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A comparative study of usability and accessibility of Norwegian educational institute websites for screen reader users based on user experience and automated assessment

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Preface

This dissertation has been written for the graduation requirement of master's degree course in Universal Design of Information and Communication Technology (ICT) regarding the reporting of the accessibility and usability challenges the screen reader students commonly face while interacting the Norwegian Institutional websites. There are so many beautiful people involved in my thesis who supported me in my difficult time.

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Abstract

A website is an essential part of the education system, mainly in schools or universities, as it aids the students with diverse abilities to access the information offering the flexibility in times and locations for learning and personal growth (Kuakiatwong & Whittier, 2011). However, due to the lack of accessibility and usability of the websites, the students with disabilities who solely rely on screen reader software faces challenges accessing the contents on the webpage.

This study aims to assess the current level of accessibility and usability issues, screen reader students frequently encounter while interacting with the Norwegian University webpages. To address the research question, this study performed the sequential explanatory design approach to collect the data in two different phases. Quantitative data were collected at first using two automated tools and questionnaire to assess the accessibility and usability level of the selected websites. In the second phase, the study implemented follow-up interviews with the participants to address the further issues which were not discovered in the first phase. Sixteen visually impaired participants were recruited and were assigned the 5 usability tasks on 4 different university websites to analyze the usability and accessibility of sampled websites.

Analysis from the qualitative and quantitative data demonstrated that none of the selected Norwegian University websites (N=4) met the minimum checkpoint requirement of WCAG 2.1. The findings further depicted that the average usability level of the educational websites in Norway was below average and, only one of the 4 evaluated websites came close to average usability score. In addition, based on the interview, the most remarkable accessibility issues discovered on Norwegian University webpages were poorly design of heading and link-list structure, screen reader incompatibility with the browsers, ambiguous link structure, and inaccessible keyboard navigation. Likewise, the majority of the participant response to most common usability issues they experienced on the webpages were poor labelling of the forms, duplication of page titles, awful labelling of links, inconsistent breadcrumb trail, and inadequate keyboard access on webpages.

Further, correlating the results reported by two automated tools concluded that there was inconsistent between the two automated tools result. On this basis, it is

recommended that manual accessibility evaluation of the website should be implemented to confirm the quantitative findings. It is further recommended that universities need to give emphasis to make a website to be accessible and usable to screen reader users. Further study is necessary to explore and overcome the limitations of the current study.

Keywords: *Web accessibility, Web Usability, WCAG 2.1, Universal Design, WCAG 2.1, University Websites, Norwegian Universities, Screen Readers*

Table of Contents

List of Tables

List of Figures

List of Abbreviations

- WebAIM - Web Accessibility in Mind
- ICT - Information and Communication Technology
- ADA - Americans with Disability Act
- WHO - World Health Organization
- UN – United Nations
- HCI – Human-Computer Interactions
- WCAG – Web Content Accessibility Guidelines
- N - Number
- SUS – System Usability Scale
- UiS - University of Stavanger
- UiT - University of Tromsø
- USN - University of South-Eastern Norway
- UiA – University of Adger
- UN – United Nations
- UD – Universal Design
- W3C - World Wide Web Consortium
- AT – Assistive Technology
- HTML – Hypertext Markup Language
- CSS - Cascading Style Sheets
- ISO - International Organization for Standardization
- JAWS - Job Access With Speech
- NVDA - NonVisual Desktop Access
- VERSE - Voice Exploration, Retrieval and SEarch
- GCC - Gulf Corporation Council)
- URL - Uniform Resource Locator

Chapter 1 Introduction

The website is an essential central location for information sharing because it provides access to services, products, and information that are not as easily attain due to user's disability factors or situation (Sierkowski, 2002b). Moreover, the website plays a significant role in education, from preschool to University, for the teaching, learning, and schooling purpose (Owston, 1997). However, web content is only useful if it is designed accessible and usable (Tomlinson, 2016).

The accessible higher educational website is in demand along with the ease of use these days because it assists a wide range of students with diverse abilities to use and access the websites regardless of time and place. School websites facilitate teaching, learning, and communication to boost performance in the education system (Carmel & Alan, 2016). Despite this, there is still a digital divide in accessing the information contents on web pages by a wide range of people because many educational websites are not designed accessible and usable to all kind of students, particularly to blind people who rely on assistive technologies to navigate websites (Kuakiatwong & Whittier, 2011). The contents on the web should be designed accessible and usable for the users who have complications interacting the website directly and are obligated to use the third-party tools like a screen reader software, are able to use the website without any hindrance.

This study investigates and compares the accessibility report generated by two automated tools with analyze to examine the current level of accessibility of Norwegian University websites against WCAG 2.1 guidelines. Additionally, this research also addresses the most common usability and accessibility issues screen readers face from the follow-up interview of the participants. Lastly, the research measures the discrepancy between the two automated tools.

1.1 Problem Statement

The Website is an essential part of the education system, mainly in schools or universities, as it aids the students with diverse abilities to access the information offering the flexibility in times and locations for learning and personal growth (Kuakiatwong & Whittier, 2011). If the educational website is accessible, then there is an equal approach for learning to both abled and students with disabilities.

Many university websites are not designed accessible which limit the students with various disabilities from obtaining the information from the website as everyone does who solely rely on assistive technologies (ATs) and enhance the learning (Day & Edwards, 1996; Klein et al., 2003). Those students who solely rely on Assistive Technologies such as screen reader tools, screen magnifier, braille keyboard, etc. find it difficult to interact directly with the webpages because the sites are not accessible to them. People with various disabilities like visually impaired users rely on screen reader tools and they struggle to browse the web due to inaccessible web content (Borodin, Bigham, Dausch, & Ramakrishnan, 2010; Vtyurina, Fourney, Morris, Findlater, & White, 2019). Further, the inaccessibility web contents produce barriers to equal access to people with disabilities and obstruct educational enhancement.

To make the web accessibility and universally designed, there have been various globally accepted guidelines and recommendations developed for people with disabilities. There also has been anti-discrimination legislation and regulations like EU-regulations, regulation on universal design of ICT solutions, etc. presented in current web accessibility laws and policies which oblige different educational institutes to follow web accessibility as per guidelines. Despite the strict laws and regulations and guidelines, the study shows that a large portion of existing websites are inaccessible and inconvenient to use (Aziz, Isa, & Nordin, 2010; Espadinha, Pereira, da Silva, & Lopes, 2011; Hackett, Parmanto, & Zeng, 2005; Kamoun & Basel Almourad, 2014; Kurt, 2011; Mohd, 2011; Thompson, Comden, Ferguson, Burgstahler, & Moore, 2013).

