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Web accessibility audit: a case study

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Abstract

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The following work focuses on concept of accessibility and its practical implementation online.

Web accessibility concerns designing online services in a way that allows them to be used by people of different abilities who make up to 20% of the world population. Enabling them to use online services has moral, business and legal incentives. There are existing guidelines for implementing accessible web services although they are not without their issues.

This work shows how accessibility can be applied practically by conducting a case study on the example of Haaga-Helia's main website. The work evaluates existing accessibility practices and analyses the data produced by SiteImprove, the automated accessibility tool, by cross-comparing its results with other tools. SiteImprove proved to perform on par with other tools.

In addition, selected pages of the website are tested manually. Manual testing uncovered several significant issues that severely affect user experience and are not detectable by automatic means.

Results collected through automated and manual testing are discussed and analyzed. They show that automated testing works well as a first line of defence and allows to quickly detect and fix some errors but is not enough to create a good user experience by itself. To ensure that the users can achieve their goals, manual testing is the essential part of the process.

At the request from Haaga-Helia, recommendations on vendor selection for website renovation are provided with the focus on accessibility. It is recommended that the selected vendor proves to be able to utilize automated tools as part of implementation and maintenance to catch easily detectable errors quickly. To add to that, the preferred vendor should also include manual and possible user testing for key user stories as part of their process. Most importantly, the vendor should be able to prove that proposed accessibility solutions will help the users reach their goals.

Keywords
Accessibility, disability, web development, case study

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1 Introduction

The following work focuses on the concept of accessibility and its implementation online. First, it provides the overview of what accessibility means for web users and its importance from business, legal and ethical viewpoints, and information on main resources and guidelines on accessibility. The thesis also reflects on existing guidelines and the issue of evaluating web accessibility for particular service, and attempts to formulate a clear and concise framework for web accessibility evaluation.

The framework is then tested in a case study. A Finnish higher learning institution, Haaga-Helia University of Applied Sciences, has allowed the use of their main website as the case study subject.

1.1.1 Thesis goals and objectives

This work will attempt to help its readers understand the concept of accessibility and the current issues around it. We will also evaluate Haaga-Helia's accessibility practices as they are. In that, we will assume the position of a web developer with some knowledge of accessibility, who is, although, not a full-time accessibility expert – a very common point of view in today's tech industry. The main objective will be to give stakeholders a data-backed opinion on what works well in their current accessibility processes and what room there is for improvement.

The main expected outcome is audit data for Haaga-Helia's existing website, analyzed and summarized for web department's future use. At the request of Haaga-Helia's web department, we will also list recommendations for choosing web services vendors in the future.

1.1.2 Scope of the thesis

Since there are some solutions for accessibility already in place and the website is scheduled for renovation, recommendations on implementing accessibility or improving the existing website fall out of scope of this work. This work is also not intended to serve as a replacement of existing accessibility guidelines such as WCAG.

The scope of this work will be limited to giving critical feedback on existing accessibility processes and procedures, formulating and assessing the accessibility evaluation framework and overall usefulness and actionability of WCAG criteria.

1.1.3 Relevance of the results

Results derived from the research will be relevant to the commissioning party in improving their own processes and their choice for future vendors of web services. The example of the accessibility audit itself will also be relevant to the wider audience of developers and stakeholders as a blueprint to adjust to own needs and evaluate their own processes.

2 Theoretical framework

In this section, we will discuss the theoretical background behind the concept of accessibility. We will explore what it is and how it applies to the Internet use, provide data on how many users are affected by related issues and in what ways, and what existing guidelines there already are, as well as explore their advantages and shortcomings.

2.1 The concept of web accessibility

According to the World Wide Web Consortium (W3C 2005b), web accessibility means that websites, tools, and technologies are designed and developed in a way that allows people with disabilities to use them, meaning they can perceive, understand, interact with and contribute to them. The vision of accessible Internet is the one where all users have equal access to information and functionality.

While the main and most discussed purpose of accessibility is to avoid excluding people with disabilities or limitations from using online resources, designers and developers generally provide better user experience for everyone when they follow accessibility principles and guidelines. For example, when a web site is built using semantically correct native HTML elements, not only it becomes easier to access for people using text-to-speech software, but it also renders correctly on wider range of devices – different browsers, mobile devices and smartwatches, even for search engine crawlers, providing better SEO without any additional results; or, when links and buttons have a larger clickable area, it benefits not only motor-impaired users but also someone browsing on their mobile device on a shaky train.

For a practical example, consider the illustration below: here, the same phrase is written using different color contrast: the top line contrast ratio is approximately 5.1:1 and the bottom line contrast ratio is about 2.3:1. The top line can be read rather easily; the bottom line, on the other hand, may cause some eyestrain even for people with healthy vision and will be hardly discernible, if at all, for visually impaired people. A proper color contrast is a very common accessibility requirement, and so, addressing accessibility in the design and implementation of a web service makes it work for more people in more situations.

Figure 1. Illustration of color contrast.

Unfortunately, so far, the tech community has been less than welcoming to people with disabilities. Vint Cerf, one of the computer scientists behind such important inventions as email and Internet, who himself has a hearing disability, has said in an interview "It's a crime that the most versatile device on the planet, the computer, has not adapted well to people who need help, who need assistive technology" (Cnet 2017). For example, Pew Research survey (2016) found that only 39% of disabled Americans feel comfortable using the internet compared to 65% of users without disability.

This issue is a complicated and complex one. All parties involved are still largely unaware of disabled people's needs, many of who are not aware themselves how technology and assistive tools can help them benefit from the same services as able-bodies users. Designers and developers, in their turn, are not taught the importance and practicalities of accessibility, creating services that are not usable or difficult to navigate. In design and development practices, accessibility is often treated like a side-track, a small something to add to the page once the main product is finished; and so, the only people with enough knowledge of accessibility are those who are forced to work on it or have a personal interest. These issues create a self-perpetuating circle, and as a result, an astonishing number of web services is unusable for people with disabilities.

Of course, the world is moving forward, and large tech companies add accessibility features to their products, but the wider community is still not up to speed. The field of accessibility has a lot of room for growth and discussion,

2.2 Understanding diversity of users

It is surely impossible to discuss accessibility and its implications for designers and developers without understanding who the target is and how it affects people practically.

Of course, each individual is unique and has their own abilities and preferences that may impact how they use the Web. Nevertheless, we can roughly attempt to sum up existing resources and definition to gain a perception of broad audience that may be affected by design. The following table follows the conceptual framework offered by Google in their

Web Accessibility learning program (Udacity 2019), where the range of abilities can be defined by category and temporality, and provides some examples:

Table 1. Diversity of users

Abilities and barriers	**Permanent**	**Temporary**	**Situational**
Auditory	Deafness	Ear infection	Can't listen to audio in open floor office
Visual	Blindness	Tunnel vision	Using a protective mask
Motor	Muscular dystrophy	Broken hand	Holding a baby in one arm
Cognitive	Dyslexia	Concussion	Working in a distracting environment

These examples highlight again how broad the concept of accessibility is and how diverse the usership is. Yet, there are even more other issues that don't quite fit into the framework above but should still be considered when discussing accessibility; W3C (2005a) names a few related points, for example:

- Age-related barriers: not only many users develop disabilities with age, there may be significant differences in their ability to use assistive tools and generally their ability to use computers and the Web;
- Combinations of disabilities: some users might have limitations that render some assistive technologies useless for them unless implemented in a certain way. For example, an individual with a combination of hearing loss and low vision (common in people with e.g. cerebral palsy or Down syndrome) will not be able to read audio subtitles unless they have proper color contrast and are size-adjustable;
- Changing or temporary barriers: people who are managing progressing or temporary limitations may not know how to use assistive technology solutions or might not even be aware of them. Someone wearing glasses might not consider themselves disabled, but if their vision was to worsen by a few degrees, they would suddenly find themselves needing further assistance.

These notions also show that a significant amount of time, knowledge and effort is required to create online content that is accessible to everyone. With that in mind, it might be tempting for developers and designers to forgo these aspects, especially under (false) assumption that users with disability represent only a minor part of their user base. In reality, the existing data on disability goes to show that the need for accessible Web is real and tangible.

