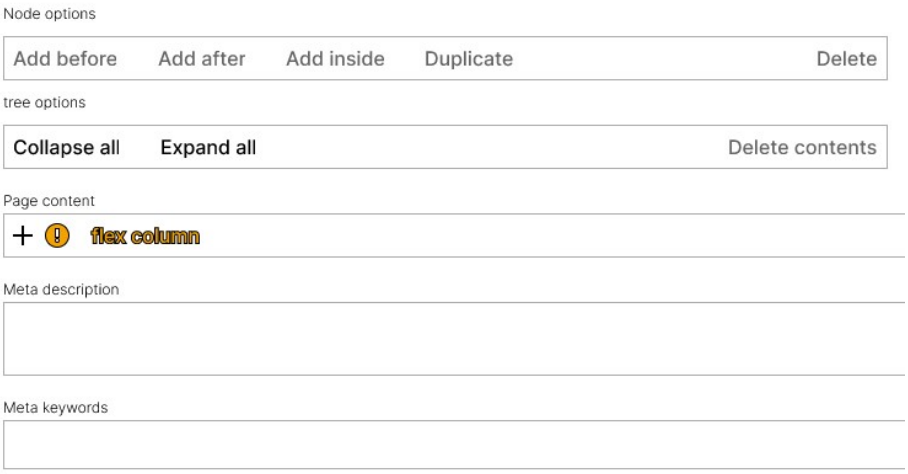


Figure 5.27: Prototype tree view. It shows a tree with a problem child node that. All possible actions are laid out and the buttons are grouped into 3 sections. Ones that affect specific nodes are on the top row, deletion actions are grouped to the right and tree manipulation on the bottom row. The options are grayed out to indicate that they have no target as no node is selected.

Upon navigating to the image node in the tree, an options menu open to the right of the screen. This has been altered as well, grouping options by what property they alter making overview easier. Presenting the user with 4 different groupings of settings with more succinct descriptions reducing cognitive load to parse by reducing the amount of reading needed to find what you're looking for. This redesign also implements explicit automatic values for the fields instead of relying on the "empty -> auto" heuristic. The aim of this is to lessen the cognitive load of parsing the information on the page as well as making identifying deviations easier. Selecting a non-auto option reveals an input field that is otherwise invisible. The aim of this is to limit the inputs prompts to the user to only the ones relevant to their intent. Also benefiting the previously mentioned potential keyboard first user by presenting the user with less focusable elements.

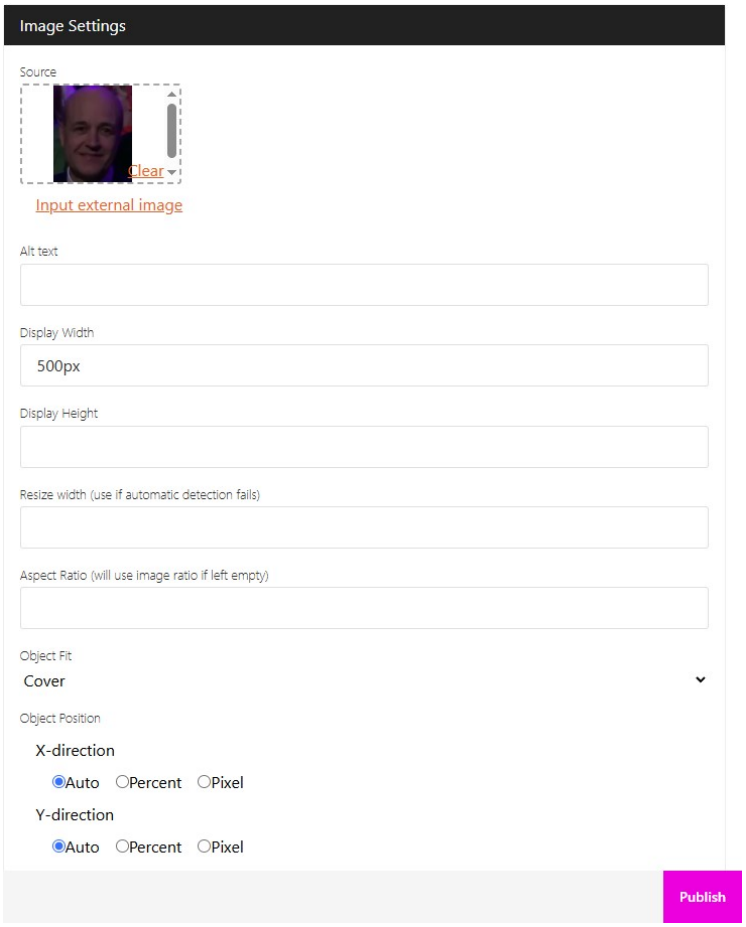


Figure 5.28: Original image settings view containing all the fields for formatting and layout as well as alt text at the top

Figure 5.29: Prototype image settings view, Model A alt text in the unresolved state, requiring either text or explicitly "no text" to be chosen

As can be seen in figure 5.29. The alt text field also has options, with the current one being in a problematic state. The current configuration states that the image should have alt text yet none is provided. To indicate this a cascading error state is marked with the relatively high contrast outline around the problem area.

To resolve the issue, text can be provided in the associated field, or the image be marked as supposed to have no text. To test just in time learning, an alternative interface was created, referred to as "model B" in figure 5.36. In this instance, the user is prompted with another question; a checkbox to mark the image as decorative with a hover effect to produce a tooltip descriptor of what constitutes a "decorative image" as per the wcag 2.1 guidelines. Both figure 5.35 and figure 5.36 contain the same functionality on the back-end and are only visually dissimilar.

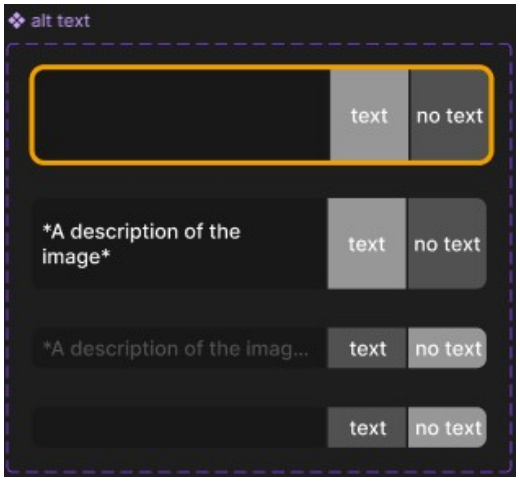


Figure 5.30: Model A alt text states

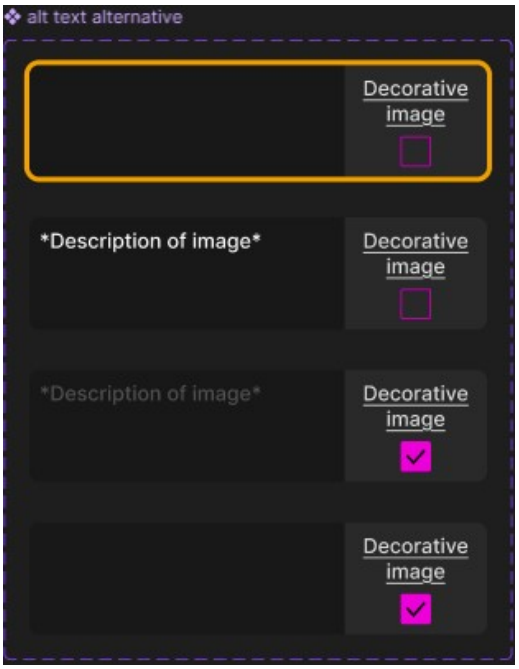


Figure 5.31: Model B alt text states

5.5 User Testing

Gathering users for the user testing took me to a so called third place [90] in Gothenburg where I asked local patrons to participate in the testing. This occured over several days of a week for a total of 25 participants. The overwhelming majority of which had little to no prior web development experience. And thus are disconnected from the personas that were developed. It was a compromise between availability of participants and likeness to the personas. The ideal participants would have been to go to the company I cooperated with, but as they were aware of the study being conducted I wanted to avoid the prior knowledge of the goal of the study to influence the results and thus I deemed this course of action to be appropriate.

I observed the users during testing with minimal intervention after explaining the premise of the test and at the end of each scenario, the result was recorded in a spreadsheet.

The Testing consisted of 8 sequential scenarios. The user had to navigate the prototype up until the state seen in figure 5.32 with either pressing the expand icon (plus sign) on the tree nodes or use the expand all button and then select the image node. After that the alt text was to be resolved by either option. After that they were instructed to press the publish button in the bottom right corner when they felt that they were confident in their choices. The sequence was always the same, starting with the model A for 2 images deemed decorative and 2 that were meaningful before switching to model B and repeating with similar images in the same categories. The rate of adoption of the expand all feature, along with the categorization for each image was recorded along with a self evaluated level of knowledge on a scale of 1-5 in both "experience with web development" and "knowledge about the European accessibility act". The measurements were stored in a spreadsheet and compiled into diagrams that can be found in the appendix.