According to data sourced from Bufdir (2017), approximately 15-20 % of Norwegians live with a disability and, 2 out of 3 children receive special education outside their class. Moreover, there has been a strict rule that every child have an accessible

school to their local area, and every people has an exclusive right to an education suited to them (Bufdir, 2017). The accessible website is not only the ethical thing to do but in many countries, it's the law (Nielsen, 1999). In Norway, the Norwegian Ministry of Government Administration, Reform and Church Affairs have made strict legislation regarding the universal design of ICT be a legal requirement for both public and private sectors (Difi, 2015).

This study implemented Web Content Accessibility Guidelines WCAG 2.1 recommendations on automated tools and user testing (user task and questionnaires) to gather the results. In response to these problems, this study aims to discover the existing barriers and issues currently occurring on Norwegian University web pages in terms of accessibility and usability. The findings of this study may promote the equal inclusive design of educational websites in Norway and further contribute by mitigating the existing barriers on screen reader tools and automated tools on accessibility and usability of the webpages.

1.2 Research Questions

To acknowledge the problems, the following research questions are prepared in this study:

1. To what level of compliance do the Nordic University websites meet the criteria for successful inclusive web design following WCAG 2.1 guidelines using automated tools?
2. Which of the most common accessibility barriers screen reader students usually face while interacting with the different Norwegian University web pages from the user experience and automated tools?
3. What recommendations are suggested to improve the Accessibility and Usability of the Norwegian University Websites?
4. What is the degree of agreement between two automated tools for the assessment of the accessibility of selected Norwegian University web pages?

Chapter 2 Research Background

2.1 Universal Design Concept

Universal design concept emerged from North Carolina State University in 1997, and the expert group of advocates developed its seven principles. They have coined the concept universal design as “The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design” (Bettye Rose Connell, 1997). In addition, they have also established the famed seven fundamental principles of universal design:

1. Equitable Use
2. Flexibility in Use
3. Simple and Intuitive Use
4. Perceptible Information
5. Tolerance for Error
6. Low Physical Effort
7. Size and Space for Approach and Use (Bettye Rose Connell, 1997).

According to (UN), Universal design is defined as “the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design”.

There has been more refined definition of Universal Design, focusing on all people. According to Steinfeld and Maisel (2012), Universal design is defined as a process which authorizes a wide range of people by enhancing the individual’s potential, health, and involvement in various social sectors.

In addition, the term universal design has been used as different names such as design for all, universal access, inclusive design, etc. and they all focus on the accessibility of interactive system for the extensive feasible range of use (Langdon, Clarkson, & Robinson, 2013). According to Design for all Europe (2007), “Design for All is design for human diversity, social inclusion and equality.” In terms of learning, UD can be defined as the design of educational information and tasks that makes the learning goal attainable despite the disabilities to see, hear, speak, move, read, write, etc. (Dell, Newton, & Petroff, 2008).

Norwegian Anti-discrimination and Accessibility Act legal definition of UD is as follows:

“Universal design” shall mean designing or accommodating the main solution with respect to the physical conditions, including information and communications technology (ICT), such that the general function of the undertaking can be used by as many people as possible (ADAA, 2013).

2.1.1. Web Accessibility

Web accessibility refers to those websites and tools to which people with disabilities can able to use them (W3c, 2019a). People with disabilities are able to get all information and use all the functionality available to users without disabilities, like links, buttons, form controls, etc. (Kuakiatwong & Whittier, 2011). In addition, web accessibility empowers disabled people or people with special needs to operate the web contents making web accessibility a fundamental matter in web design (Kamal, Alsmadi, Wahsheh, & Al-Kabi, 2016b). Designing accessible websites allows users affordable, technically feasible ways to create a Website accessible to people with disabilities (Clark, 2001).

W3C (2016c) further elaborates requirements included in accessibility as:

1. Requirements that are more specific to people with disabilities – the website should work well with assistive technologies (AT) like screen reader tools, screen magnifiers, and voice recognition tools for the text input.
2. Requirements that are general usability principles – included in the requirement of accessibility as they can be significant barriers to people with disabilities.

One of the factors for the successful delivery of accessibility of the web is the developer’s awareness of the aspects involved (Sierkowski, 2002a). The levels of web accessibility are very low in today’s majority websites though there have been the tools and guidelines developed to achieve and there is no apparent reason in practice for this (Lazar, Dudley-Sponaugle, & Greenidge, 2004). However, there are various techniques and suggestions in order to develop accessible web.

W3C (2018a) has introduced various essential components for the web to be accessible to people with disabilities:

1. Natural information, such as text, images, and sounds.
2. Web browsers, media players, and similar user agents.
3. Assistive technologies (screen readers, alternative keyboards, switches, scanning software, etc.).
4. User's knowledge and experience of web pages.
5. Web developers and designers (including developers with disabilities and users who contribute content).
6. Authoring tools for the creation of the site.
7. Automated Web accessibility evaluation tools (HTML validators, CSS validators, etc.).

2.1.2. Usability in Web

The term "usability" is the context to which a product or system can be used by particular users with specified objective in particular situation with effectiveness, efficiency, and satisfaction (ISO, 2018). Usability is defined in various terms. To some people, usability is 'ease of use' (Martyn, Chetz, & Anne, 2007). In a simple context, the product is considered usable if a person is satisfied using it. When a person purchases products, he/she expects them to function well and easy to use in order to meet his/her needs (Sunil, Ravi, & Edna, 2002).

The concept of usability is introduced as the general term of software-ergonomic quality, and using this concept, a methodology of conformance testing is explained (Dzida, 1995). In the web, the term usability refers to how well a user can navigate and use the web contents in terms of need (Valentine & Nolan, 2002). Website usability is determined by the quality of the user's experience while using the website. If the website is difficult to use and users get lost on the page, they ultimately leave (Nielsen, 2003). In addition, Nielsen (2003) has defined usability using five key components:

1. **Learnability** – How easy is for users to accomplish tasks the first time they encounter the design?

2. **Efficiency** – Once users have learned the design, how quickly can they perform tasks?
3. **Memorability** – When users return to the design after a period of not using it, how easy can they reestablish proficiency?
4. **Errors** – How many errors do users make, how severe are those errors, and how easy can they recover from the errors?
5. **Satisfaction** – How pleasant is it to use the design.

From all the ideas and definition from above, it is understood that usability is concerned with effectiveness, efficiency, and satisfaction. University's website should be accessible because almost every school or University use their websites to share information, latest news, and all the academic announcement via the web. Therefore due to internet accessibility, students are too dependent on this technology (Lin & Tsai, 2002).