2.2.1 The need for accessibility: global statistics

Since disability is an umbrella term that may cover a very wide range of barriers and limitations, gathering an exact statistic can be a tough task. For reasons stated above concerning the temporal and varying nature of disability, statistical data by itself can never show the whole picture. Nevertheless, it is an important and tangible piece of data that can be a tipping point for decisions made about accessibility, and a range of data collected from various sources can give a believable estimate of how many people are affected by these issues.

In USA, the related data belongs to the responsibility of United States Census Bureau. According to the latest report available (US Census Bureau 2018), about 27,2% of the US population (roughly 85 million people) are living with a disability. The Americans with Disabilities Act (1990) prohibits discrimination in access to government entities and places of public accommodations, and although it does not specifically mention websites, the influx of successful accessibility-related lawsuits reveals that web accessibility is a very relevant issue.

Around 80 million people (roughly 15% of the population) in the European Union have a disability (European Parliament 2018), driving the European Parliament to approve the web accessibility directive obliging websites and apps of public administrations, hospitals, courts and other public sector bodies to be made accessible to everyone. In November 2018, the European Parliament and the Council came to a provisional agreement on the Commission's proposal for a European Accessibility Act, with final adoption expected in April 2019.

In addition to these numbers, it is important to remember the issue of global population aging. With many disabilities showing themselves later in life, the number of users with visual, hearing and/or motor barriers will only grow in the future; these people will have to adapt to the new, technology-driven society where knowing how to use a digital device will be more and more important.

Still, even today, with the approximately 15-20% users with disabilities consistently found across the world, the number of people affected by accessibility-related issues is already significant enough to become a legal issue and significant enough for stakeholders to take actions in their web services.

2.2.2 Accessibility in Finland

Unfortunately, there is no reliable and conclusive statistical data on people with disabilities in Finland (Vammaisfoorumi 2014, 3). Part of the reason for that is the fact that statistics on certain disability is usually gathered by interested parties, responsible groups and associations rather than in a centralised way; e.g. the number of people with disorders of autistic spectrum is estimated at 55000 (Liikenne- ja viestintäministeriö 2017, 14), but this number comes from Autismi- ja Aspergerliitto ry and not from a centralized source like a governmental body, complicating the disaggregation of data by age group, socioeconomic situation or other disabilities and its systemic analysis. Some statistical data can also be found from KELA, the social security institution of Finland, but since it is collected through the prism of granting people social benefits due to a disability it does not include everyone. By rough estimation, about 19,5% of Finnish population have some sort of disability (Liikenne- ja viestintäministeriö 2017, 13).

WHO and the bodies overseeing the UN's international human rights conventions have repeatedly stated the need for more comprehensive data from Finland (Tilastokeskus 2013) but still provides a generalized global estimate of 15-20% (Worldbank 2018) of the population, which would amount to about 1 million people in Finland. Finland ratified the Convention on the Rights of Persons with Disabilities (CRPD) in 2016, where Article 31 complies the country to “collect appropriate information, including statistical and research data, to enable them to formulate and implement policies to give effect to the present Convention” (UN 2019).

The question of aging population is also very relevant for Finland, where the proportion of people over 65 years of age was about 12% 30 years ago and over 20% today; according to the forecast from Tilastokeskus, the statistical bureau of Finland, by 2030 that number will grow over 25% (Liikenne- ja viestintäministeriö 2017, 38). From the same source, we know that people in that age group are also becoming more active users of new technologies: 38% of them use the Internet several times per day and have a smartphone in their personal use.

The issue of lacking and spread out data is also true for Finnish legislation on disability: in general, the legislation concerning equality is spread over a number of different documents (Vammaisfoorumi 2014). Luckily, the Finnish government is attempting to implement some legislation concerning specifically digital accessibility at the time of this writing. On 12 February 2019, the parliament approved the draft national law on the provision of

digital services, which will likely come in full force in the spring of 2019 (AVI 2019). Aluehallintovirasto will act as the responsible governmental organ for advising, monitoring and controlling accessibility requirements for online services.

2.3 Accessibility guidelines and best practices

Accessibility, being a wide and all-encompassing topic, might appear intimidating and hard to comprehend. Therefore, people and organizations attempt to provide basic guidelines for accepting accessibility as part of the design.

As of today, the most widely accepted and well-known document on accessibility is Web Content Accessibility Guidelines (WCAG). Created and maintained by W3C, it aims to provide recommendations for various aspects of creating an accessible web service. The first version of WCAG was released in 1999, and WCAG 2.0 was published at the end of 2008, with minor version 2.1 published in the end of 2018 which provides updated guidelines for some issues that arise for mobile users. WCAG guidelines are divided into three conformance levels (A-AA-AAA) where the higher levels are more restraining for web page design but at the same time will help the most variety of people. It is worth noticing that strict AAA-level compliance is discouraged by the W3C themselves, since not all content can satisfy these requirements (W3C 2018b).

At the time of this writing, WCAG guidelines are used as a basis for local accessibility legislation in 25 countries, directly or as a derivative (W3C 2018c); for example, the European Parliament requires web services of public sector bodies to conform with WCAG level AA.

WCAG guidelines are not technology-specific since their audience varies wildly. Instead, they focus on providing principles and guidelines to work towards and establishing success criteria to be used when necessary.

Regarding web development, many of WCAG's recommendations constitute common sense and well-known good design practices, such as readable font sizes, alternative CAPTCHA for different perception disabilities or sufficient contrast. Other are less obvious; for example, WCAG discourages the use of flashing elements on web pages that can trigger photosensitive epileptic seizures.

There has been come criticism of WCAG's content and accomplishments. For example, in June 2006, a formal objection has been signed by about 40 people claiming that WCAG 2.0 does not sufficiently address the needs of users with learning disabilities despite its

claims, with the intent to encourage W3C to continue work in this area (Seeman 2006). Other aspects of WCAG fallen under critique include wordiness and unclear definitions, poor guidelines for multimedia, and general inaptitude to the real-world use of the Web. The A-AA-AAA grading system has also been criticized due to the fact that AAA compliance level is hard to claim due to ambiguous definitions, although it does little to eliminate any additional barriers and, by W3C's own admittance, is not recommended to be required (W3C 2018b). Nevertheless, so far WCAG seem the most adequate and useful guidelines as of today, and no viable alternatives of the same level are found.

Since WCAG's recommendations seem to be unclear for many people involved in the accessibility design process, many attempts to summarize and transform them into actionable items have been made; at the time of this writing, a Google search for "accessibility checklist" returns 168 000 000 results. While still better than ignoring accessibility completely, this forms what we will call a "checklist attitude" which presents a problem in itself: it is absolutely possible to make a website that will formally conform to WCAG's guidelines and its users will still fail to complete the task at hand. Vasilis van Gemert (2019) offers an example: Guideline 1.2 of WCAG 2.0 requires to provide text transcripts for audio clips, which is a rather common sense requirement; still, it does not take into account the fact that sign languages have a different grammatical and structural logic, so, although it might make the site more accessible for some users, the transcript would on the other hand be very complicated to understand for Deaf people. This example is brought up here not to blame the designers who cannot be expected to foresee all possible usage scenarios but rather to highlight the fact that a lot of guidelines on accessibility are centered around assumptions which often turn out to be not so good by themselves.

The issues existing around WCAG can be discussed more in depth but that falls out of scope of this work; the main point here is to illustrate that even though discussions on online accessibility have been around almost as long as the Web itself, the one and only solution for all accessibility problems is still yet to be found. However widely accepted these accessibility guidelines might be, poor guidelines will always yield poor results, so it is always useful to approach them critically and put users and not guidelines in the center of the process.

2.4 Conclusion

Looking at the arguments above, it is clear that even though people with disabilities are often perceived to be a fractional minority of online users, excluding them by means of poor design affects a significant lot of people.