The results show that the model B approach had slightly better accuracy than the model A. The solutions that were the combined state of text being provided yet the image marked as decorative or having no text were counted as no-text entries as that would be the way the system would handle that state.

The adoption of the expand all button increased as testing advanced. The adoption at the end were 92% (23/25 users).

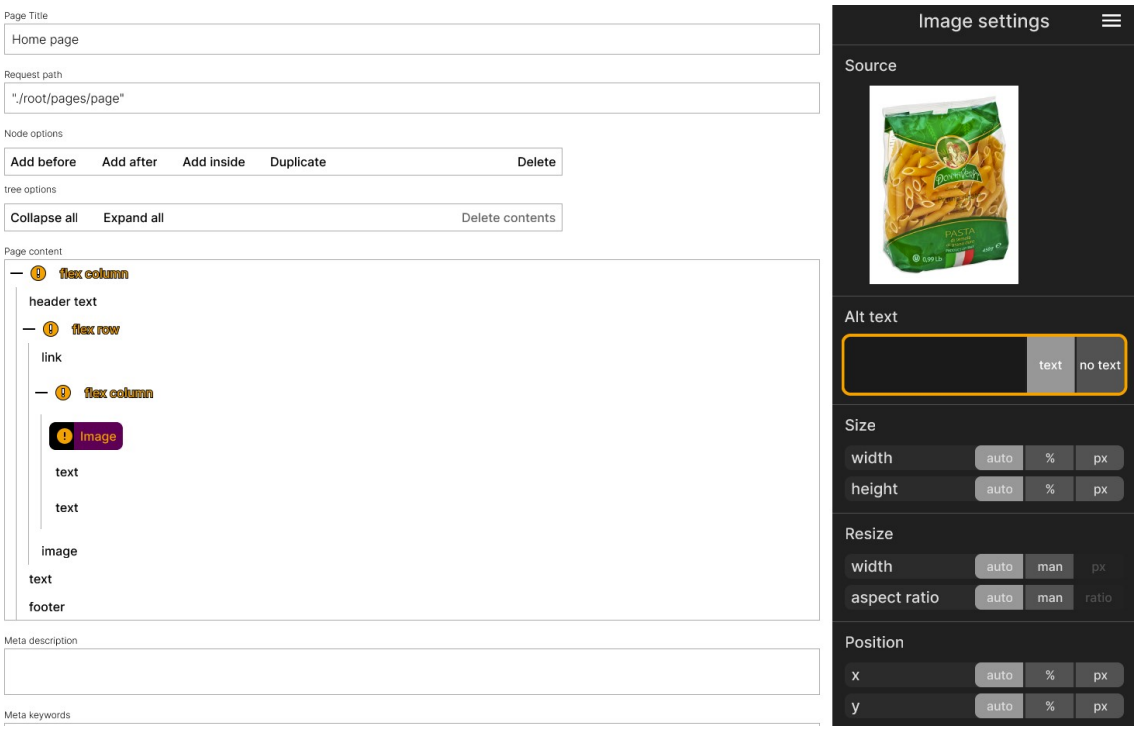


Figure 5.32: The end view for each user before resolving the test, this was the goal of the navigation of the tree through either clicking the plus icons next to the tree nodes or by using the "expand all" button in the top left corner.

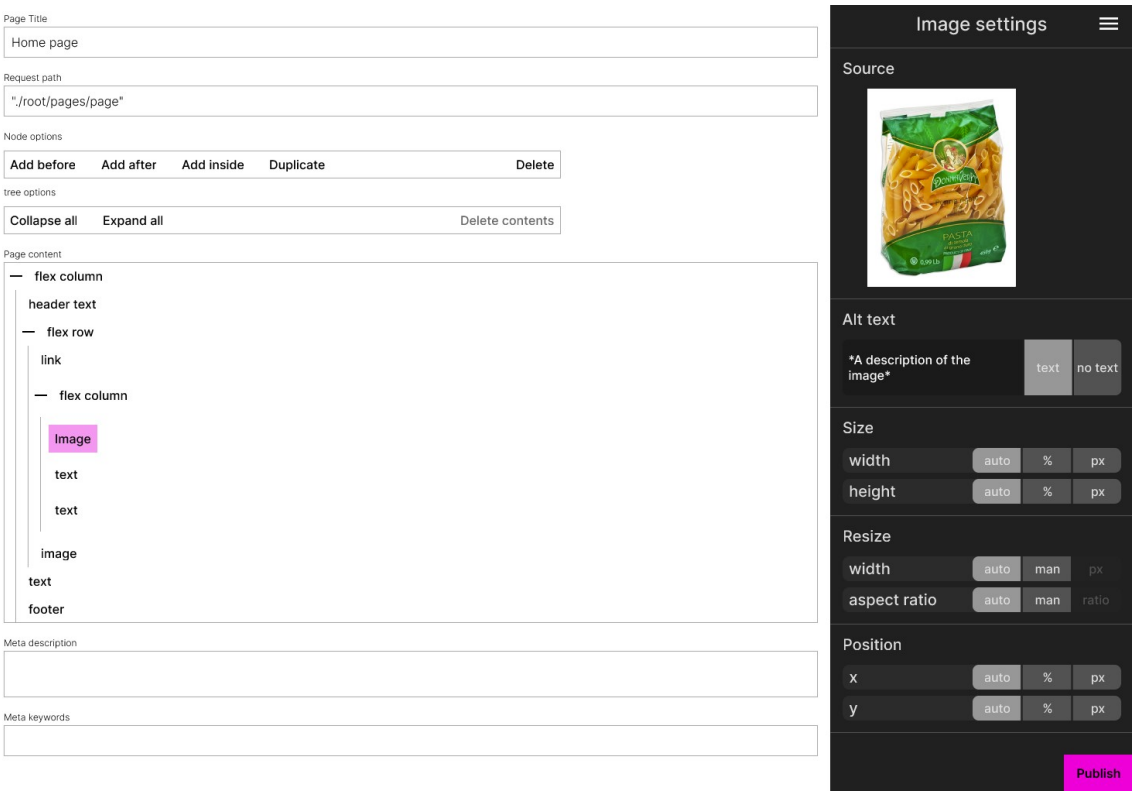


Figure 5.33: End state after resolving the issue, with visual alert indicators beign removed along with the high contrast highlights.

upon resolving the issue, the tree was updated to signal the resolved issue by removing the yellow outlines as can be seen in figure 5.33.

The photos used for testing where 2 of each category:

- Background image (Decorative)
- Frame Decor (Decorative)
- Product Image (Meaningful)
- Logotype (Meaningful)

With one of each per model being tested.

The categorizing of images could be tested. And in a larger scale testing, controlling for the image sets would have been possible, but due to streamlining the testing and the relatively low number of participants this was deemed acceptable by me. Particularly so as it does not form the basis of any sweeping statements, rather should display a trend or not.

5.6 Prototype test takeaways

Two prototypes for alt text implementation were developed as part of the study, these were made to be tested with users see to which extent the different designs

impacted user accuracy scores. Taking inspiration from the A/B testing method however with a greatly lesser amount of testers. This was measured by having the users simulate navigating through the prototype to find the Images missing alt text and solving the problem by either marking them as decorative or providing text. Each of the models had got images in the same 4 categories as can be seen in figure 5.34.

The A/B testing of 2 prototype alternative alt text interfaces yielded interesting results. It showed that the B model found in figure 5.36 produced more accurate categorizations in all categories of images by varying degrees. The explanation of this might be due to the last of the following principles that guided the design: **Contextual guidance through progressive disclosure**. But there are two others who's effect are worth mentioning: **Explicit categorization of images** and **Visual state indicators**.

5.6.1 Example of implementation - Alt text

For a concrete example of how some of these principles can be added, I highlight the prototype used in this study. There are some useful findings to take from the result of its testing that might be applicable in similar situations, when implementing how the configuration of alt text should work in your CMS to both address the technical requirements of WCAG and the practical needs of your users.

5.6.1.1 Explicit categorization of images

Having the user explicitly categorize images into meaningful or decorative, a way of removing the possibility of forgotten fields to go unnoticed by both the CMS as well as for automated accessibility evaluation tools. Eliminating this grouping of false positives and reintroducing them as true negatives to allow them to be spotted and subsequently handled. This still allowed for false positives by way of users erroneously categorizing images, yet this effect could be reduced with the aid of "Contextual guidance through progressive disclosure" and showed positive results scaling with user expertise.

This finding connects directly to the Cognitive Load Theory discussed in Section 3.2, as explicit categorization reduces intrinsic cognitive load by breaking the task into smaller, more manageable components [41]. It also addresses the mental model misalignment identified in Section 3.3 by providing a structured decision path that bridges the gap between technical implementation and user needs [45] [91].