2.1.3. Web Accessibility vs. Web Usability

In the web, accessibility means the people with disabilities can perceive, understand, navigate, and interact with the websites tools and features contributing equally without barriers (W3c, 2016a). The people with disabilities can have equitable access to the functionality of the web than that of the people without disabilities when it comes to inclusive web design. Similarly, web usability is the measurement of the quality of a user's experience when they browse a website. In simple terms, web usability means the ease of use of the website in terms of user experience. Kamal, Alsmadi, Wahsheh, and Al-Kabi (2016a) argues web accessibility with device technologies but not the same way the usability does, and it differs from the dependability of the device.

Many scholars have tried to define usability and accessibility in their own words. Still, these terms are often getting misunderstood and misused. One can conclude that the website is not usable unless it is accessible (Krug, 2013). In other words, it can be said that usability is a subset of usability; however, whilst usability implies accessibility, the contrary is not necessarily true (Brajnik, 2000). It means a website must be accessible to be usable, but it doesn't need to be usable to be accessible (Krug, 2013).

While accessibility is intended for the people with disabilities, the inclusion of accessibility in the system also improves usability for everyone (W3C, 2016c).

2.2 Disability and Its Types

The term “disability” has been defined differently by various authors, institutions, or organizations. Americans with Disability Act (ADA, 2009) has described the disability of a person as any person with a physical or mental impairment which significantly obstructs one or more primal life activities or even a person is considered to have a disability if he/she is recognized as having such impairment by other people. World Health Organization (WHO) identifies disability as an umbrella and not necessarily need to have health issues but covers impairments, participation exclusion, and constraint on activities. Similarly, a person with a disability is defined by The UN Convention on the Rights of Persons with Disability (United Nations) as “those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.”

In Human-Computer-Interaction (HCI), disability is divided into three classifications based on the functional requirement for input and output:

1. **Perceptual Disabilities**: Vision and hearing impairment
2. **Motor/Physical Disabilities**: Impairment in hands, arms, and speech
3. **Cognitive Disabilities** (Lazar, Goldstein, & Taylor, 2015).

2.3 Screen Reader Tools

Screen readers are one of the most popular assistive technologies, particularly used by blind or visually impaired users which reads out loud anything that is displayed in within the web or computer screen, in computer-synthesized speech (Lazar, Allen, Kleinman, & Malarkey, 2007). This tool is supported various devices nowadays like mobile, tablets, desktop, laptops, etc. Perceiving the contents on the website with screen reader tools is a challenging task because of the accessibility and usability issues within the web contents and the screen reader software itself (Borodin et al., 2010). One needs a prior experience use the screen reader tool efficiently as the output speech from the software is distinct from humans sounding somewhat robotic and monotone (WebAIM, 2017a). From the survey conducted by (WebAIM, 2017b),

the screen reader responded that the most common screen reader tools they use are JAWS and NVDA while other popular were as follows:

- JAWS – 46.6%
- NVDA – 31.9%
- VoiceOver – 11.7%
- ZoomText – 2.7%
- System Access or SA To Go – 1.7%
- Window-Eyes – 1.5%
- ChromeVox – 0.4%
- Narrator – 0.3%
- Other – 3.4%

In addition, the documentation reported by the survey from the disabled participants reported that there were other people with disabilities who rely on screen reader tools as well:

- Blindness
- Low Vision/ Visually – Impaired
- Cognitive
- Deafness/ Hard-of-Hearing
- Motor

2.4 Web Content Accessibility Guidelines (WCAG) Guidelines

Web Content Accessibility Guidelines (WCAG) is a set of guidelines that suggests the requirement needed to fulfill a wide range of people. There have been earlier versions of WCAG developed, i.e., WCAG 1.0 and WCAG 2.0 and later WCAG 2.1 guidelines were developed to substantiate the previous two guidelines with additional new success criteria. On June 5, 2018, World Wide Web Consortium (W3C) released the updated WCAG 2.1 guidelines extending the recommendations of WCAG 2.0 (W3c, 2018b). WCAG investigates the broad range of recommendations to make the web contents as much as accessible and usable to a wide range of people with disabilities, however, only relying on these guidelines will not address every requirement of such people (Kirkpatrick & Cooper, 2018). The guidelines and success criteria of WCAG are categorized into four principles:

1. **Perceivable** - Information and user interface components must be presentable to users in ways they can perceive
2. **Operable** - User interface components and navigation must be operable
3. **Understandable** - Information and the operation of user interface must be understandable
4. **Robust** - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies (W3c, 2008).

As all the success criteria of WCAG 2.0 are included in WCAG 2.1 new versions, the latest version comes up with the updated guidelines with 17 additional success criteria to answer the issues related to:

- Mobile accessibility.
- People with low vision.
- People with cognitive and learning disabilities (W3c, 2019b).

2.5 Web Accessibility Automatic Testing Tools

There are different ways of testing web accessibility to check the accessibility and usability barriers of the websites (Brajnik, 2006; Brajnik & Lomuscio, 2007; Brajnik, Yesilada, & Harper, 2011; Coyne & Nielsen, 2001) and automated testing is one of the quick and systematic tools (Martínez, Martínez-Normand, & Olsen, 2009). Automatic testing checks the accessibility and usability barriers of the websites using its internal algorithm, so it is beneficial when one needs to assess the large websites, however, the report generated by such tools needs human judgment for reliable results that's why relying only on such tools doesn't address the existing web accessibility issues (Martínez et al., 2009).

There are several automated tools recommended by (W3c, 2017b) to examine the accessibility barriers and issues of the websites against WCAG 2.1 guidelines which is available for free and premium. These tools support different web browsers as and some of them can even be employed as a browser extensions or desktop applications. Although these tools assist web developers and researchers to address the accessibility barriers, the automated tools should not be used entirely as an evaluation approach as the tool only aids to detect the accessibility of the websites but don't utterly determine the barriers (Brajnik, 2004; W3c, 2017b).

Chapter 3 Literature Review

This section covers the review of related studies on usability and accessibility of websites conducted by various scholars and researchers.

3.1 Review of Related Studies

Various studies have been undertaken to evaluate/assess the usability and accessibility of different websites in terms of universal design. In one study, Alahmadi and Drew (2017) conducted the accessibility evaluation of randomly selected 20 top-ranked University webpages using the automated accessibility evaluation tool “Achecker” to compare the decade long improvement in the accessibility of university webpages between 2005 and 2015. This study evaluated the three webpages of each university: 1. Home Page, 2. Admission Page, and 3. Course Description Page of twenty selected websites. Moreover, while analyzing each webpage of 20 selected university websites, the result concluded that there was a lack of accessibility errors of 37.42% in homepages, 29.55% of total errors in admission pages, and 33.03% of total errors in course description pages. Comparing these statistics with the previous studies, there was a slight progress in the accessibility level of selected university websites between 2005 – 2015. The result further demonstrated that the accessibility levels amongst the world top-ranked universities showed no significant differences with each other.