From business point of view, ignoring people with disabilities would mean losing potential customers. By estimate, online businesses in the UK have lost £11.75 billion in 2016 because their disabled potential customers preferred to move on from a website that was too difficult for them to use (Click-Away Pound 2016). Vice versa, one could easily expect better retention of customers with disability who could be expected to stick with a service that works well for them. For example, a wildly popular radio show This American Life boosted their inbound traffic by almost 5% simply by providing transcripts of their shows (3Play Media 2014).

Since accessibility is becoming a legal requirement, it is also important to remember that non-compliance with accessibility standards might be very costly; for example, American retailer Target had to pay $6 million settlement in a class action lawsuit after their site was found unusable for vision-impaired customers (Cnet 2008). This is a trend on the rise, and one to be aware of for all stakeholders. In the light of this, a good recommendation is for accessibility to be owned by product managers who can assess the related business benefits, how it affects the organization, and understands its legal responsibilities (Kalbag 2017, 40).

Even forgoing the business and legal incentive, accessible online services are a social responsibility in the same key as using sustainable practices in manufacturing physical goods, and current legal practices are trending towards regarding accessibility as a right and not as an option. Also, by bringing people with disabilities into the process, companies have a chance to stumble onto an innovation like it happened to many inventions we use in our daily lives such as subtitles, audiobooks or voice assistants.

Moreover, one could argue that for those involved in creation of digital services, accessibility is the part of the job – not only because it is a legal or business requirement, but because the essence of design and development is caring about the users, and if anything prevents them from using the service, that constitutes a failure of design and execution.

Among designers and developers, attempts at making websites more accessible are being made but still leave a lot to be desired. Even though an individual who has found themselves in a team that doesn't value accessibility can make a difference in their own line of work, success can only be guaranteed within a systemic approach. To back it up, more comprehensible guidelines and better processes are necessary, and this is a tangible need in the community. In today's world, the core issue is to raise awareness of the importance of accessibility and the benefits that it brings, making it a goal rather than an afterthought.

3 Case study: website audit

In this section we will describe the offered accessibility testing framework and the background for the case study, perform an accessibility audit for a learning institution's website and discuss its results.

3.1 Case study background

In this study, the main website of Haaga-Helia University of Applied Sciences will be used as a target of the accessibility audit. Currently, the accessibility-related issues in Haaga-Helia's web services are the sole responsibility of one person, Haaga-Helia's Web Manager.

The website itself is built by external consultants and is based on Drupal 7.68. Drupal claims to strive for accessibility for visitors and developers (2019), citing such out-of-box features as encouraging semantic markup, form labelling and many others. Drupal also offers quite a few accessibility modules for developers to use and encourages development of accessible modules, but none of additional accessibility-related modules are currently in use. In addition, Haaga-Helia's website uses SiteImprove, a cloud-based SaaS solution which promises to locate and fix detectable accessibility errors.

Overall, Haaga-Helia's approach to accessibility shows awareness of the issues around it, so the main objective of this audit is to test how the current approach stacks against the real-world requirements – a situation in which many online services will soon find themselves in the light of new legal changes.

In addition, the site is scheduled for a renovation, so this provides a good opportunity to look back on current practices and evaluate which are working well and which do not. One of the criteria for choosing the subcontractors for the new website will be how well they can implement accessibility for the new website, so another important point of the audit would be to give important points to pay attention to when choosing a new web services provider.

3.2 Audit plan and methodology

For this audit, the main working method will be a hands-on case study which will include a critical analysis of quantitative data available from automated accessibility checkers, as well as qualitative data acquired practically through manual checks and observational analysis. The combination of these methods is chosen in order to both collect data that is

objective and easy to act upon and see the service from a subjective point of a potential user, thus combining conformance to industry standards and empathetical approach to individuals.

The following sources and tools will be used in the audit:

- Collected data and tooling from SiteImprove
- Axe Accessibility, an open source tool by Deque Systems that detects accessibility issues
- Accessibility Insights (https://accessibilityinsights.io/), a recently open sourced tool from Microsoft that measures compliance to WCAG AA-level criteria.

The following steps are planned for the audit and were approved by the project's steering group of Haaga-Helia staff:

1. Quantitative data collection:
    a. Analyzing data provided by SiteImprove. In this stage we will see what range of problems this service can detect; how well can it perform; and whether it enables its users to easily fix them.
    b. Running automated checks with other automated tools. Axe Accessibility and Accessibility Insights are chosen for that purpose.
2. Qualitative data collection:
    a. Performing assisted and manual checks. Accessibility Insights will be partly used for that step.
3. Data analysis:
    a. Analyzing the collected data against and outside of WCAG criteria. The main goal of this step is to see how well the automated tools can detect issues and reflect on the overall usefulness of WCAG criteria and what room there is for improvement.
    b. Cost-time-benefit analysis. In this part, we will attempt to estimate the time and costs of assessing accessibility versus the potential benefits for the site's visitors.
    c. Summarizing and providing feedback. The goal of this step will be to evaluate Haaga-Helia's current practices as a whole, give feedback on possible improvement and providing recommendations for web services vendor selection accessibility-wise.

3.3 Audit results

3.3.1 SiteImprove accessibility tools

We will start the audit by exploring the current situation and looking at currently used tools and services, i.e. SiteImprove. As already mentioned above, SiteImprove is a SaaS solution aimed at website owners, administrators and editors who can delegate routine and automatable tasks to the service. SiteImprove delivers the benefits by using several types of website crawlers that can detect presence of absence of certain conditions in webpage code that are related to accessibility, SEO and overall user experience (classified as Quality Assurance). It also allows to introduce custom website policies, e.g. specific data formats or opening external links in a new tab. In this analysis, we will focus on what SiteImprove's accessibility tools offer and what insights they can give.

The main accessibility dashboard shows a visual representation of SiteImprove's own accessibility score which measures how well a site meets the standards set out in WCAG 2.0 based on automatically detected issues. It also offers its dynamics over time and details of the score. One good thing about this choice for data visualization is that it encourages the users to take action on the found issues playing on human psychology of completionism and perfectionism. In this aspect it can almost be called a gamified experience. The downside to this approach is what we have already defined as the checklist attitude - the implication that accessibility is can be achieved by following a rigid set of rules and crossing the appearing issues off the list.

Figure 2. Haaga-Helia's accessibility overview from SiteImprove (30.03.2019).

SiteImprove also provides a detailed breakdown on the issues that need to be fixed and matching them to WCAG's A-AA-AAA levels, allowing its users to focus on the most critical issues first. It also splits the issues by role so that people of various skills and access levels can fix the issues within their domain. This system can be useful for those product owners who are required by laws or other policies to conform to a certain WCAG level

and, although the role division seems rather arbitrary, it can help delegate work in a real-world team. The found issues are also classified by severity into:

- Errors - automatically determined failures to meet WCAG success criteria;
- Warnings - automatically determined failures to meet WCAG best practices;
- Reviews - potential failures to meet WCAG best practices or success criteria which can only be verified by a manual inspection.

This classification serves well for the users with limited resources to dedicate to accessibility since it can pinpoint the most critical issues to fix first.

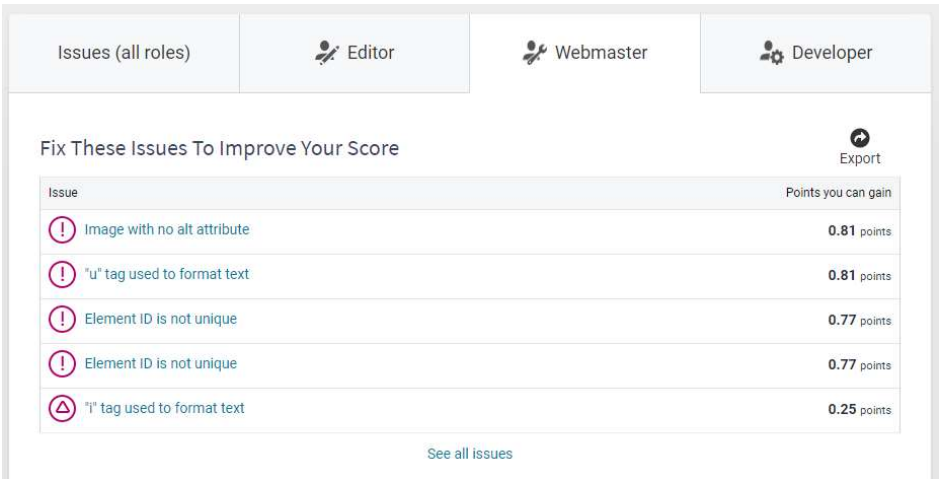

Figure 3. Issues tracking in SiteImprove (30.03.2019).