5.6.1.2 Visual state indicators

The prototype's implementation of clear visual indicators for incomplete or problematic accessibility states showed strong adoption among users. The yellow high contrast outline highlight system for unresolved alt text was immediately understood by all but one (96%) of test participants.

This approach connects to the Recognition Over Recall principle in cognitive design [59]. Allowing users to quickly identify which elements require attention instead

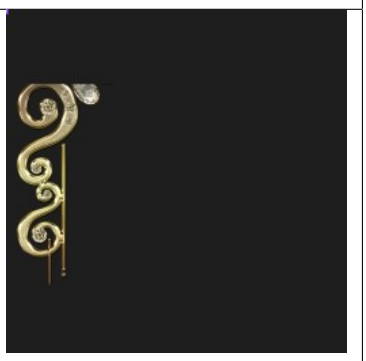
	Model A	Model B
Decorative frame decor		
Decorative background		
Meaningful product image		
Meaningful logo		

Figure 5.34: A grid of images used for user testing broken up into category by row and for model by column.

Figure 5.35: Model A alt text field. Contains two toggle buttons selecting between meaningful and decorative labeled as "text" and "no text" respectively.

Figure 5.36: Model B alt text field, hovering the underlined text shows tooltip explaining the meaning of the word "decorative". Contains a checkbox for keeping track and indicating state

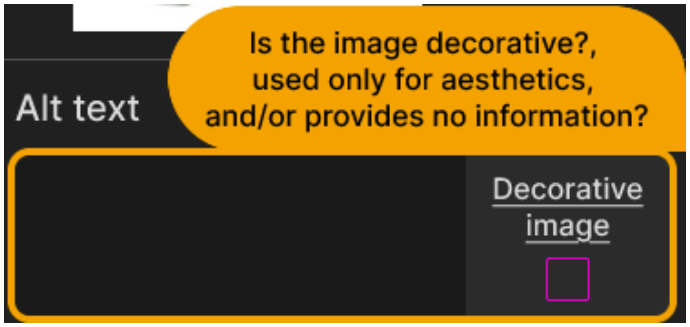


Figure 5.37: Model B with expanded tooltip

of parsing names or other information to ascertain the state of the node, reducing cognitive load [41]. It also addresses the problem of "forgotten" accessibility attributes identified in the CMS user interviews, particularly for users who follow workflows similar to Sofia's (duplicating content across mobile and desktop versions).

5.6.1.3 Contextual guidance through progressive disclosure

The Model B implementation in figure 5.37 of a tooltip explaining decorative images demonstrated the value of just-in-time learning [50] by way of tests results. The findings directly support the claim by Watkins and Mazu that the JIT learning practices helped support the corrections of misconceptions [56], in this case meaningful vs decorative images. The progressive disclosure approach prevents overwhelming users with technical information while still providing necessary guidance at the decision point.

6

Results

This chapter includes Guidelines that help answer the research question: **How can the design of Content Management Systems aid their users in complying to the Web Content Accessibility Guidelines?**

The guidelines presented in this chapter are distinct from the guidelines found in WCAG, both in content and in target audience and target context. WCAG are primarily intended to be applied by web content creators in general, CMS users beign a subset of these content creators. The guidelines presented in this chapter are instead intented to be used by CMS developers to aid CMS users in applying the WCAG. The primary downstream effect of both of these being to increase the accessibility of the web to users with accessibility needs. Illustrations of the differences of these can be seen in figures 6.1 and 6.2. Guidelines in this chapter are unless stated otherwise those pertaining to CMS developers and are the ones illustrated in figure 6.2.

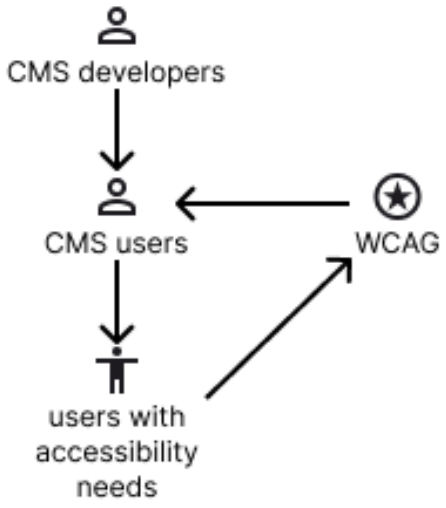


Figure 6.1: A chart displaying how WCAG are informed by users with accessibility needs to be applied by CMS users.

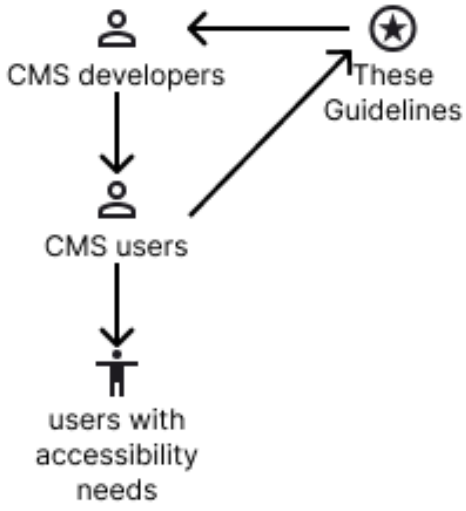


Figure 6.2: A chart displaying how the guidelines presented in the study are informed by CMS users and users with accessibility needs to be applied by CMS developers.

These guidelines can roughly be divided into three different categories that each represent different identified needs the CMS users have when trying to adhere to the WCAG: Reducing cognitive load, help identifying accessibility issues (Evaluation), help correcting accessibility issues (Execution). As the European Accessibility Act (EAA) goes into effect june 28th demanding new web content in Europe to adhere to the WCAG, these guidelines should find applicability soon enough by prospective CMS designers that aim to help their users meet these demands.

The guidelines are summarized as follows with more in-depth description in this chapter:

- **Streamline navigation**

  Provide shortcuts in areas that are frequently traversed.

- **Design for sporadically disrupted long term use**

  Use recognizable colors, icons etc. to convey system state.

- **Make automated decisions visible**

  Make input of human judgment visually distinct through the use of layout, styling, and if necessary text.

- **Provide alternative feedback for accessibility settings**

  Display the impacts of accessibility settings in a way that does not require third party tools or evaluators.

- **Support Just-in-time learning**

  Tooltips, examples to display differences between good and bad implementations to guide users at decision points.

- **Use user-centered language**

  Formulate questions of accessibility in ways that are understandable to the un-initiated person. Assume no prior knowledge of the user.

Secondly, a showcase of some limitations when looking at accessibility through the lens of complying with test criteria instead of adopting a user-first approach. These warrant further validation yet can serve as the starting point for future research or as a part of a broader perspective on the design implications in the field of web accessibility.

6.1 Guidelines

The key practical takeaways from this study is a set of six design guidelines displayed above for those that are tasked with designing a CMS. These are explained in further detail in the following sub-sections, divided into the three different needs they address.

6.1.1 Cognitive Load

Aside from both the evaluation and execution as separate fields, the task of managing cognitive load for the user is important in all stages. It is a stressor that lowers the capacity of the user to complete their task at hand or introduces user error by way of exhaustion. This takes the practical form of streamlining the navigation of the user in the CMS, shortening the time and effort spent searching and traversing the tool.

6.1.1.1 Streamline navigation

Similar to the guideline found in WCAG with a similar name: Guideline 2.4 "Navigable" [92]. This keeps the same intent, as they state:

> "help users find the content they need and allow them to keep track of their location."[92]

The desired effect is different however and the context is different. This aims to allow the CMS user to spend more time and effort on the difficult tasks that require human judgment inside the CMS to produce better results, a good user experience being the means to an end. The analysis of user behavior during testing showed that participants increasingly adopted the "Expand All" button that expands the entire tree view in the CMS recursively, displaying all child nodes (reaching 92% usage by the end of testing) when navigating the content tree. This suggests that tools that reduce navigation overhead are widely preferred by users and by a varying amount reduces the cognitive load [41] and thus the rate of erroneous data input by users.

The less time users spend navigating, the more cognitive load can be spent making the important choices of nuance that have a high impact on the end users [41]. For an example of a good implementation of this, look at figures 6.3 and 6.4.

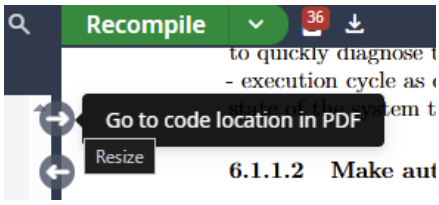


Figure 6.3: Hovered button allowing me to scroll to the corresponding place in the pdf to where the current selected part of the source code compiles to. Tooltip present explaining the functionality.