Similar to the above research, (Kurt, 2011, 2017) investigated the accessibility evaluation of ten university websites in an interval period of 5 years based on two automated tools, AChecker and Sortsite. The second evaluation of the sites was performed to compare the accessibility progress of same websites evaluated at first. In the first study (Kurt, 2011), the authors concluded that none of the assessed websites minimum success criteria, while the follow-up study in the second phase Kurt (2017) demonstrated that the improvement of the same websites over 5 year period hadn’t much changed, but there was even a marginal decrease in accessibility. Moreover, comparing evaluations of the websites in different phases, the most occurred accessibility issue was a Level A accessibility standard issue.

Another study from 100 visually impaired participants on the challenges faced by screen reader users has been examined by (Lazar et al., 2007) using time diary data

collection method. From the study, the researchers discovered top causes of frustration while interacting with the website using screen reader software as:

1. Design of the page resulting confusing screen reader response.
2. Incompatibility of screen reader software with the internet browsers.
3. Poorly designed unlabeled forms.
4. Missing alt-text for images.
5. Inaccessible PDF and a crash of screen reader tools.

The study further discovered that there was an average of 30.4% loss on time due to frustration while using the website.

After investigating the barriers faced by the screen reader and voice assistant blind users, (Vtyurina et al., 2019) designed the VERSE (Voice Exploration, Retrieval and SEarch) prototype, a combination of both screen reader and voice assistant tools, that facilitates both voice-based and gesture-based interaction. The tool was developed after analyzing an online survey consisting of 44 questions with a total of 55 blind participants who use both screen readers and voice assistant tools. The VERSE system was designed after identifying the strengths and weaknesses of screen reader and voice assistant tools using the online survey.

In another study, researchers concluded that although the accessibility features of the university websites are increasing to some extent in compared to the previous study, they are basic and easy to implement on webpages (Thompson, Burgstahler, & Moore, 2010). In the study, after evaluating the home pages of 127 higher education websites over 5 years period with manual accessibility checks from experts, there was some significant improvement in web accessibility. However, the most issues were in keyboard navigation accessibility which authors assume it might be due to the emergence of new dynamic web contents.

Human factors too play a huge role in web accessibility and usability to make an accessible website. Abanumy, Al-Badi, and Mayhew (2005) conducted a study mainly focusing on the web accessibility guidelines, web accessibility tools, and investigated the role of human factors for the implementation of successful e-Government websites of Saudi Arabia and Oman by the ‘W3C Web Accessibility Guidelines’ conformance. The scholars evaluated the e-Government websites in 5

stages. The manual check and automated accessibility evaluation tools were used as a first stage to check 27 websites (13 from Saudi Arabia and 14 from Oman) compliance with WCAG guidelines. In the second stage, the researchers also used various tools like multiweb, LYNX, and W3C validator tools to check whether the selected websites work with assistive technologies and input devices if the site can be accessed in a text-mode browser and to check the HTML syntax errors. The third stage was to test the supporting hypotheses. Moreover, in the fourth stage, the authors used the tools two phases to test the website accessibility in the English language since the tools didn't support the website accessibility testing in the Arabic language. In the final stage, the authors conducted an online email survey with the webmasters of government websites interrogating them about the aspects that obstruct and authorize the accessibility and usability of government websites. The findings of this study showed that the government websites of these two GCC (Gulf Corporation Council) countries; Oman and Saudi Arabia were inaccessible needs a lot of consideration to make these websites accessible. Further, the study showed that the lack of government awareness and showing less interest in accessibility resources and accessibility guidelines. Likewise, (Masood Rana, Fakrudeen, & Rana, 2011) evaluated the accessibility performance of 25 University websites in Saudi Arabia with two automated accessibility evaluation tools; Functional Accessibility Evaluator and Cynthia Says. Although the evaluations were only focused on Level A criteria for WCAG 1.0 and WCAG 2.0 checkpoints, yet, the study concluded that none of the websites met the minimum Level A criteria for WCAG 2.0. The scholars further analyzed that more than 80% of the evaluated universities had substandard accessibility levels and failed Level A WCAG 1.0 conformance.

Kesswani and Kumar (2016) and Masood Rana et al. (2011) noted that most of the countries still need to give more emphasis on educational institutes in order to comply with the guidelines. The comparative analysis of top University websites of different countries showed that most of the schools met less than 50% of the accessibility guidelines. The study was conducted using the automated accessibility tools under WCAG 2.0 guidance.

Additionally, to ensure the accessibility of the University webpages, some recommendations are suggested to design the University homepages (Ismail &

Kuppusamy, 2018) which authors concluded after analyzing the common errors on 302 Indian universities with WCAG 2.0 conformance level guidelines using three automatic accessibility evaluation tools (WAVE, AChecker, and Web-page Analyzer) which are summarized below:

1. Text alternatives for all non-text web content should be provided.
2. Headers need to be included for each page, including section and table.
3. The support of color contrast and other keyboard functionalities needs to be supported.
4. Well-structured forms should also be taken into consideration along with their interactive features.
5. Adjustment control of color contrast should be included and clearly visible in webpages.
6. The media players should allow users to have full control to resize and reposition media in videos/audios.

Moreover, the research conducted on the above study concluded that none of the tested University websites met the WCAG 2.0 accessibility recommendation criteria.

The studies have shown that in some countries, web developers are more interested in the performance of the websites in terms of accessibility and usability due to the popularity of websites within the nation. The study carried out by (Ismailova & Inal, 2018) of 60 university websites from 4 countries, i.e. Azerbaijan, Kazakhstan, Kyrgyzstan, and Turkey using AChecker automated tools showed that most of the websites failed to meet the WCAG 2.0 accessibility criteria. In this study, the authors picked top 15 universities from each abovementioned country and reported the average accessibility issues for each country against three levels of conformance, i.e. A, AA, and AAA. For Level A conformance against WCAG 2.0, the study reported Azerbaijan universities had comparatively the best performance with an average of 29 errors, while Kazakhstan universities had the worst average errors of 108. Further, the study concluded that only four university websites attained Level A conformance, two from Kyrgyzstan and two from Kazakhstan. Additionally, the observed study showed that For Level AA conformance, Universities in Azerbaijan achieved the best with an average of only 7 errors and Turkish Universities had the worst accessibility performance with an average of 28 errors. Finally, the AChecker

automated tool reported that Kazakhstan Universities had the best Level AAA conformance performance with an average of 2 errors, while Azerbaijan universities had the worst Level AAA conformance performance with an average of 73 errors.