SiteImprove allows for some flexibility for its users on how they want to structure their workflow. It allows to view all found issues in one place and see all pages that are affected by a certain type of issue, or review each page and see what issues it has, although the latter may be a bit harder to process since a lot of information is placed on one sidebar and the user would have to click in and out the issue as seen in the image below.

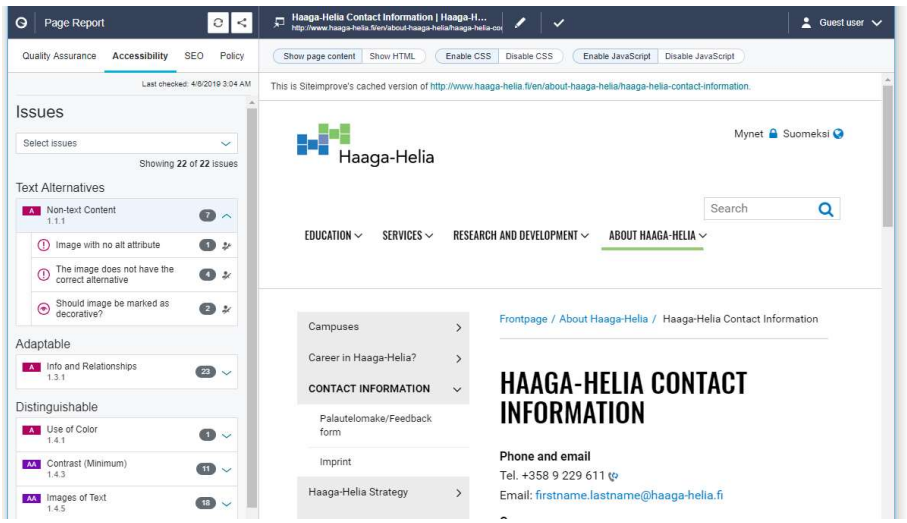

Figure 4. Page review in SiteImprove

Since SiteImprove uses page crawlers to detect possible errors, only machine-detectable errors can be found through it. There is always a question of reliability which we will attempt to assess further on by comparing its outputs to ones given by an alternative solution, but from a glance, it seems to perform decently; neither missed issues nor false positives were discovered while studying the tool reports. A useful feature is highlighting the found issue on the webpage or in HTML as seen below:

Figure 5. Highlighting accessibility issues in SiteImprove

Still, SiteImprove offers, although limited, assistance and guidance for issues that cannot be detected by robots. For example, its crawlers are able to detect audio content and offer to check manually whether an alternative is provided as per WCAG 1.2.9.

SiteImprove allows to view the WCAG criteria for which no automatic checks exist but the feature is implemented with popups without an easy way to view and read the material. In addition, the WCAG criteria are simply copied word for word; no attempts were made to convey their meanings in a simpler way. It suggests actions that the user could take to fix the issue, but it doesn't always provide actionable points, guidance or best practices. For example, SiteImprove can detect images that are missing alternative text and will advise to display decorative images using CSS only or provide an empty `alt` tag, but it doesn't give any recommendations on how to write a good alternative text for an image – something that, as practice shows, webmasters can often struggle with.

To summarize, in practice SiteImprove provides a rather easy-to-use and comprehensive service. An important benefit that it brings is cutting down on manual labor and providing actionable insights based on collected data, keeping its users in check. For teams and product owners who are not themselves experts in accessibility, it is a great starting point. However, it does not suffice as the end-all solution: it still requires a lot of self-driven learning from interested parties and, at best, it can only help create a tolerable experience

for people with disability. It is up for its users then to go further and put an effort in into giving them a good user experience.

3.3.2 Axe and Accessibility Insights: browser accessibility tools and cross-comparison

In this section, we will test different accessibility tools to explore a different approach to the issue of implementing and maintaining an accessible website. These tools will be used also to analyze how well SiteImprove can detect errors relatively to other solutions on the market. There is a great amount of similar browser tools aimed at developers, each with their own benefits and downsides. For our purpose, we will be using Axe Accessibility and Accessibility Insights.

Axe Accessibility is a highly popular tool which has over 1 million downloads as of April 2019 and open source tool built by Deque Systems Inc, a company specializing with web accessibility and working with tech leaders such as Google and Microsoft (Deque Systems, Inc 2019) and was chosen due to its popularity and proven track record.

Accessibility Insights is a recently open sourced tool built and maintained by Microsoft. It was chosen among others due to its rather unique combination of automated, assisted and manual assessment tooling, its strong market potential (open source and having a major company behind it at the same time) and having special features aimed at developers (a possibility to file GitHub issues based on the encountered automatic check failures).

The following steps were taken to compare the output that different tools can provide:

1. A sample of pages from Haaga-Helia's website was picked out for testing. Since Haaga-Helia's website is mostly consisting of text content, a significant part of that of a similar structure, sample size was limited to 10. The pages were hand-picked based on relevance to potential visitor (i.e. applicant or student), perceived frequency of use and/or content, for example:
    a. the front page, contact information page and a sample degree program description page were chosen for relevance;
    b. "How to apply" page was chosen for frequency of use and rich hypertext content;
    c. feedback page was chosen for content including a webform.
2. Each page was scanned with automatic tools: SiteImprove, Axe Accessibility and Accessibility Insights. For this stage, manual or assisted checks were not performed.

3. Found issues on A- and AA-levels were cross-referenced against each other and matched where possible, comparing how well each individual tool performed.

The analysis was performed over the span of several days of April 1 to 4, 2019.The raw collected research data can be found in Appendix 1.

It is important to notice that not all issues could be matched to each other precisely. This should not be used exactly as a measure of the tool's quality since the very point of having several coexisting tools is finding optimal ways to perform the machine analysis through different approaches. Still, it is important to consider at points when it had an impact impacted the data. For example, SiteImprove and Axe Accessibility implement automatic checks for landmarks or headings, e.g. checks for non-empty headings and heading nesting. Accessibility Insights treats both of those as something to be checked manually and provides *assisted* checks, stating requirements, providing guidance and a visual helper highlighting relevant nodes on the webpage. Therefore, in comparison Accessibility Insights did not score lower that other tools for those parameters.

Overall, as the data shows, SiteImprove performed on par with other tools, finding 318 errors in 10 pages against Axe's 302 errors and Insights' 197 errors. Considering that SiteImprove is also able to detect some errors on AAA-level that was intentionally left out while collecting data, it is a great result.

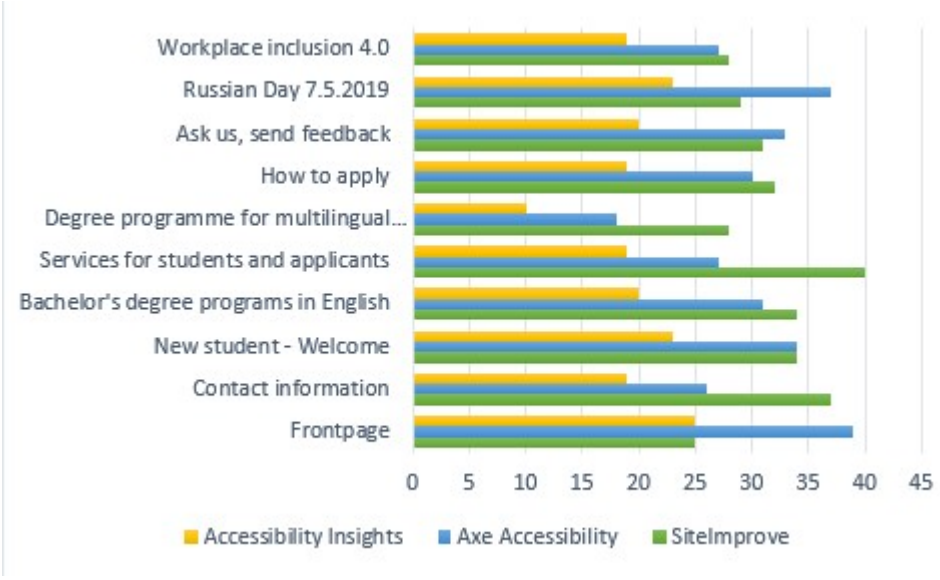

Figure 6. Errors found per page by automated accessibility tools.