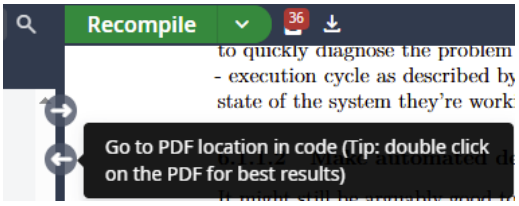


Figure 6.4: Hovered button allowing me to open the relevant source code file that compiles to the selected part in the pdf. Tooltip present explaining the functionality as well as providing an alternative workflow by double clicking the pdf.

These significantly reduces the time spent reading through the pdf or skimming through source files when trying to find the corresponding place; reducing fatigue from reading.

6.1.2 Evaluation

The first half of the Evaluation/Execution cycle as described by Norman[57]. This pertains to understanding the current state of the system. In the case of a CMS that would be the state both of the entire page, as well as of all the individual components that make it up. The following guidelines are to help the CMS user in understanding the state of their content within the CMS, including help diagnosing problems as well as understanding how their current content is perceived.

6.1.2.1 Make automated decisions visible

Nielsen argues for the benefits of providing defaults for data [93], letting the tool take creative liberties about user intent in order to produce a better experience for end users. but these should still be visible on the backend. It is different for the user if the information exists there by default or is inserted invisibly at compile time. The former provides a JIT opportunity to the user [50], [93].

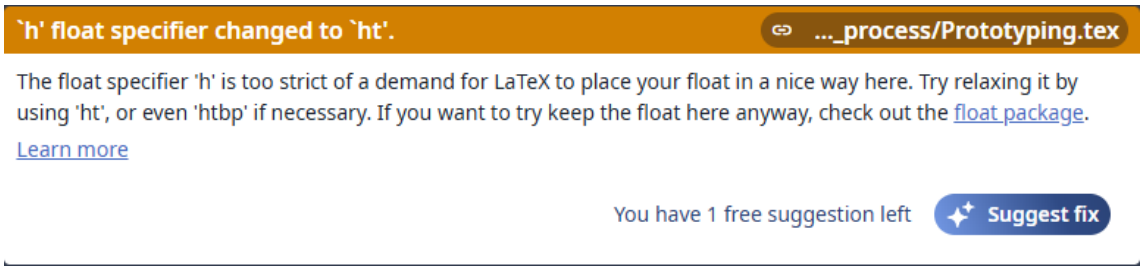


Figure 6.5: A warning message in the Overleaf latex editor. Warning the user about problematic argument to a function, simultaneously informing the user what the issue is and how it was resolved. Also provides link to the source code where the error occurs.

Similar to the warning seen in figure 6.5, a message about missing alt text and subsequent marking of the image as decorative would aid the evaluation on the users part. This would Convey both what the problem is and how it was resolved, serving both the evaluation and execution parts of the cycle [57]. The lack of this led to misses from the CMS users interviewed in the study.

6.1.2.2 Design for sporadically disrupted long term use

The research identified that accessibility implementation typically occurs in sporadic bursts rather than as continuous activity. This places a need for understanding the state of the content as fast as possible when returning after a significant period of time.

Implementing state indicators lets the user recognize over recall [59] by ways of icons, color schemes, or other visual standards that recognizably allows the user to spot problem areas that require attention. Error messages with red highlights in forms for example makes it easy to spot a faulty input among many, and crucially without having to parse the input and evaluate it manually. This allows the user to quickly diagnose the problem and ties into the evaluation part of the evaluation - execution cycle as described by Norman [57] where users have to understand the state of the system they're working with to know what they can do to alter it.

Examples of good adherence to this guideline have already been displayed in this chapter. Figure 6.4 shows a top bar where the error generated error messages are accrued. Allowing me to return to a document after months of neglect. Find a error message like the one in figure 6.5 that points me to the source file that the error occurs in without having to remember the file system. Allowing me to fix it and later view the result by pressing the button in figure 6.4.

Interviewees mentioned going back intermittently to edit a testimonial page as new testimonials came in. Producing a need of repeatedly understanding the state of the same page as the time in-between visits were enough to forget about the intricacies of the page. Having to relearn the heading order each time, or forgetting to do so and accidentally breaking the heading hierarchy.

6.1.2.3 Provide alternative feedback for accessibility settings

When changing settings that affect the visual layout of the site, the impact of the implementers' choices are easy to understand and the feedback loop is relatively short, increasing correct execution as per Normans theory [57]. However, for many accessibility settings, this immediate feedback is absent unless the results are tested with assistive technologies and thus suffer in implementation quality/accuracy.

The research found that none of the interviewed CMS users regularly tested their content with screen readers or other assistive technologies, creating a significant gap in the feedback loop. The small sample size of CMS users make this believable if WebAIM's screen reader user surveys are to be believed [33]. Where roughly 10% of screen reader users had no disability and thus were probably comprised of a mix of testers, and others. An almost negligible minority of web-developers in total.

If CMS users use operative systems such as Linux as some of those interviewed in this study, actually testing with screen readers might prove difficult due to software incompatibility and in those cases alternative ways of providing alternative feedback in the tools is the only way to make the impacts of the accessibility settings visible to the CMS user.

Examples of this could be hiding all non-keyboard-navigable elements before testing, seeing if you could complete the intended use case without a mouse. A more integrated solution could be something akin to the adobe color conflict visualizer found in figures 6.6 and 6.7.

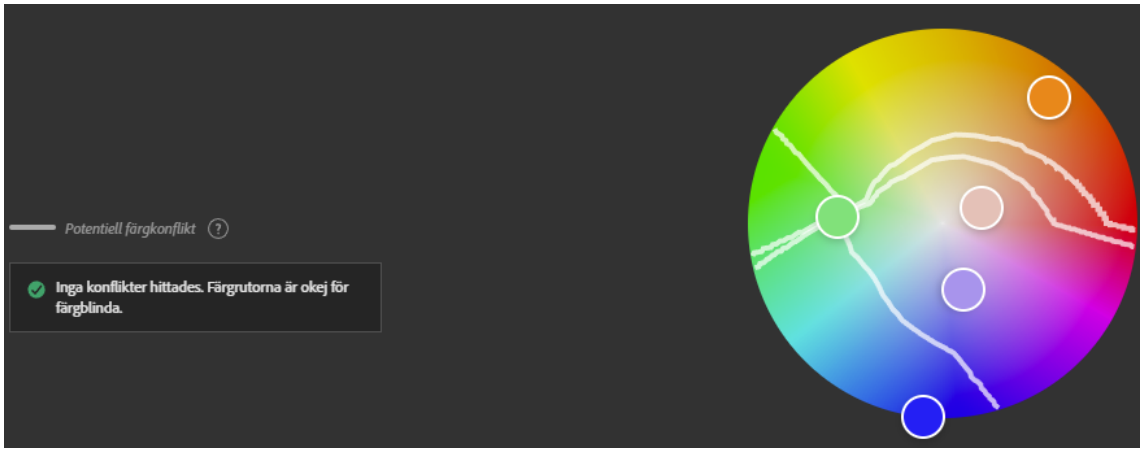


Figure 6.6: A color wheel with several nodes on it. From a highlighted node arcs lines that if colliding with other nodes indicates color conflict.

Figure 6.7: Like figure 6.6. Shows an error state with lines drawn indicating which colors produce conflicts with each other.

These can be used at the time of selecting color on an element, with the other colors on the page displayed on the wheel, letting the user immediately know which colors are not discernible from each other and thus not appropriate to categorize content as the sole distinguishing factor. In practice it also allows the user the same fine-tuning

work done when positioning content on the screen, allowing for slight adjustments with immediate feedback until a satisfactory state is achieved.

Both of these still put a lot of responsibility on the CMS user and as such are not ideal. Further research would be needed for other good examples in the field of visualization of accessibility.

6.1.3 Execution

The other half of the Evaluation/Execution cycle, pertaining to the actions the user takes to affect the state of the system. In the case of the CMS, it is the creation and alteration of content on the web pages produced in the system.

6.1.3.1 Support Just-in-time learning

The user testing demonstrated that embedding contextual learning elements directly into the interface significantly improved classification quality. Users interacting with Model B, which provided tooltips explaining decorative images, showed a higher accuracy rate in properly categorizing images compared to those using Model A without contextual guidance.

This finding aligns with the theoretical framework described in Section 3.4 "Just-In-Time Learning". Where Brandenburg posits that knowledge is most effectively built when learners can immediately apply new information to solve real problems [55]. Shortening the feedback loop between learning and applying knowledge enforces the rate of knowledge accumulation [55].

While a good example has already been provided in the example in figures 6.4 and 6.3. Another example from overleaf might prove beneficial as well.