The study has also assumed that in order to achieve the potent web accessibility criteria, financial investment and human resource plays a significant role. A study (K. A. Harper & DeWaters, 2008) performed on the evaluation of homepages of 12 Universities in the United States reported that only one university met all the accessibility criteria against WCAG three priority levels A, AA, and AAA. The authors approached webmasters to evaluate and assess the accessibility performance of selected universities using an automated tool, i.e. Watchfire Bobby to comply against WCAG 1.0 guidelines. The results showed that only 50% of the websites met priority 1 and priority 2 criteria and 33% of the websites met priority 1 conformance.

(Menzi-Çetin, Alemdağ, Tüzün, & Yıldız, 2017) conducted a usability evaluation of the university website with six visually impaired students using interviews, usability tasks, and satisfying surveys on university web pages. The tasks weren't completed by all users and the result showed that the most challenging task the students faced was finding the final exam dates on the university calendar, whereas, the most time-consuming task the participant experienced was discovering the course schedule on the web page. Moreover, missing search form on each page was complained by the visually impaired students who relied on screen reader software. A text version for all pages and proper link-list were suggested by the participants in the study.

(Lazar, Olalere, & Wentz, 2012) evaluated the accessibility and usability of online job portal sites from sixteen blind participants across eight south-eastern states in USA. After given participants the tasks of applying for at least two job positions online using automated tools, the researchers concluded that most of the usability issues were the same for visually impaired users and people without disabilities. The study further reported that user testing is fruitful when the participant performs the tasks that include navigation between the various web pages and when the user thinks out loud during the testing procedure. Additionally, from the research, the authors figured out that most of the online accessibility and usability issues are easy to locate and can be fixed by little effort by the designers.

Chapter 4 Methodology

The main aim of this study was to discover the current level of accessibility and usability issues of Norwegian University web pages against WCAG 2.1 guidelines. In addition, this research also investigates the most common accessibility and usability barriers the screen reader students encounter while surfing the University web pages.

To answer the research questions, the mixed method approach was presented in this research for data collection and evaluation purpose. Within the mixed method, a sequential design approach method was used. In this method, quantitative and qualitative data were collected at the different time, prioritizing the quantitative data collection first, in which qualitative study depends upon the quantitative results (John W. Creswell & Plano Clark, 2011). The reason for choosing the mixed approach is because the initial quantitative data results are explained further with the qualitative data (J.W. Creswell, 2014).

In addition, two automated evaluations tools WAVE and Total Validator were also presented to evaluate the accessibility and usability of the web pages.

4.1 Research Method

4.1.1 Quantitative Research Method

John W. Creswell and Creswell (2018) states that quantitative research methods are used for collecting numerical data and analyzing them using statistical procedures. The quantitative method is based on the measurement of quantity or amount (Kothari, 2004). In this study, the questionnaire was employed to collect the participant's opinion and response after the usability testing. The questionnaire is one of the most commonly used quantitative methods (John W. Creswell & Creswell, 2018). Further, the quantitative result of automated tools is also analyzed in this study.

4.1.2 Qualitative Research Method

Qualitative methods are primarily used for in-depth analysis of the research problem or user's experience than from theories and cannot be measured in numeric form (John W. Creswell & Creswell, 2018). Data collection in qualitative research comes

with the variety of methods, i.e. observations, interviews, textual or visual analysis, etc. (Silverman, 2013). Still, the most common method used in qualitative research are interviews and focus group (John W. Creswell & Creswell, 2018; Silverman, 2013). In this research, the post-interview with the participants was implemented after the collection of quantitative results data.

4.1.3 Mixed Research Method

In this study mixed method approach was presented for data collection and evaluation purpose. In some situations, it may be practicable and suitable to perform either qualitative or quantitative method but it is usually better to run a mixed (both qualitative and quantitative) study to generate a comprehensive picture of user's performance, experiences, and preference (S. Harper & Yesilada, 2010). Further, this approach combines the strengths and counterbalance the limitations of both approaches, especially while tackling the complex and myriad of issues (Tariq & Woodman, 2013).

Within the mixed research method, a sequential explanatory design approach was used to ensure the collected data will assist in answering the aforementioned research questions more efficiently.

4.1.3.1 Sequential Explanatory Mixed Design Method

John W Creswell, Plano Clark, Gutmann, and Hanson (2003) have mentioned that the sequential explanatory mixed design consists of two distinct phases – quantitative followed by qualitative design. In this design approach, quantitative and qualitative data are collected at the different time, prioritizing the quantitative data collection first, in which qualitative study depends upon the quantitative results (John W. Creswell & Plano Clark, 2011). The reason for choosing this approach is that the quantitative data and their later analysis extends the general interpretation of the research problem (Ivankova, Creswell, & Stick, 2006).

This study addresses the current level of accessibility and usability issues in Norwegian University websites and further aims to discover the most common accessibility and usability barriers that screen reader students face while interacting with them.

4.2 Selection of Websites

The objective of the research was to discover the most common accessibility barriers of Norwegian University websites, the screen reader users. Therefore, four internationally recognized Norwegian University's websites were chosen for this research for automated evaluation and user testing:

1. University of Stavanger (UiS) – https://www.uis.no/
2. University of Tromso (UiT) - https://en.uit.no/
3. University of South-Eastern Norway (USN) - https://www.usn.no/
4. University of Adger (UiA) - https://www.uia.no/

The above-listed websites were chosen randomly other than top 5 Norwegian University ranking listed in The Times Higher Education World University Rankings 2019 (Times Higher Education, 2019). According to the list, during top 5 ranked Norwegian Universities are:

1. University of Oslo
2. University of Bergen
3. Norwegian University of Science and Technology
4. The Arctic University of Norway
5. Norwegian University of Life Sciences

This research excludes the top-five Norwegian University websites. The ranking is determined based on expert peer review investigating the full range of a top university's traits like teaching excellence, research excellence, knowledge transfer sectors, and finally international outlook. All these four Universities are available in both English and Norwegian languages and the potential students who visit the web pages of these Universities for information may be of different nationalities, i.e. Native students from Norway and international students. Homepage (and pages 1-level down) were evaluated. We evaluated Homepage, Contact Page, and About Page using two different automated tools of each 4 Universities. The homepage was evaluated at first because it is the portal through which the user visits to access the website and if the home page is inaccessible, the user with a disability cannot access the part of the website (Lazar & Greenidge, 2006). Moreover, pages 1-level were evaluated because the homepage alone does not represent the accessibility and

usability of the entire website and the homepage and level-1 represent the site (Hackett & Parmanto, 2009).