Some differences in data can be accounted for the different approaches used by the tools' creators. One repeating case that was encountered on almost every page is the missing alternative text for ad tracking images. Haaga-Helia's website uses 1px x 1px images for

visitor tracking purposes on every page with `display:none` CSS attribute. SiteImprove will always display an error for images with no `alt` attribute even though CSS attributes `display:none` and `visibility:hidden` remove the element from the visual flow of the page and those elements are not picked up by screen readers. Other tools were smart enough to recognize that and did not fire the error, but SiteImprove seems to lean towards the safer side and prefers to fire a potential false positive.

In other aspects though, SiteImprove performs impressively well. It is, for example, able to detect skip links, see if the same text is used for different links and needs an additional `aria` attribute, or warn the user about non-descriptive link text such as “Click here” or “Read more”. Inside the page review, it also brings up non-machine detectable errors that could potentially occur on the page depending on its content. For users and teams without access to expert knowledge on accessibility, this aspect might make a crucial difference in whether they will pay attention to this sort of error or not.

Speaking of the nature of errors encountered, the most typical errors detected came from improper color contrast (up to 50% of total errors on page) and navigation errors such as non-discernible link text, links using same text for different destinations and improper `tabindex` (up to 60% of total errors on page). It is worth noticing that a significant number of those typical errors came from the same elements reused on different pages, such as social media buttons or notification panel for use of cookies on the website. By clearing those elements first, Haaga-Helia’s accessibility score would improve considerably with big payoff for the effort required.

To summarize, SiteImprove was proved to perform on par with other tools and even exceed expectations in some respects. It is not a perfect tool, but it gives a good enough result to justify adopting it as the main tool for maintaining the website’s accessibility on a good level. Still, it can cover only some aspects but not the others, so adding another tool or an accessibility expert to the process would improve things even more.

3.4 Assisted and manual accessibility checks

In this section, we will describe the assisted and manual check process aimed at covering the issues that are not necessarily detected by automated tools.

To facilitate the process, the assisted and manual check tools from Accessibility Insights were used. For that, Accessibility Insights generates a list of instances to evaluate, such as navigation and focus, headings and links, different types of content etc. It also provides

guidelines for testing and visual assistance in the form of highlighting nodes where possible. Accessibility Insights allows its user to mark the test as “Pass/Fail” and, in case of failure, to manually record the failure instance. The results of the audit can be then reviewed and exported where all records of successes and failures will be listed together with comments.

The following steps were taken to test the manual process:

1. Of 10 pages tested automatically, 3 were chosen depending on content and perceived frequency of use:
    a. Front page – first page where many users will arrive;
    b. Degree program description page – a page containing links and text, similar to many pages on the website by context
    c. How to apply – a page with rich text and hypertext content and dynamic element.
2. Full range of manual checks was performed
3. Found issues were recorded and matched with automatic testing data where possible

At certain points, Chrome’s screen reader extension ChromeVox was used in addition to assess the audio experience for vision-impaired users.

The collected data findings are summarized below. The raw collected data can be found in Appendix 2.

Mostly, Haaga-Helia’s web pages scored rather well. A noticeable number of encountered errors stemmed from automated check failures that were discovered earlier, and if that was taken care of beforehand (as the workflow that we suggest in this work assumes), they would not have resurfaced in this test. There were no pages that were completely inaccessible or unparseable for screen reader.

There were some points, unfortunately, where the website would fail its disabled users seriously. One of the more serious offenders was the implementation of keyboard navigation: proper functioning is really important for a wide range of users - many users with motor disabilities rely on it for navigating the website, blind people also use the keyboard together with a screen reader, and people with many other disabilities may use devices that mimic the behavior of a keyboard. For them to succeed with their tasks, all links and controls must be usable with a keyboard and act predictably, and it should always be appar-

ent which element has focus currently. Another important point to consider is that keyboard navigation is sequential; users must tab through all links in order to reach a desired element, so the webmaster might consider using webpage landmarks or skip links to quickly bypass the whole areas on the page.

The front page of Haaga-Helia's website uses two carousel elements to display several embedded YouTube videos and the list of partners. These both elements are what is commonly referred to as a "keyboard trap" – once the user navigates there through keyboard tabbing, he has no way to escape the element. The indefinite scrolling through a circle of elements is frustrating enough by itself, and, considering that a vision-impaired user would not be able to see other content and know it is even there, it is enough to make users leave the site.

Another repeating element of the website with the same problem is the navigation header: it is simply not usable from the keyboard, since the dropdown headers function as links (that do not redirect the users anywhere) and the dropdown elements do not drop down on key press as standard accessibility techniques suggest (W3C 2018, WAI-ARIA Authoring Practices). This is a behavior that directly interferes with users' intentions and will prevent them from reaching their goals unless they manage to find the necessary information through website search. In addition, a navigation bar is in principle a largely visual element and its textual representation does not make a lot of sense by itself. For that purpose, it is a good rule of thumb to provide a so-called skip link that will take the users to main content of the page. No skip links are provided for navigation; as a result, vision-impaired users have to tab through an element that makes no sense and provides no value to them. This altogether makes for rather poor user experience.

Overall, the most significant errors were discovered in the elements that are shared across different pages (e.g. navigation dropdown menu) and on the page layout level (missing landmarks and skip links). Again, these are the kind of errors that, if fixed once, would significantly improve user experience for the whole website, and should be prioritized by developers and other interested parties.

3.5 Cost-benefit analysis

In this section, we will give a short overview of the time spent on various tasks during the audit and will attempt to estimate the time requirements and costs that would be required for improvements.

For automated checks, the time requirements are quite modest by the very nature of those checks – the workflow assumes that most of the time-demanding work that would be collecting and analyzing data is done without any human input. After the data is collected and processed by crawlers, the only tasks remaining are the fixes themselves. Our data shows that most of the fixes that fall within the capabilities of the webmaster (that is, they don't require major design or layout changes or rearrangements) are quick and easy to perform, consisting mostly of markup cleanups. Considering that of the tested pages, most of them had less than 10 errors total related to markup, about 1-2 hours per week would already be a generous allocation for fixing those that could already make a difference.

The manual checks by their nature require more time and effort; how much exactly is, of course, heavily dependent on the page content. For the pages in our test, it took approximately 90 minutes to fully test the main page, and less time was required to perform the same tests for other pages due to repeatable content and elements and overall skill increase. Although it provided invaluable information, it is still a significant amount of time, especially when scaling it to all the website's pages, so it is necessary to consider the best approach to it. A possible solution could be identifying the key pages and elements that definitely need to be tested manually and then make a decision on how to allocate the remaining resources.

It might be difficult, of course, to convince all stakeholders to dedicate more resources to accessibility and especially the importance of issues that seem small to users without disabilities. But with over 10,000 students and 640 staff (Haaga-Helia 2019) in Haaga-Helia, it is certain that some of them will have some sort of barrier for web use. Due to GDRP and medical confidentiality, it is hard to estimate how many people that will be, but even if we take a number of 5% - which is three times less than the country average – that would already make it over 500 people that could benefit from improved accessibility on the website. Of course, the school's website is not what ultimately brings people to study or work there, but in some cases that could be an entry point, so it is important to consider it also as part of the brand image and the way to attract talent. It is for stakeholders to decide how to allocate the resources in the light of this information, but from our point of view, it is significant enough to consider allocating more resources to accessibility.