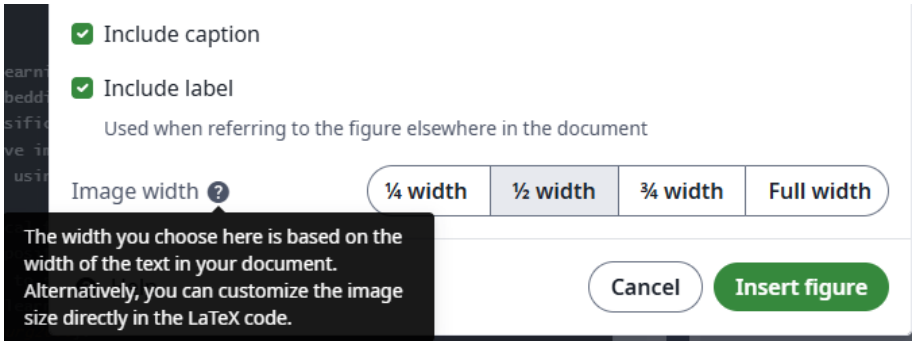


Figure 6.8: An expanded tooltip in the menu to insert an image into overleaf. In the selection of image width, an explanation of how it works and where you are able to change it after proceeding exists.

In figure 6.8 the information of how to work with image width is provided at the time of implementation, providing a short feedback loop between learning and applying the knowledge and reinforcing the learning of it and improving user accuracy[56].

6.1.3.2 Use user-centered language

Assume that the user is not knowledgeable about the intricacies of web accessibility and take care to phrase the prompts in a way that is understandable to them.

The prototype testing revealed that interfaces presenting complex technical decisions as simplified conceptual choices improved implementation accuracy. Rather than requiring users to understand ARIA roles, states, and properties (as shown in Figure 5.5), breaking decisions into user-friendly questions (like "Is this image decorative?") resulted in implementations more closely aligned with WCAG requirements. This puts the question closer to the users mental model [45]. This results in more correct end user experience by way of making the evaluation of the user easier and the subsequent execution as well[57]. An example of this would be the tooltip in figure 5.37.

This is similar to how wizards are used in other programs to guide the user to input correct information through a set of curated questions that funnel the user into an outcome, the complexity of which is hidden from the user [91]. This comes with the same drawback and benefits of wizards: Broad usability among the populous at the cost of frustration upon repeated usage. Having alternative ways of replicating existing content without having to go through the wizard again is a good way to circumvent this.

6.2 Problems that arise when relying on tools over people in accessibility

The findings from both the interviews with CMS developers and CMS users stated that they were unaware of the functioning of assistive technologies, such as screen readers, and how users that rely on said tools navigate the web with them. None used screen readers to validate their designs and thus only relied on their development tools and automatic evaluators to make sure that their designs were "correct" since they had no way of ascertaining this for themselves in the way a CMS user can for example spot a section of text that is too large to fit the layout, and subsequently fix it.

The examples of incidents that were problematic fell outside of the scope of what automatic validation tools can catch as stated in [28]. The naïve solution and observed behavior is then to run lighthouse or other automatic audit/evaluation tools to validate their designs. This is an example of function creep as described by Koops [94]. Where a tool starts getting used outside of it's intended purpose. Though in a relatively shy way, Lighthouse states in various places in their tool that manual review is required and that the score should be taken with a grain of salt. This is however in stark contrast to the large, high contrast sections that clearly communicate that everything looks good to the tool. It is not hard to see how a user would believe that the tool communicated "all good" after seeing a perfect green 100 as seen in figure 6.9 in their evaluation tool.

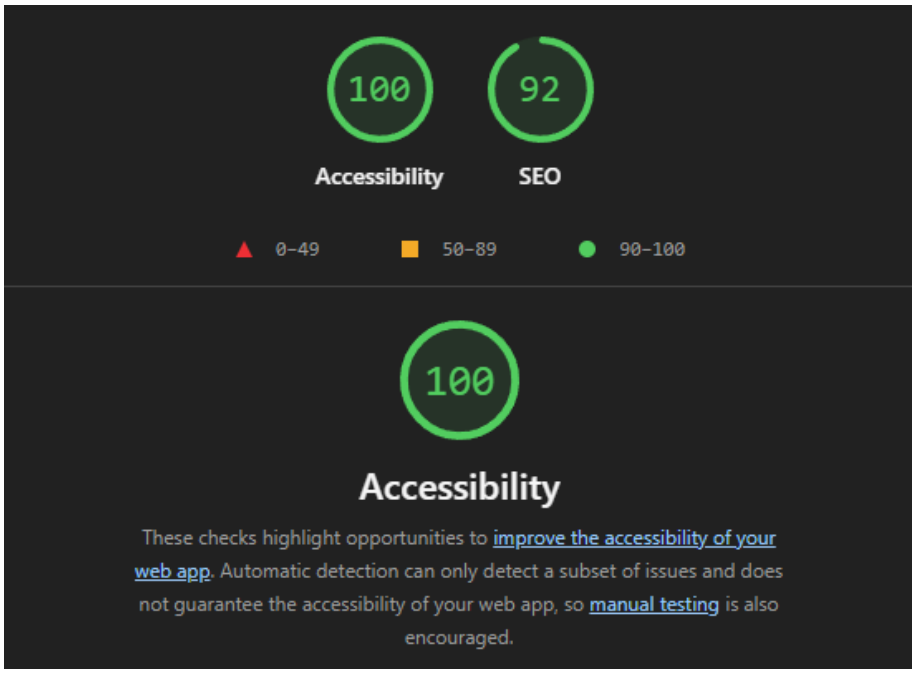


Figure 6.9: A lighthouse evaluation result screen of a page analyzed for Accessibility and SEO criteria.

This marks a clear point at which the efficacy of tools as safeguards ends and the problem of the larger design process begins. At some point in the process, actual users of these assistive technologies are needed to spot these problem interactions that are invisible to both the development tools as well as the automated accessibility checkers [27].

Tools can be designed to educate the user during using but they have a harder time providing user experience for the developer of the content being developed through the lens of a person with accessibility needs[27]. The personas that were developed work to function as potential users but still suffer the same inexperience that inevitably leads to inaccessible designs [95]. As such, they are useful when determining what extra information needs to be conveyed to the user. However, they do help address the problem of inexperience or lack of validation by means of testing with assistive technologies and their users.

This indicates a larger need of a restructuring of the workflow to integrate third parties in the pre or post design evaluations by people with experience and thus not strictly relevant to the needs on the development tools.

7

Discussion

This chapter examines the broader implications of the research findings, contextualizes them within the existing literature, and discusses limitations and opportunities for future work. The discussion reflects on how the insights gained can inform more effective approaches to accessibility implementation in content management systems.

7.1 The Guidelines

The six design guidelines that emerged from this research represent a synthesis of theoretical principles and empirical findings from stakeholder interviews and prototype testing and tinkering. While these guidelines offer promising directions for improving CMS accessibility implementation, their validation and broader applicability require consideration.

The guidelines are in alignment with established design principles from human-computer interaction research. The emphasis on streamlining navigation and reducing cognitive load directly reflects Sweller's Cognitive Load Theory [37], particularly the concept of minimizing extraneous cognitive load to preserve mental resources for essential accessibility decisions [41]. The guideline to "make automated decisions visible" connects directly to Norman's Gulf of Evaluation [57], addressing the problem that accessibility implementation often occurs without meaningful feedback as mentioned in this study.

The prototype testing provided initial validation for several guidelines. The improved accuracy rates observed with Model B's tooltip-based guidance support the theoretical premise that just-in-time learning can improve implementation quality[56]. The high adoption rate of navigation shortcuts (92% by the end of testing) provides empirical support for the "streamline navigation" guideline, suggesting that users readily adopt tools that reduce cognitive overhead.

While the guidelines emerged from the research, they require validation from additional expert perspectives to ensure practical viability. Accessibility experts could evaluate whether the guidelines adequately address the needs of users with disabilities, while CMS developers could assess implementation feasibility across different technical architectures. The prototype testing involved primarily novice users, but real CMS environments include users with diverse experience levels and organizational contexts. The ideal case would be to have a small team apply these guidelines to the

design of a CMS, have CMS users develop web content with it and have accessibility needs users test their creations. The time and coordination this would require is outside of the scope of this study but could be feasable given that being the goal from the start.

Several guidelines present implementation challenges that require consideration. The directive to “provide alternative feedback for accessibility settings” is theoretically sound but technically complex, requiring CMS developers to simulate accessibility impacts without access to assistive technologies. The guideline to use “user-centered language” also might prove hard to implement as it risks oversimplifying complex accessibility requirements. As mentioned in the false positives theory section, there could also be groups to whom it becomes oversimplified while not being simple enough for others.

7.2 Accessibility needs outside WCAG

The interviews with accessibility needs users revealed significant gaps between WCAG 2.1 compliance and actual user experience—a finding that has important implications for CMS design. While the WCAG provides a valuable baseline, several observed accessibility barriers fall outside its explicit criteria or exist in the "gray areas" of interpretation.