4.3 Evaluation using Automated Evaluation Tools

A plethora of automated accessibility and usability evaluation tools are available for both commercial and free purposes for web accessibility evaluation. In this paper, we have chosen two automated tools WAVE (WebAIM, 2019) and Total Validator (Total Validator, 2019) to evaluate and assess the accessibility level of University web pages and compare the results with each other. Automated tools are essential to check the minimal accessibility level of the website and totally relying on automated tests alone has negative effects as automated tools cannot thoroughly check accessibility issues of the web pages (Kurt, 2011; Vigo, Brown, & Conway, 2013). That's why further user testing is also implemented in this research to support the additional accessibility issues on the web pages. Due to the limitation of time, manual evaluation was not implemented in this study.

Based on the tools used in previous existing research (Ahmi & Mohamad, 2016; Bakhsh & Mehmood, 2012; Ismail & Kuppusamy, 2018; Reis et al., 2017; Solovieva & Bock, 2014), the researcher in this study chose two automated accessibility evaluation tools Total Validator and WAVE to report the accessibility issues of the websites. Total Validator is a free software for accessibility testing of webpages which ensure the accessibility of the website and uses valid HTML and CSS with no broken links, and check against the WCAG 2.1 compliance (Total Validator, 2019). Similarly, WAVE (Web Accessibility Evaluation Tool) is a WAVE is a free web accessibility evaluation tool which presents a visual description of accessibility issues in webpages (W3C, 2006). These both tools test webpages against the latest WCAG 2.1 guidelines, supports direct ULR submission strategy and generate the detailed WCAG 2.1 conformance level (A, AA, and AAA). These are the reasons two automated tools are selected to evaluate the selected University Websites. The sampled screenshot report of these two tools are illustrated in Screenshot of web accessibility issues reported by WAVE Tool*Figure 4.1* and *Figure 4.2*.

Figure 4.1 Screenshot of web accessibility issues reported by WAVE Tool

Figure 4.2 Screenshot of web accessibility issues reported by Total Validator tool

4.3.1 Procedure for Automated Accessibility Testing

The automated tools are simple to use, and they provide the necessary checks beforehand regarding the accessibility or usability issues based on accessibility guidelines. In this study, the following procedures have been followed to check the existing accessibility issues of the University web pages:

1. Select webpages from the University and enter into the automated tool URL Address toolbar (**WAVE and Total Validator**) for evaluating the accessibility reports of the selected university web pages.
2. The automated tools then report the usability and/or accessibility barriers of the webpages.
3. The gathered results of same webpages from different automated testing tools are compared and correlate each other. This step is to address the most common accessibility and usability challenges the screen reader users against the WCAG 2.1 guidelines.
4. The test results are again analyzed using Web Accessibility Metrics to address the level of accessibility issues the web pages encounter.
5. The web accessibility metrics of similar web pages are compared with each other.

4.4 Test Metrics and Measurements

Web accessibility metrics are important tools that provide the debrief report on accessibility level of websites (W3c, 2012). We used two automated evaluation tools as mentioned in the above section to evaluate the different web pages of University websites against Web Content Accessibility Guidelines (WCAG) 2.1 which is categorized into four principles; 1. Perceivable, 2. Operable, 3. Understandable, and 4. Robust and they are further subdivided into 13 guidelines. Among those guidelines, we selected the checklists for screen reader users which are presented in

Post Web Accessibility Interview

1. What were the most remarkable accessibility issues you encountered while browsing the different webpages of University from screen reader?
2. What do you think the main reasons behind the occurrence of these issues?

Appendix G

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WCAG 2.1 has further defined its guidelines with three different levels of conformance: A (lowest), AA, and AAA (highest). In this study, only conformance Level AA of the webpage is tested because according to (W3C) documentation, Level AAA conformance is not a must in a general policy for the whole website as it not practicable to meet the whole Level AAA Success Criteria for some content. We chose Level AA conformance because it fulfills both Level A and Level AA conformance of the web pages.

4.5 Participants

To investigate the research problem and research questions, we conducted both observational and experimental study with 16 visually impaired participants. A pilot testing study with 1 visually impaired residing within Norway and 1 fully blind participant residing in Nepal (remotely) was conducted to get the beforehand experience in facilitating the time and test tasks. The pilot studies are considered the best practice to determine the feasibility of full-scale study and it strengthen the feasibility of the entire study (Thabane et al., 2010).

15 Nepalese and 1 Norwegian with some type of visual disabilities volunteered to take part in research. Ten of the total participants were partially blind and 6 were legal blind. In addition, all the participants had more than 2 years of experience in interacting the webpages with screen reader tools. The average age of the participants was 29.5 years old and all were at least bachelor's degree graduate. All participants used their own personal computer for the user testing. In addition, among the participants, 9 used the NVDA screen reader tools and 7 were JAWS screen reader users.

4.5.1 Duration of User Testing

The user testing duration for each participant took around 1-1.5 hours on average varying based on the number of tasks per University websites they were assigned. Although it was expected from the pilot testing that it would take more than 2 hours for each participant to evaluate the usability and accessibility feedbacks of four different university websites, the testing with other participants went smoother and quicker than expected. Comparatively, remote user testing on usability and accessibility tasks took longer time than face-to-face user testing because of the various external technical issues.

4.6 System Usability Scale (SUS)

System Usability Scale, also known as SUS is a Likert scale tool consisting of 10-item scale which provides the overall view of subjective assessments of usability of system (Brooke, 1996). In this study, SUS was used as a usability metric to evaluate the usability of the Norwegian University websites. (ISO, 2018) suggests usability metrics must cover following aspects:

- **Effectiveness**: The accuracy and completeness with which users accomplish specified goals in specific environment.
- **Efficiency**: The resources dispersed in relation to the accuracy and completeness of tasks with which users achieve specified goals.
- **Satisfaction**: The overall ease and acceptability of use of the system.

SUS score tells us our usability interpretation of the system in the aspects of effectiveness, efficiency, and satisfaction (UIUX Trend, 2017).

SUS has various attributes that make it a good alternative for general usability practitioners (Bangor, Kortum, & Miller, 2008):

1. The survey is technology free and is flexible enough to cover a broad range of technology.
2. It is relatively fast and easy to implement.
3. The survey provides a single score on a scale that is easily understood by the wide range of people even to people who have little experience on usability or human factors.
4. It is nonproprietary, making it a cost-effective tool.