3.6 Conclusions

The most important conclusions of the audit will be regarding the learnings from the collected data and reflections on the current process in Haaga-Helia and what room there is for improvement.

3.6.1 Reflections on audit results

SiteImprove, the main tool that is used for maintaining an accessible website, has proven to perform quite well in the automated checks test. The question is still out whether it is enough to be the *only* tool used to test accessibility. In a perfect world, results received from SiteImprove would also be cross-referenced with other tools by someone with a good knowledge on accessibility who could assess the results critically and act upon them accordingly. In real life, of course, teams and individuals have limited resources that do not always allow that. A good compromise that we could suggest is to add an automated check with an alternative tool of choice after fixing the errors encountered by SiteImprove to make up for possible differences in the tool's approach.

Overall, the data collected from SiteImprove was not surprising. Haaga-Helia's web department shows awareness about the existing issues and ability to solve them, and the number of errors was not very high and did not render the pages unusable for disabled users. However, this presents a topic for further reflections.

While automated tools have been proved to work, it is obvious that they are not a silver bullet for website accessibility. Luckily, automated testing works very well for the kind of nitpicky errors that human testers are prone to skip or misuse; however, these tools are only as good as their makers thought to make them. It is quite complicated to find out whether the checks only check for the "happy path" or are able to encompass a wider range of issues - until the human tester encounters one of those cases, there is no way to know for sure. In real world, there is always misused or poorly written code, which often causes some side effects. An interesting case of this was encountered in the student guide pages: the link to the Finnish version of the website has an accessible name in Finnish, but it also contains a small image with alternative text that could help the user understand its meaning. However, since the link already has text, the image's accessible name is not reachable for the screen reader.

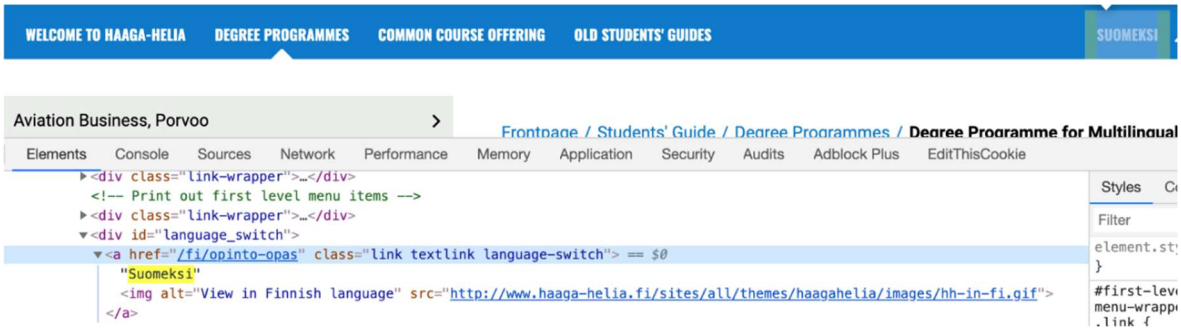

Figure 7. Example of inaccessible markup.

Another case where the automated tools don't work well enough is when a context is necessary to understand the element usage. For example, in our test SiteImprove was able to detect poorly written link text such as "Read more" or "More information" while other tools were not – these checks were passed by omission, not because the element was actually accessible; in reality, these links would still work poorly for users. Automated tools will not report an error for poorly written `alt` text or improperly used ARIA attributes since the syntax itself is valid. Very few tools overall are able to test for various states of interactive context: none of the automated tools were able to detect errors for collapsed vs. expanded navigation bar or carousel slides – it would take a human tester to say for sure whether there were actually any errors. When relying on the automated tools, it is important to remember that computers cannot detect the broader context in which the element operates, and act accordingly.

The findings from assisted and manual testing also support the notion that automated tools cannot be the only solution used for accessibility. For example, the automated tools were well-fitted for detecting color contrast errors, but none of them were able to detect insufficient contrast for focus outline; if not for manual testing, this would not have been discovered. It is an inconvenience for some, but it does not completely break the user experience. Far worse errors, unfortunately, are also left out of scope of capabilities of automated check tools: none of them were able to detect the abovementioned issues of keyboard trap or unreachable navigation.

This is all not to say that automated testing serves no purpose or does not provide enough value; on the contrary, considering that currently Haaga-Helia has limited resources to dedicate to accessibility and that SiteImprove can run checks often enough without human involvement, it is a great way to catch errors quickly when they happen. The key to an accessible website is not to stop there and use it as a stepping stone towards shifting the focus to user research and user centered design.

To summarize, the optimal solution for website accessibility would be a multi-faceted approach. Automated tools like SiteImprove work well for catching "low-hanging fruit". They are a great way to introduce accessibility to a website and prevent basic failures, but they don't necessarily work so well for more complex situations, such as syntactically correct but semantically wrong code, state changes, and broader context of the page. They cannot completely replace manual testing and human judgement, which can uncover the whole different range of issues crucial for good user experience. Once these errors are fixed, the automated tools could once again be used, this time in maintenance mode. This

kind of well-rounded and multi-aspect approach to accessibility testing is the best way to ensure the quality of the result.

3.6.2 Reflections on WCAG criteria

Both automated and manual testing was performed based on WCAG 2.0 criteria. Using these criteria allowed to discover critical issues on the website, but the question remains how well WCAG criteria worked in our case overall.

The goal of accessibility on Haaga-Helia's website should not only be to comply to WCAG criteria or legal requirements; what it should be is to enable its users to easily find relevant information or accomplish their tasks. In that sense, the WCAG criteria checks used by SiteImprove and other tools did not necessarily bring us to that goal – they simply made sure that the site was not *unusable* and was able to work with assisted technologies, however poor that user experience might be. Even in the most basic and well-known criterion 1.1.1 on alternative text for images, for most cases it would be highly subjective what exact alternative text might best convey the content of an image. The absence of quality control in that guideline produces varying levels of accessibility for images that still formally pass the check.

Another important aspect to consider is that sometimes WCAG guidelines worked poorly or were hardly applicable. WCAG still provides rather scarce recommendations for learning disabilities – since it was designed to be "testable", some accessibility techniques are left out due to that requirement, even though they would certainly improve accessibility, while others use arbitrary success criteria. Overall, for our case, those WCAG guidelines have very limited application. Applying them would hinder the webmasters' ability to provide the content that fits best for their target audience while also introducing unnecessary workload, and the resulting content would still have questionable value. The examples that follow explain the issue in detail.

As a learning institution, Haaga-Helia provides accommodations to students with dyslexia. Their user experience could be largely improved by a simple step of introducing an alternative typeface such as Dyslexie font, and overall, clear and concise site navigation and layout would benefit them along with all users, but for most part, such recommendations and techniques are overlooked in WCAG, supposedly due to their untestability.

Most cognitive disability recommendations are centered around reading comprehension, suggesting i.e. “supplementary content” for reading level above lower secondary education – a very arbitrary definition, not mentioning how hard it will be to convince stakeholders of a higher learning institution to dedicate time and resources for that.

Success criterion 3.1.4 suggests providing expansions or explanations for abbreviations. As of April 2019, Haaga-Helia’s website finds about 1440 occurrences of the abbreviature “e.g.”. Even though it is an AAA-level guideline, meaning that it is strictly optional, the person responsible for content is presented with a dilemma whether to knowingly abandon the guideline and not claim AAA-level conformance or provide each occurrence inside of an `<abbr>` HTML element with the expected explanation. It is not unreasonable to expect a person involved with a higher-level learning institution to know the meaning of “e.g.” abbreviation, but acting on that expectation would be, strictly speaking, a failure for this criterion.

All these examples suggest that making a website accessible is not only the matter of following the WCAG guidelines. While those are still important and useful as a basis for further decisions, they are not to be followed blindly and formally. Responsible parties need to take one step further and put the user in the center of the process. At all steps of the process, it is important to consider critically how exactly the guideline helps the users reach their goals, and act on that notion accordingly.