The "Willys incident" documented in Section 5.1.4.3 exemplifies this gap. The user tried to get the screen reader to announce the price but ended up confused as it upon repeated clicks kept repeating "forwardslash kg" instead of the price of the cucumber in question. While the fragmentation of price information across multiple `<span>` elements technically did not violate any specific WCAG success criterion, yet it created a significant usability barrier for screen reader users. This supports the criticism raised by Groves [96] and Petri and Federici [97] regarding the limitations of standards-based approaches to accessibility, as discussed in Section 3.1.1. Mainly that the complex problems of accessibility often are hard to capture in standards due to their complex and often novel contexts. It should only be seen as the bare minimum, not the end all-be all for accessibility. This is similar to "following code" or meeting standards in any industry.

Similarly, the observation that neither of the blind users interviewed was aware of skip links, hidden links to page content that are displayed when keyboard-navigating, despite their prominence in accessibility recommendations—raises questions about the gap between technical implementation and practical value. This finding aligns with Giacomo Petri and Christian Federici’s [97] critique that many accessibility solutions are designed from a compliance perspective rather than a user-centered one.

This disconnect between compliance and usability suggests that CMS interfaces should move beyond a purely standards-based approach to incorporate more user-centered design principles. As argued by the "Nothing about us without us" movement discussed in Section 3.1.1, meaningful accessibility requires direct involvement of users with disabilities throughout the design process. The research supports this

position, demonstrating how even technically compliant implementations can fail to address real-world user needs.

The findings also highlight the conflict between SEO optimization and accessibility, particularly in the treatment of alt text. As described in Section 5.1.4.3, the practice of embedding SEO keywords in alt text rather than providing meaningful descriptions creates a significant barrier for screen reader users. This practice, while technically meeting the WCAG requirement for non-text content, fundamentally undermines the purpose of alt text.

These observations suggest that CMS interfaces must go beyond simply providing fields for WCAG-required attributes. Instead, they should guide users toward implementations that serve the spirit of accessibility guidelines rather than merely satisfying technical requirements. This would involve incorporating more explicit instruction about the purpose of accessibility features and providing contextual feedback on the quality of implementation from a user perspective.

7.3 The importance of being able to fail

Errors in automated testing serves a purpose and serve as a crucial last line of defense for CMS users that do not understand the impacts of their choices. Getting feedback from third parties that something is broken might be the only way for some CMS users to notice that a problem exist within their creations. Pairing with the propensity of CMS users not using assistive technologies to verify their designs, this creates a development environment where the CMS users are not able to spot when they are making errors.

However even with this final line of defense, it would only serve to be able to catch the problems around formatting of content, not any complex problems that arise in more complex use cases. The "Willys incident" and "Darkening of background to create a foreground/background" described in Section 5.1.3.4 exemplifies how technically compliant implementations can still create substantially inaccessible user experiences. Subverting the user's expectation of understanding the context by being read incomplete information that did not allow her to understand the context. By having text spread out structurally on different levels in the HTML in a way that is not readable to screen readers yet remain readable on the flat representation on the screen, problems that automated tools would not detect because the individual components meet the requirements of WCAG criteria in a vacuum, but in the aggregate create an inaccessible whole. These false positives [29] as mentioned in the theory chapter only work to obfuscate the true extent of work needed to be done to make the information accessible, and increases the gulf of Evaluation [57] for the CMS users.

The implications of this apply to the entire workflow, where the implementation of actual user testing with people with disabilities are crucial to spot the high level dynamic accessibility issues that go beyond technical specifications for the content.

7.4 Methodology

This section examines the methodological choices made throughout this research and their implications for the findings. The investigation employed a mixed approach combining stakeholder interviews, personal involvement, and prototype development. While this methodology provided valuable insights into accessibility implementation challenges, it also introduced certain limitations that warrant discussion.

7.4.1 Interviews and first person experiences

The interview phase of this research yielded a limited dataset, with only six formal interviews and two observations conducted. This small sample size, while sufficient for generating initial insights and identifying key problem areas, limits the generalizability of findings.

The limited data collection was influenced by several practical constraints, including the specialized nature of the participant groups required (CMS developers, users, and individuals with accessibility needs) and the time consuming nature of conducting contextual interviews. It was particularly hard to access individuals with accessibility needs, and it took more time and effort than anticipated.

This limitation in data collection necessitated a more personal involvement in the research process. Rather than relying solely on participant accounts of CMS usage and accessibility implementation challenges, I engaged directly with the tools and processes under investigation. This methodological shift from purely observational research to participatory engagement became a defining characteristic of the study and provided complementary insights that likely would not have emerged from interviews alone. The empty alt-text leading to hidden images being a good example.

7.4.2 Personal involvement and bias

My direct engagement with the CMS platform and accessibility implementation tools introduced both valuable perspectives and potential biases into the research. As someone without formal web development training, my struggles with the CMS interface provided insights into the novice user experience that complemented the expert perspectives of the interviewed participants. This beginner's perspective proved particularly valuable given that most CMS users interviewed had several years of experience and had developed workarounds for interface limitations.

However, this personal involvement also introduced potential biases that must be acknowledged. My educational background in interaction design and my growing familiarity with accessibility standards throughout the research process may have influenced how I interpreted both the tools and the participant experiences. Additionally, my position as a researcher embedded within the company developing the CMS could have affected how participants responded during interviews and observations.

The benefits of this personal involvement align with arguments made in first-person research methodologies [98]. As Ellis et al. argue, such approaches "acknowledge and

accommodate subjectivity, emotionality, and the researcher's influence on research, rather than hiding from these matters or assuming they don't exist" [98]. My direct experience with screen readers and other assistive technologies, prompted by initial confusion about their operation, provided insights that purely theoretical study could not have yielded.

This personal engagement also informed my decision to examine the limitations of tool centered approaches to accessibility. My own frustrations with automated accessibility checkers and the gap between technical compliance and actual usability led to investigating these themes more deeply through literature review and targeted observations with accessibility users.

7.4.3 Formative research

All research conducted in this study should be characterized as formative rather than summative in nature. This orientation was necessitated by the limited access to participants and the exploratory nature of the research questions. Rather than testing predetermined hypotheses or validating established theories, the research aimed to identify problem areas and generate design insights for future investigation.

The user testing of the prototype interface exemplifies this formative approach. While structured as a comparative evaluation between two interface designs, the testing lacked the methodological rigor required for summative conclusions about interface effectiveness. The testing was conducted with convenience sampling in a public space, used a limited number of test scenarios, and involved participants who largely lacked relevant domain expertise. Despite these limitations, the testing served its intended formative purpose of highlighting potential areas for interface improvement and suggesting directions for future research.

The formative nature of this research requires particular attention to transparency in reporting findings and their limitations. As Howell et. al argue in their trioethnography work, moving away from "success narratives" in design research toward more honest accounts of process and limitations can provide more valuable learning opportunities for the field [99]. This transparency becomes especially important in formative research, where preliminary findings may be misinterpreted as definitive conclusions if not properly contextualized.

7.4.4 Personas

The personas developed during this research represent one of the weaker methodological elements of the study, yet they are included here for transparency and methodological honesty. While derived from interview data with real CMS users, the personas suffered from insufficient validation and limited application throughout the design process.

As Cooper et al. emphasize, effective personas require extensive user research and validation to avoid becoming stereotypical representations rather than research-grounded design tools [60]. Me being alone doing this work further problematizes this.

However, the three personas created for this study—Sofia the Marketing-Focused Content Creator, Lars the Experienced Web Manager, and Erik the Technical Developer were based on only a handful of interviews and were not validated through additional research or feedback from representatives of each user type.

Furthermore, the personas played a minimal role in actual design decisions during prototype development. Rather than serving as consistent reference points for design choices, they were largely developed to organize findings from the interview phase.

Despite these limitations, the personas are presented in the appendix as artifacts of the research process. They serve as one attempt to synthesize the user research findings and may provide value for future researchers working in similar contexts, particularly when developed more rigorously through additional user research.

7.4.5 Prototyping

The development of the prototype interface for alt-text implementation served dual purposes: testing potential solutions to identified problems and clarifying the design principles that emerged from the research. However, it is important to acknowledge that the guidelines presented in the results chapter were largely derived post-hoc from the prototype development process rather than driving the initial design decisions.

During prototype construction, design choices were made primarily in response to specific issues identified during the formative research phase—such as the invisibility of accessibility implementation states and the difficulty of categorizing images correctly. The theoretical frameworks that later informed the guidelines (cognitive load theory, just-in-time learning, and recognition over recall) were identified retrospectively as useful lenses for understanding why certain design decisions appeared effective.