The participants were assigned to perform a series of usability tasks for four different websites using screen reader tool and were asked to score the ten questionnaires with the scale ranging from Strongly Agree to Strongly Disagree consisting of 5 Likert scale in each questionnaire as follows:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

From the above ten questions, we only changed the word “system” with “website” in each item to collect the response from the participant. In addition, in each item above, the participants were asked to score with one of the five immediate responses ranging from Strongly Agree to Strongly Disagree without thinking too long as follows:

- Strongly Disagree: 1 point
- Disagree: 2 points
- Neutral: 3 points
- Agree: 4 points
- Strongly Agree: 5 points

Interpreting SUS scores

Deploying SUS score is fast and easy. Sauro (2011) has simply explained the scoring technique of SUS from the collected results as follows:

1. For odd items (1,3,5,7,9): subtract one from the user feedback.
2. For even-numbered items (2,4,6,8,10): subtract the user feedback from 5.
3. This scales all values from 0 to 4 (The most positive response is the highest number four).
4. Sum up the converted responses for each participant and multiply the total calculated value by 2.5.

The average SUS score is 68 which means that a score of above 68 is considered above average and anything under 68 is below average (Brooke, 1996). Below measure gives us the basic understanding of SUS score:

Table 4.1 SUS Score Grading Overview

SUS Score	*Grade*	*Adjective Rating*
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay

51 - 68	D	Poor
< 51	F	Awful

4.7 Web Accessibility Questionnaires

The tasks are based on the following checks categorized into five headings as per (W3c, 2017a) documentation:

- ❖ Page title
- ❖ Image text alternatives ("alt text") (pictures, illustrations, charts, etc.)
- ❖ Text:
    - Headings
    - Contrast ratio ("color contrast")
    - Resize Text
- ❖ Interaction:
    - Keyboard access and visual focus
    - Forms, labels, and errors (including Search fields)
- ❖ General:
    - Moving, Flashing, or Blinking Content
    - Multimedia (video, audio) alternatives
    - Basic Structure Check

4.8 Ethical Considerations

This section covers the ethical codes and policies conducted while performing research mainly during the data collection procedure. Ethics has become foundation for conducting a successful and significant research (Drew, Hardman, & Hosp, 2007). While conducting research, there are some elements in ethical codes to be considered throughout the interview process of the participants. Some of the principles include:

1. Discuss intellectual property frankly
2. Be conscious of multiple role
3. Follow informed consent-rules
4. Respect confidentiality and privacy

5. Tap into ethics research (Smith, 2003)

This study used all of the above principles in hope of ensuring the promotion of research like knowledge, truth, and avoidance of error (Resnik, 2011). Before user testing process took place, the participants were all clearly informed their involvement in the research, what they were consenting to, and the result of participation in the study (NSD, 2019).

Further, they were all informed that they could withdraw from the research study at any time. The identity of the participants was remained anonymous and no personal information like participant's name, address, date of birth, video/photo recording, sound recording, genetic/biometric information, etc. were recorded. Since only anonymous information of participants is processed, the project was not reported to the Norwegian Centre for Research Data (NSD) for approval.

Chapter 5 Data Collection and Results

This section covers the results obtained from automated tools, questionnaires, and interviews.

5.1 Automated Evaluation Tools Reports

In this study, we used two automated tools to evaluate the accessibility level of Norwegian University web pages. Homepage (and pages 1-level down were assessed using the automated accessibility evaluation tools. Total of 12 web pages of the four University websites: Homepage, Contact Page, and Study Program Page were evaluated using these tools. The homepage was evaluated at first because it is the portal through which the user visits to access the website and if the home page is inaccessible, the user with a disability cannot access the part of the website (Lazar & Greenidge, 2006). Moreover, pages 1-level were evaluated because the homepage alone does not represent the accessibility of the entire website and the homepage and level-1 represent the site (Hackett & Parmanto, 2009).

5.1.1 Automated Testing Total Errors Overview

This section outlines an overview of accessibility issues generated by WAVE and Total Validator automated tools for the home pages, contact pages, and master's program pages of four University websites. These both tools report the total errors and total alerts/warnings as per WCAG 2.1 accessibility guidelines. In addition, the WAVE tool also reports the contrast ratio of each webpage which the Total Validator does not outline. The total errors illustrated by these tools signify the issues needed to be fixed immediately whereas, total alerts or total warnings indicate the potential issues may require further human evaluation. Similarly, the contrast issues reports that there is low contrast ratio between the text and background which needs so that people with low vision do not have complications reading the contents on the web (W3c, 2016d).

WAVE

The WAVE accessibility evaluation tool was run on OS Windows 10 using web browser Google Chrome Version 70, 64-bit to check the accessibility issues on UiS, UiT, USN, and UiA web pages.

i. **Automated Results of Main Page**

Feil! Fant ikke referansekilden. and Feil! Fant ikke referansekilden. provide a summary of the accessibility issues detected by WAVE and Total Validator tools for the homepages of each selected university websites against WCAG 2.1 guidelines. The Wave tool reports the issues into errors (valid errors), alerts (possible errors), and contrast errors while total validator detects the problems into errors (valid errors) and warnings (possible errors).

ii. **Automate Results of Course Program Taught in English Page**

Similarly, **Feil! Fant ikke referansekilden.** and **Feil! Fant ikke referansekilden.** presents the accessibilities issues detected by WAVE and Total Validator tools for the Program Taught in English web page of each selected university websites.

iii. Automate Results of Contact Page

The accessibility errors of the contact page of four University website are described in **Feil! Fant ikke referansekilden.** and **Feil! Fant ikke referansekilden.**. As explained in the above section, WAVE tool reports the accessibility of errors into three parts as errors, alerts, and contrast errors while Total Validator tool outlines the accessibility issues of the contact page of selected universities into errors and warnings. WCAG 2.1 Guidelines AA checkpoint violated by University Web Pages

The tables in this section explain each checkpoint errors of four selected University against WCAG 2.1 principles: 1. Perceivable, 2. Operable, 3. Understandable, and 4. Robust reported by the automated tools. We chose to evaluate the webpages against Level AA conformance of WCAG guidelines, which tests both Level A and Level AA. As mentioned in the above methodology section, we opted out Level AAA conformance WCAG guidelines evaluation in this study.

5.1.2 University of Stavanger (UiS) Results Overview

Feil! Fant ikke referansekilden. and **Feil! Fant ikke referansekilden.** demonstrates the problems or issues identified by WAVE and Total Validator tools concerning the WCAG 2.1 success criteria in Level A and AA on three selected webpages of University of Stavanger website.

5.1.3 University of Tromso (UiT) Results Overview

Feil! Fant ikke referansekilden. illustrates the problems identified by WAVE and Total Validator tools concerning the WCAG 2.1 success criteria in Level A and AA on three selected webpages of the University of Tromso website.

5.1.4 University of South-Eastern Norway (USN) Results Overview

Similarly, **Feil! Fant ikke referansekilden.** and **Feil! Fant ikke referansekilden.** explains the problems or issues identified by WAVE and Total Validator tools against the WCAG 2.1 success criteria in Level A and AA on three selected webpages of University of South-Eastern website.