3.6.3 Reflections on accessibility testing framework

Overall, the testing framework used in this case study performed well and highlighted significant issues on different stages of the process. Every step provided significant information that would not be obtainable without it. The chosen order of steps also made sense, since some issues that are most prominent during manual testing can already be detected with automated tools and, if fixed before moving onto the next step, can cut the time and costs of manual testing. Resource requirements also showed to be reasonable, with the total testing time barely over 7 hours.

Thus, this framework can be recommended for future use and can be shortly summarized as follows:

1. Define the scope of evaluation, e.g. key user stories, paths or use cases for the product.
2. Select a representative sample for evaluation.

3. Analyze and, if possible, fix (before moving onto the next step) programmatically detectable accessibility errors for chosen paths. If resources allow, consider double-checking with different accessibility tools.
4. Analyze manually detectable accessibility errors for chosen paths.
5. Fix encountered errors, prioritizing:
    a. Errors critical for successful completion of key user stories (e.g. search);
    b. Errors appearing on multiple pages (e.g. navigation);
    c. Errors appearing on frequently used pages (e.g. home page).

This workflow is technology agnostic and does not lean towards any particular tools and technologies. Depending on available resources, there are possibilities to adjust it to the own needs; for example, user testing can be included as a part of the manual testing.

3.6.4 Recommendations for web services vendor selection

At the request of Haaga-Helia's web department, we will attempt to provide some recommendations for selecting a new vendor for web services regarding accessibility.

Keeping in mind the discoveries made before, the ideal vendor will be able to:

1. Communicate with the target audience of users with disabilities and prove the understanding of their needs. Learning how they use the website will help prioritize the right issues and make working on accessibility efficient and effective.
2. Identify key tasks and content for that target audience. With the condition of limited resources, it is important to make the right call when it comes to priorities.
3. Implement new functionality accessibly and consistently, validating it at early stages. This will help catch the possible errors early and lower the development costs.
4. Include users with disabilities into the process. Validating design solutions with the target audience in the process will, again, make the most efficient use of time and resources.
5. Demonstrate that high-impact content (i.e. most used pages and elements) works accessibly and the implementation helps users with disabilities achieve their goals. Being able to prove that will mean that the goal of accessibility process is achieved.
6. Leverage the power of automated accessibility testing tools during implementation. Again, catching low-hanging fruit will make impact quickly with lower costs.
7. Suggest and configure authoring tools such as CMS for accessibility. This will ensure that accessibility is maintained even on most basic levels by people who are not accessibility experts themselves.

8. Integrate automated accessibility testing tools for Haaga-Helia to maintain after the project is completed. Collecting accessibility data throughout the lifespan of the website will ensure that the site remains accessible even with updates and changes.

4 Discussion

Haaga-Helia's website data collected from automated tools can be deemed trustworthy and objective, collected through the number of impartial sources and verified through repeating the same steps. That does not necessarily mean that the collected numbers will be reproduced exactly due to dynamical nature of the website and the fact that work is done regularly on both finding new errors and fixing the existing ones, but in principle it is reproducible.

The data collected from manual testing is, of course, more subjective. One could argue that the data collected by a non-disabled user is less representative that it could be if collected through user research and that users of assistive technologies could possibly use them in a different or more efficient way. This is true to some extent; still, many of the discoveries are still true independently from the user who encountered them, and since one of the main objectives of this research was to look at accessibility from the position of a web developer, the data still serves its purpose. In the end, accessibility itself is quite a subjective process, depending largely on judgement calls and understanding of different perspectives, so the data and its interpretation only highlight that fact.

This research could be vastly improved by introducing user tests into the process. Having a user with disability or someone regularly using assistive technology in their internet browsing habits to interview and perform UX testing with, seeing how they use the web services, would provide a great source of data and enable to investigate the issue from quite a different and a very important angle. Unfortunately, this was not possible to do in our case due to resource and time limitations, but it is highly recommended to include in the process for any research on accessibility and would be suggested for anyone willing to take this particular topic further.

Another way to improve the outcomes of this thesis would be to perform accessibility testing on a mobile device, given increasing mobile-first usage and the fact that mobile assistive technologies have improved a lot over the last few years. Since improving the website itself was not the goal of this audit, it was deemed to provide rather small value for the time spent, and the decision was made to leave this part out. For cases where the results will be used to improve the web service, it is definitely recommended.

The results of the thesis have limited application and are mostly valuable for the Haaga-Helia's staff and decision makers who will have stakes and vote on the web technology

service vendors. However, the most value to other interested parties would be in the process rather than the results; the steps taken in this research and summarized in the chapter 3.6.3 allow the results to be spread to the wider audience and can also be replicated for other parties or used as a basis for developing own ideas about improving accessibility for online products and services.

In itself, this case study provided a great learning opportunity for the student. Even with some previous knowledge on accessibility, many discoveries followed after this knowledge was applied in practice, the most important of which probably being the importance of empathy towards the product's users and making accessibility the part of the process – many major encountered issues would not be discovered without the attempt to put oneself in the position of a disabled user, and many would not appear if accessibility was planned for during the design stage in the first place.

There are a lot of opportunities for further research on the topic of accessibility which is itself quite vast; aside from already mentioned user testing and countless directions where it might lead, such topics as differences between various testing tools, accessibility testing workflows (e.g. browser tools vs. CLI tools), or leveraging the power of artificial intelligence and machine learning for accessibility (such as AI-generated alternative text for images or using ML for generating simplified text for users with cognitive disabilities), could be subjects of future research.

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Appendices

Appendix 1. Collected data from automated tools

Table 2. Summary

Page	URL	SiteImprove	Axe	AI
Front page	http://www.haaga-helia.fi/en/frontpage	25	39	25
Contact information	http://www.haaga-helia.fi/en/about-haaga-helia/haaga-helia-contact-information	37	26	19
New student - Welcome	http://www.haaga-helia.fi/en/koulutus/for-new-students	34	34	23
Bachelor's degree programs in English	http://www.haaga-helia.fi/en/education/bachelors-degree-programmes-english	34	31	20
Services for students and applicants	http://www.haaga-helia.fi/en/services/services-students-and-applicants	40	27	19
Degree programme for multilingual management assistants	http://www.haaga-helia.fi/en/students-guide/degree-programmes/degree-programme-multilingual-management-assistants-pasila-campus	28	18	10
How to apply	http://www.haaga-helia.fi/en/for-applicant/applicant/how-apply	32	30	19
Ask us, send feedback	https://www.haaga-helia.fi/en/library/ask-us-send-feedback	31	33	20
Russian Day 7.5.2019	http://www.haaga-helia.fi/en/events/russian-day-russkiy-den-752019	29	37	23
Workplace inclusion 4.0	http://www.haaga-helia.fi/en/rdi-projects/workplace-inclusion-40-erasmus	28	27	19
		318	**302**	**197**

Table 3. Front page

Issue type	SiteImprove	Axe	AI
Distinguishable	**56 %**	**41 %**	**52 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	14	16	13

Markup	**40 %**	**33 %**	**8 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	2	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	0	0	0
Page must contain a level-one heading	1	2	0
Headings must not be empty	4	4	0
Heading levels should only increase by one	2	2	0
Navigation	**4 %**	**26 %**	**40 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	10	10
Elements should not have tabindex greater than zero	0	0	0
Link text used for multiple different destinations	0	0	0
	25	**39**	**25**

Table 4. Contact information

Issue type	SiteImprove	Axe	AI
Distinguishable	**41 %**	**38 %**	**58 %**
The image does not have an alt text but there is a mouse over text (title attribute)	4	0	0
Elements must have sufficient color contrast	11	10	11
Markup	**14 %**	**27 %**	**16 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	2	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	1	1	1
Page must contain a level-one heading	0	0	0
Headings must not be empty	0	0	0
Heading levels should only increase by one	1	1	0
Navigation	**46 %**	**35 %**	**26 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	0	4	0
Link text used for multiple different destinations	16	0	0
	37	**26**	**19**

Table 5. New student - Welcome

Issue type	SiteImprove	Axe	AI
Distinguishable	**32 %**	**47 %**	**48 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	11	16	11