This post-hoc derivation of guidelines presents both strengths and limitations. On one hand, it ensures that the guidelines are grounded in practical design challenges rather than theoretical abstractions. The guidelines emerged from actual attempts to solve real problems encountered by CMS users. On the other hand, this approach risks retrofitting theoretical justifications to design decisions that may have been influenced by other factors or researcher intuitions.

This methodological approach aligns with what Schön describes as "reflective practice" in design, where understanding emerges through cycles of action and reflection rather than linear application of predetermined knowledge [100]. The iterative nature of prototype development, informed by ongoing literature review and reflection on design decisions, represents a form of research through design that generates knowledge through making rather than through traditional hypothesis testing.

7.5 Research scope and limitations

This study focused specifically on the content management system user experience rather than the broader ecosystem of web accessibility implementation. Several

important scope considerations shaped both the methodology and the generalizability of findings.

Platform specificity: The research was conducted with a single CMS platform and its associated user base. While this provided deep insights into specific implementation challenges, it limits the generalizability of interface design recommendations across different CMS architectures and user communities.

User population constraints: Access to individuals with accessibility needs proved significantly more challenging than anticipated, resulting in fewer direct user perspectives than originally planned from CMS developers and users. This limitation was partially addressed through extensive literature review and validation of findings against existing research, but direct user input remains an area for future investigation

Temporal constraints: The prototype testing was conducted in controlled, short-duration sessions rather than longitudinal observation of real-world implementation patterns. This approach captured immediate usability responses but may not reflect how interface design impacts long-term adoption and implementation quality.

Despite these limitations, the research provides valuable insights into the gap between accessibility standards and implementation practice, offering a foundation for future work that could address these constraints through expanded scope and longer-term observation. These additions maintain the analytical depth of your other discussion sections while addressing the specific themes you've developed throughout your thesis. The "importance of failing" section connects to your findings about false positives in automated testing and the invisibility of accessibility impacts, while the scope section acknowledges the constraints while defending the value of your focused approach.

7.6 Future work

The findings of this research point to several promising directions for future work in this area.

7.6.1 Longitudinal studies of accessibility implementation

This research provided valuable insights into how users interact with accessibility features in controlled testing environments. However, a longitudinal study examining how these patterns evolve over time in real-world implementation contexts would provide deeper understanding of sustainable adoption patterns. Such research could track how mental models develop with experience and how implementation quality changes across multiple projects.

7.6.2 Integration of assistive technology feedback

The observation that none of the interviewed CMS users regularly tested their content with assistive technologies suggests an opportunity to integrate direct feedback from these tools into the CMS interface. Future research could explore how screen reader

output or automated accessibility testing results could be incorporated into the content creation workflow, providing immediate feedback on implementation quality.

7.6.3 Cross-platform comparison studies

This research focused on a single CMS platform. Comparative studies across multiple CMS environments could identify which accessibility interface patterns are platform-specific and which represent more universal user needs. Such research could lead to the development of both more specific and more widely applicable guidelines.

7.6.4 SEO and accessibility alignment strategies

The observed tension between SEO optimization and accessibility implementation, particularly in alt text, suggests a need for research into strategies that can align these sometimes competing objectives. Future work could explore interface designs and educational approaches that help users achieve both SEO and accessibility goals simultaneously.

7.6.5 Impact of AI on accessibility implementation

The observation that one CMS user had developed a GPT prompt specifically for generating alt text suggests an emerging trend toward AI-assisted accessibility implementation. Future research could explore both the opportunities and risks of this approach, examining how AI tools might be integrated into CMS interfaces while still maintaining implementation quality.

7.6.6 Limitations and Future Validation Needs

The current validation of the guidelines faces several limitations. The prototype testing occurred in an artificial environment with predetermined tasks and with predominantly non-web-developers, which may not reflect the complexity of real content creation workflows. Most significantly, the guidelines were developed primarily from CMS developers and users, with limited direct input from users with accessibility needs. This means the guidelines may not fully address the gap between technical compliance and meaningful accessibility that the research identified as problematic, furthering the divide.

These guidelines should be viewed as components of broader accessibility practices rather than comprehensive solutions. The research findings consistently pointed to the limitations of tool based approaches, suggesting that guidelines for CMS design must be coupled with organizational commitment to user testing and expert consultation.

8

Conclusion

This research began with the question: **How can the design of Content Management Systems aid their users in complying with the Web Content Accessibility Guidelines?** The practical answer to which is answered through the six guidelines: streamlining navigation, designing for sporadically disrupted long-term use, making automated decisions visible, providing alternative feedback for accessibility settings, supporting just-in-time learning, and using user-centered language. User testing demonstrated improved accuracy in categorizing images through contextual guidance and clear state indicators.

However, as the investigation progressed through stakeholder interviews and real-world observations, it became clear that a second, equally important question demanded attention: **What are the limitations of this tool-centered approach to achieving web accessibility?** This evolution in research focus reflects a fundamental insight that while better tools are necessary for accessibility implementation, they are not sufficient.

The study revealed concerning patterns where accessibility features were co-opted for SEO optimization, with alt text filled with keywords rather than meaningful descriptions. This demonstrates how tool-centered approaches, without proper understanding of accessibility's human purpose, can actually perpetuate exclusion while appearing to address it.

The study also uncovered fundamental limitations that tools alone cannot address. Real-world examples from blind users demonstrated how technically compliant implementations can still create substantial usability barriers. WCAG compliance, while necessary, represents only a baseline rather than true accessibility. The gap between meeting technical criteria and creating genuinely accessible experiences cannot be bridged through better CMS interfaces alone. It requires direct involvement of users with disabilities in the design and validation process.

The path forward requires both better tools and better processes. CMS interfaces that make accessibility implementation clearer and more immediate, combined with development practices that include users with disabilities as essential collaborators rather than distant beneficiaries. Only through this dual approach can we bridge the persistent gap between accessibility guidelines and accessible user experiences.

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A

Appendix: User testing diagrams

This contains the results of the tests done:

1. Model A decorative image 1
2. Model A decorative image 2
3. Model A meaningful image 1
4. Model A meaningful image 2
5. Model B decorative image 3
6. Model B decorative image 4
7. Model B meaningful image 3
8. Model B meaningful image 4

The bar diagrams are color coded, green denotes the correct answer for that image. The model A and model B testings are presented anachronistically next to each other to make them easier to compare.