Markup	**18 %**	**15 %**	**13 %**
Frames must have title attribute	4	1	1
<html> element must have a lang attribute	0	0	1
Document must have one main landmark	0	1	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	1	1	1
Page must contain a level-one heading	0	0	0
Headings must not be empty	0	0	0
Heading levels should only increase by one	1	1	0
Navigation	**50 %**	**38 %**	**39 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	9	9
Elements should not have tabindex greater than zero	6	4	0
Link text used for multiple different destinations	9	0	0
Link identified only by color	1	0	0
	34	**34**	**23**

Table 6. Bachelor's degree programmes in English

Issue type	***SiteImprove***	***Axe***	***AI***
Distinguishable	**32 %**	**43 %**	**55 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	11	13	11
Markup	**21 %**	**27 %**	**20 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	1	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	2	2	2
Page must contain a level-one heading	0	0	0
Headings must not be empty	0	0	0
Heading levels should only increase by one	2	2	0
Navigation	**47 %**	**30 %**	**25 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	6	4	0
Link text used for multiple different destinations	9	0	0
Link identified only by color	0	0	0
	34	**30**	**20**

Table 7. Services for students and applicants

Issue type	***SiteImprove***	***Axe***	***AI***
Distinguishable	**28 %**	**41 %**	**58 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	11	11	11

Markup	**13 %**	**26 %**	**16 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	2	*0*
All page content must be contained by landmarks	0	1	*0*
id attribute value must be unique	1	1	1
Page must contain a level-one heading	0	0	*0*
Headings must not be empty	0	0	*0*
Heading levels should only increase by one	1	1	*0*
Navigation	**60 %**	**33 %**	**26 %**
No option to skip repeated content	0	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	6	4	*0*
Link text used for multiple different destinations	18	0	*0*
Link identified only by color	0	0	0
	40	**27**	**19**

Table 8. Degree programme for Multilingual Management Assistant

Issue type	***SiteImprove***	***Axe***	***AI***
Distinguishable	**14 %**	**22 %**	**30 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	4	4	3
Markup	**29 %**	**44 %**	**50 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	0	1
Document must have one main landmark	0	1	*0*
All page content must be contained by landmarks	0	2	*0*
id attribute value must be unique	3	3	3
Page must contain a level-one heading	1	0	*0*
Headings must not be empty	0	0	*0*
Heading levels should only increase by one	1	1	*0*
Navigation	**57 %**	**33 %**	**20 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	2	2
Elements should not have tabindex greater than zero	0	4	*0*
Link text used for multiple different destinations	14	0	*0*
Link identified only by color	1	0	*0*
	28	**18**	**10**

Table 9. How to apply

Issue type	***SiteImprove***	***Axe***	***AI***
Distinguishable	**34 %**	**48 %**	**58 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	11	14	11

Markup	**19 %**	**21 %**	**16 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	0	1
Document must have one main landmark	0	2	*0*
All page content must be contained by landmarks	0	1	*0*
id attribute value must be unique	1	1	1
Page must contain a level-one heading	1	0	*0*
Headings must not be empty	0	0	*0*
Heading levels should only increase by one	1	1	*0*
Navigation	**47 %**	**31 %**	**26 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	0	4	*0*
Link text used for multiple different destinations	13	0	*0*
Link identified only by color	1	0	*0*
	32	**29**	**19**

Table 10. Ask us - send feedback

Issue type	***SiteImprove***	***Axe***	***AI***
Distinguishable	**38 %**	**45 %**	**55 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	14	15	11
Markup	**16 %**	**21 %**	**15 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	2	*0*
All page content must be contained by landmarks	0	1	*0*
id attribute value must be unique	1	1	1
Page must contain a level-one heading	1	0	*0*
Headings must not be empty	0	0	*0*
Heading levels should only increase by one	1	1	*0*
Navigation	**30 %**	**27 %**	**25 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	0	4	*0*
Link text used for multiple different destinations	9	0	*0*
Link identified only by color	1	0	*0*
Forms	**16 %**	**6 %**	**5 %**
Form elements are not grouped	5	0	0
Buttons must have discernible text	1	1	1
Radio inputs with the same name attribute value must be part of a group	0	1	0
	37	**33**	**20**

Table 11. Russian Day

Issue type	SiteImprove	Axe	AI
Distinguishable	**48 %**	**46 %**	**65 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	14	17	15
Markup	**17 %**	**30 %**	**13 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	2	2
Document must have one main landmark	0	5	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	0	0	0
Page must contain a level-one heading	0	0	0
Headings must not be empty	1	1	0
Heading levels should only increase by one	1	1	0
Navigation	**31 %**	**24 %**	**22 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	0	4	0
Link text used for multiple different destinations	8	0	0
Link identified only by color	1	0	0
	29	**37**	**23**

Table 12. Workplace inclusion

Issue type	SiteImprove	Axe	AI
Distinguishable	**39 %**	**41 %**	**58 %**
The image does not have an alt text but there is a mouse over text (title attribute)	0	0	0
Elements must have sufficient color contrast	11	11	11
Markup	**21 %**	**26 %**	**16 %**
Frames must have title attribute	3	1	1
<html> element must have a lang attribute	0	1	1
Document must have one main landmark	0	2	0
All page content must be contained by landmarks	0	1	0
id attribute value must be unique	1	1	1
Page must contain a level-one heading	1	0	0
Headings must not be empty	0	0	0
Heading levels should only increase by one	1	1	0
Navigation	**36 %**	**33 %**	**26 %**
No option to skip repeated content	1	0	0
Links must have discernible text	0	5	5
Elements should not have tabindex greater than zero	0	4	0
Link text used for multiple different destinations	9	0	0
Link identified only by color	1	0	0
	28	**27**	**19**

Appendix 2. Collected data from manual testing

Table 13. Front page

Time	*90 minutes*
Passed	**81 %**
Errors	
Keyboard navigation	Dropdown menu unreachable with keyboard
	No way to skip navigation
	Carousel elements (YouTube videos and partners' list) trap keyboard navigation
Focus	Blue outline on blue elements is hard to see
	Headline image text not read by screen reader (jumps to "Read more")
Headings	Heading element E-SIGNALS-EN not functioning as a header
Timed events	Partners' carousel element cannot be paused, stopped or hidden
Images	Decorative header image has long alternative text
Language	Backticks used instead of apostrophes
	"Suomeksi" button is in a language different from the rest of the page but is not coded as such

Table 14. Degree programme in Multilingual Management Assistant

Time	*80 minutes*
Passed	**77 %**
Errors	
Keyboard navigation	No skip links provided for navigation
Landmarks	No main landmark
Links	Open UAS link is coded as linked image with text which is unavailable through other means
Custom widgets	AddThis sharing buttons have poor accessible text (e.g. "Share to FacebookFacebook")
Focus	Focus has poor color contrast
	Social media sharing buttons receive focus first instead of main content
	Poor UX for sidebar nav: after selecting another section, the user must scroll through all navigation again
Headings	"The information below applies to the students…" sections function as a heading but are not coded as such
	Anchor link targets are coded as headings containing links
Sequence	Search button moves away from search field when CSS is disabled
Language	"Suomeksi" button is in a language different from the rest of the page but is not coded as such
Text legibility	Footer text has insufficient color contrast

Table 15. How to apply

Time	*40 minutes*
Passed	**82 %**
Errors	
Keyboard navigation	Dropdown menu unreachable with keyboard
	No skip links provided for navigation
Focus	Social media sharing buttons receive focus first instead of main content
Landmarks	No main landmark
Headings	"AND MUCH MORE IN SOCIAL MEDIA" heading is coded as heading but does not necessarily function as such
Links	Accordion links do not have appropriate ARIA role
	Opintopolku.fi link's accessible text in Finnish
	Footer social media links do not have accessible names
Language	"Suomeksi" button is in a language different from the rest of the page but is not coded as such

Appendix 3. List of abbreviatures

ARIA – Accessible Rich Internet Applications

CLI – Command Line Interface

CMS – Content Management System

W3C – World Wide Web Consortium

WCAG – Web Content Accessibility Guidelines