Figure A.1: Decorative image 1

Figure A.2: Decorative image 3

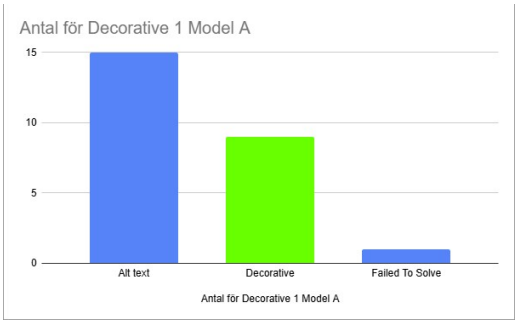

Figure A.3: Results Model A decorative image 1

Figure A.4: Results Model B decorative image 3

Figure A.5: Decorative image 2

Figure A.6: Decorative image 4

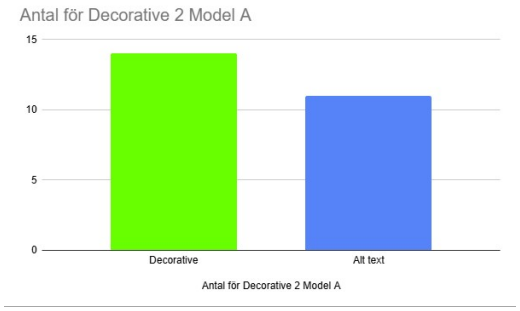

Figure A.7: Results Model A decorative image 2

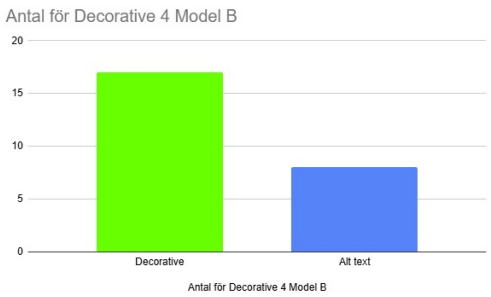

Figure A.8: Results Model B decorative image 4

Figure A.9: Meaningful image 1

Figure A.10: Meaningful image 3

Figure A.11: Results Model A meaningful image 1

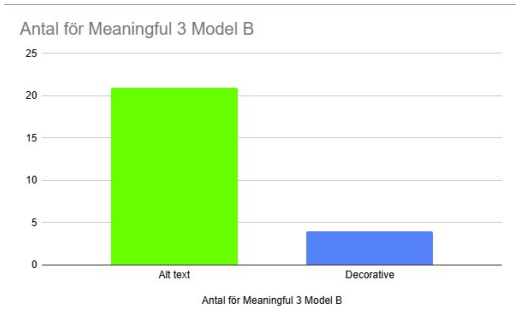

Figure A.12: Results Model B meaningful image 3

Figure A.13: Meaningful image 2

Figure A.14: Meaningful image 4

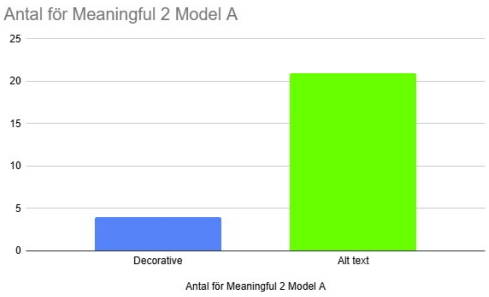

Figure A.15: Results Model A meaningful image 2

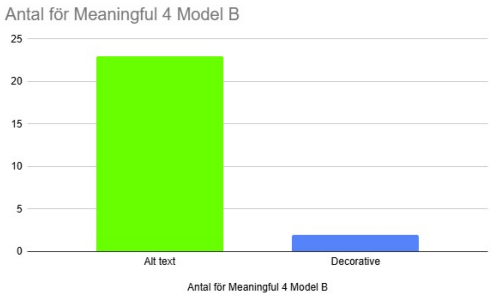

Figure A.16: Results Model B meaningful image 4

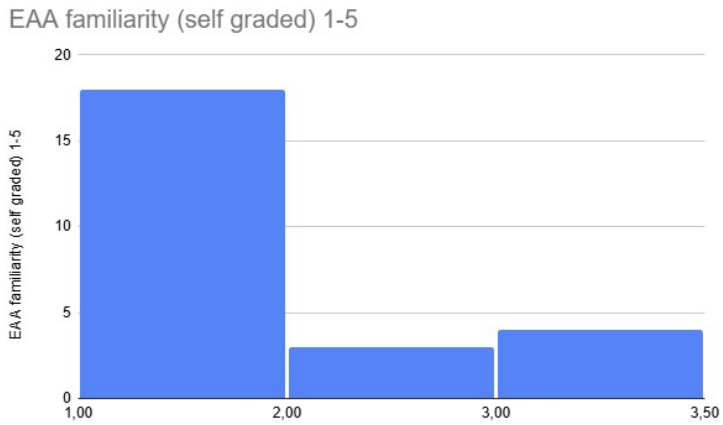

Figure A.17: European Accessibility act familiarity among user testers

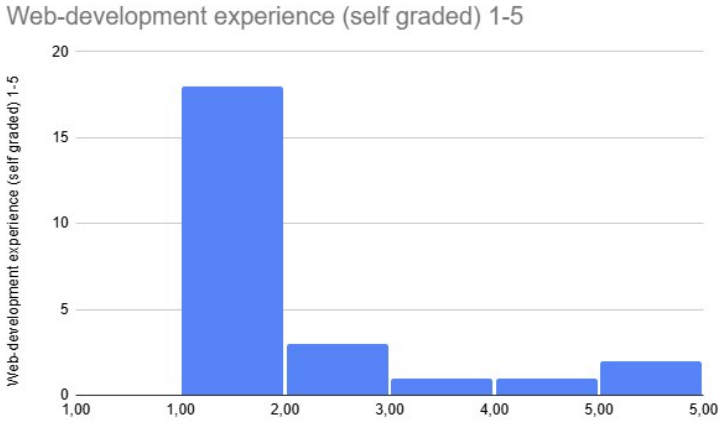

Figure A.18: web development experience among user testers

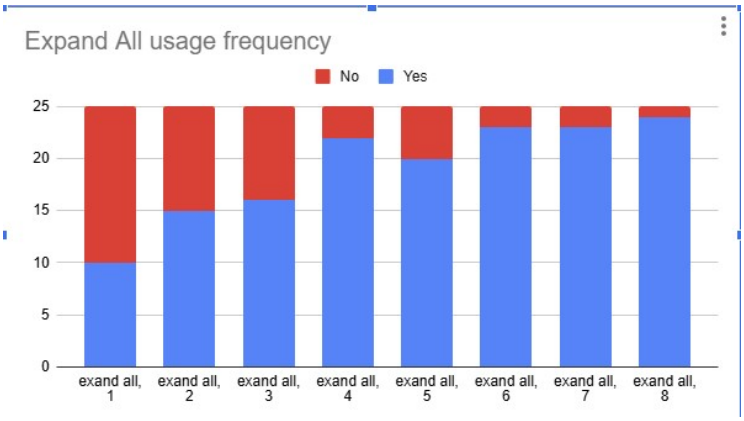

Figure A.19: Expand all button usage over test index

B

Personas

B.1 Persona 1: Sofia – The Marketing-Focused Content Creator

Sofia represents users whose primary focus is creating marketing content within a CMS with limited technical knowledge or formal training in web development.

Background & Context

Sofia is 28 years old with a Bachelor's degree in Marketing and 3 years of experience in web content creation. She works at a medium-sized e-commerce company and focuses primarily on creating product listings and promotional content. She has no formal training in web development or accessibility principles.

Technical Skill Profile

- Proficient with visual CMS interfaces
- Limited understanding of HTML/CSS (basic modifications only)
- Comfortable with digital marketing tools and analytics
- No knowledge of accessibility standards or requirements

Workflow Characteristics

Sofia typically works with a three-monitor setup, using one for the CMS interface, one for content preview, and one for reference materials. She relies heavily on external tools like ChatGPT for content generation, Figma for visual references, and post-it notes to remember technical details like color codes and CSS values.

Mental Model of Accessibility

Sofia conceptualizes accessibility primarily through an SEO lens. When she encounters accessibility features like alt-text fields, she typically sees them as opportunities for keyword placement rather than as aids for users with disabilities. Her limited understanding of how assistive technologies function makes it difficult for her to connect CMS inputs to user experiences.

Key Challenges

- Lacks understanding of how accessibility settings are perceived by end users

- Faces time pressure that prioritizes content production over thoroughness
- Frequently forgets to update all the info when duplicating pages

Key Quote

"I wish there was a way to see which fields I haven't completed yet. I often duplicate content for mobile versions and forget to update all the details."

B.2 Persona 2: Lars – The Experienced Web Manager

Lars represents users who have developed practical web knowledge through years of experience despite lacking formal technical education.

Background & Context

Lars is 42 years old with 15 years in the marketing industry and 3 years in his current position. He has a background in traditional marketing with a self-taught transition to digital. He works for a retail chain managing their online presence with a focus on driving sales.

Technical Skill Profile

- Expert CMS user who "stretches" system capabilities
- Moderate HTML/CSS knowledge gained through experience
- Limited JavaScript understanding
- Basic awareness of accessibility guidelines but prioritizes SEO

Workflow Characteristics

Lars uses a single monitor setup with multiple browser tabs and applications open simultaneously. He frequently copies existing pages as templates and focuses heavily on SEO optimization. He relies on analytics to guide content decisions and uses direct preview feedback to catch errors early.

Mental Model of Accessibility

Lars understands accessibility as a set of technical requirements to be met rather than as a user experience consideration. He recognizes the importance of compliance but tends to implement features mechanically without deeper consideration of their purpose or impact.

Key Challenges

- Feeling hindered by the CMS's constrained interface
- Does not understand the impact of accessibility settings
- Getting distracted by people in his environment

Key Quote

"Mobile is where we see 80% of our traffic, so that's where I focus my testing time. Desktop is really just about making sure transactions complete successfully."

B.3 Persona 3: Erik – The Technical Developer

Erik represents users with formal technical education who work primarily with code rather than visual interfaces.

Background & Context

Erik is 34 years old with a Bachelor's degree in Computer Science and 7 years of experience in web development. He specializes in CMS implementation and customization and works for a digital agency serving multiple clients with diverse needs.

Technical Skill Profile

- Advanced HTML/CSS skills
- Strong JavaScript knowledge
- Familiar with multiple CMS platforms
- Basic understanding of accessibility requirements

Workflow Characteristics

Erik works primarily from home on a Linux system with a laptop and external monitor setup. He prefers HTML view over visual representation during development and uses split-screen coding approaches. He prefers to exclusively use the keyboard to do his work unless forced to use a mouse, allowing him to sit reclined in his sofa while working.

Mental Model of Accessibility

Erik views accessibility through a compliance-focused lens, meeting a problem specification is enough in his mind. He understands the technical requirements but approaches them as checkboxes to satisfy client requirements rather than as essential user experience considerations.

Key Challenges

- Operating System hinders the use of screen readers for validation
- Client priorities often favor SEO over accessibility
- Limited budget for proper implementation of accessibility features

Key Quote

"When SEO and accessibility conflict, SEO always wins because that's what the client is measuring. That is what keeps them coming back to us."