5.1.5 University of Adger (UiA) Results Overview

Likewise, **Feil! Fant ikke referansekilden.** and **Feil! Fant ikke referansekilden.** show the problems or issues identified by WAVE and Total Validator tools with reference to the WCAG 2.1 success criteria in Level A and AA on three selected webpages of University of Adger website. User Testing

5.1.6 System Usability Scale (SUS)

After conducting the usability testing, the participants were instantly asked to answer the ten questionnaires relating the website usability via Google Form. To measure the usability level of four Norwegian University websites, we implemented the System Usability Score (SUS) to collect data and contrast them with each other. Table 5.1,

Table 5.2,

Table 5.3, and Table 5.4 Illustrates the SUS score rating of 16 participants on four

SUS Questionnaires	Participant ID															
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
1	4	3	3	3	4	5	5	3	4	5	3	4	4	3	4	4
2	1	2	2	3	3	3	3	2	1	3	2	1	3	1	1	1
3	4	4	4	2	3	3	3	4	4	3	4	4	4	3	5	4
4	1	1	2	3	2	1	1	1	1	1	1	1	1	4	2	1
5	4	3	3	3	4	4	4	3	4	4	3	4	4	2	3	4
6	2	2	3	4	3	2	2	2	2	2	2	2	2	2	2	2
7	4	4	3	3	4	4	4	4	4	3	4	4	4	4	4	4
8	3	3	2	4	3	3	2	3	3	3	3	3	2	2	2	3
9	4	3	3	3	3	5	5	3	4	3	3	4	4	3	5	4
10	2	2	2	4	2	2	2	2	2	5	2	2	2	3	2	2
Total	29	27	27	32	31	32	31	27	29	32	27	29	30	27	30	29
SUS Score	77.5	67.5	62.5	40	62.5	75	77.5	67.5	77.5	52.5	67.5	67.5	75	57.5	80	77.5

University websites. In the table, SUS questions are presented in one separate column and the response from the Participants are displayed in another column with individual participant ids. The interpretation of the SUS score is calculated in reference to the section explained in section 0.

Table 5.1 System Usability Score of University of Stavanger (UiS)

SUS Questionnaires	**Participant ID**															
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
1	3	2	4	3	2	3	3	2	3	3	4	3	2	4	3	3
2	4	3	2	4	4	4	4	3	4	4	2	3	4	2	4	4
3	2	4	4	2	2	2	2	3	2	2	4	2	4	4	2	2
4	4	2	2	4	3	4	4	2	4	4	2	2	4	2	4	4
5	3	3	3	3	2	5	3	4	5	3	3	3	3	3	3	5
6	2	3	3	2	4	2	2	3	1	2	3	3	2	2	2	2
7	2	3	4	4	3	5	3	3	4	2	4	5	3	4	2	5
8	3	2	2	3	3	3	3	2	3	3	2	3	3	2	3	3
9	4	4	4	3	4	3	4	4	3	4	4	4	4	4	4	3
10	4	2	2	2	2	4	3	2	3	4	1	4	3	1	4	4
Total	31	28	30	30	29	35	31	28	32	31	29	32	32	28	31	35
SUS Score	42.5	60	70	50	42.5	52.5	47.5	60	55	42.5	72.5	55	50	75	42.5	52.5

Table 5.2 System Usability Score of University of Tromsø (UiT)

SUS Questionnaires	Participant ID															
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
1	3	2	2	3	3	2	3	2	2	2	3	3	2	3	2	4
2	2	4	4	3	3	3	2	4	4	3	2	4	2	4	4	2
3	2	2	3	4	4	2	2	3	3	3	3	3	3	3	2	4
4	4	3	4	3	2	3	4	2	3	3	3	3	2	3	4	1
5	2	3	3	3	3	2	2	3	4	3	2	3	2	3	3	3
6	3	3	3	4	2	2	3	2	3	2	3	3	2	2	3	2
7	3	3	2	3	2	3	3	3	4	4	4	4	3	3	4	4
8	2	3	3	4	3	3	2	3	3	3	2	2	2	3	3	2
9	2	3	3	3	4	2	3	3	3	3	4	3	3	4	4	3
10	4	3	2	3	4	3	4	3	2	2	2	2	1	3	3	2
Total	27	29	29	33	30	25	28	28	31	28	28	30	22	31	32	27
SUS Score	42.5	42.5	42.5	47.5	55	42.5	45	50	52.5	55	60	55	60	52.5	45	72.5

Table 5.3 System Usability Score of University of South-Eastern Norway (USN)

SUS Questionnaires	Participant ID															
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
1	4	3	3	3	4	5	5	3	4	5	3	4	4	3	4	4
2	1	2	2	3	3	3	3	2	1	3	2	1	3	1	1	1
3	4	4	4	2	3	3	3	4	4	3	4	4	4	3	5	4
4	1	1	2	3	2	1	1	1	1	1	1	1	1	4	2	1
5	4	3	3	3	4	4	4	3	4	4	3	4	4	2	3	4
6	2	2	3	4	3	2	2	2	2	2	2	2	2	2	2	2
7	4	4	3	3	4	4	4	4	4	3	4	4	4	4	4	4
8	3	3	2	4	3	3	2	3	3	3	3	3	2	2	2	3
9	4	3	3	3	3	5	5	3	4	3	3	4	4	3	5	4
10	2	2	2	4	2	2	2	2	2	5	2	2	2	3	2	2
Total	29	27	27	32	31	32	31	27	29	32	27	29	30	27	30	29
SUS Score	77.5	67.5	62.5	40	62.5	75	77.5	67.5	77.5	52.5	67.5	67.5	75	57.5	80	77.5

Table 5.4 System Usability Score of University of Adger (UiA)

SUS Questionnaires	Participant ID															
	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**	**P16**
1	3	3	3	4	3	4	4	4	4	4	3	4	4	3	4	3
2	2	2	2	3	2	2	2	2	2	2	2	1	3	2	2	2
3	3	3	3	3	3	4	4	4	4	4	3	3	3	3	3	3
4	2	2	2	1	2	1	1	2	1	1	2	2	1	2	2	2
5	4	4	4	3	4	4	4	4	3	5	4	3	4	4	3	4
6	2	2	2	4	3	2	2	1	2	3	2	2	2	3	1	2
7	4	3	3	3	4	4	4	4	4	4	4	3	3	3	4	3
8	2	3	2	2	3	2	2	2	2	1	2	3	2	3	2	2
9	4	3	4	4	3	4	4	4	4	4	4	4	4	3	3	3
10	2	3	3	3	3	2	2	2	1	2	2	1	2	3	2	3
Total	28	28	28	30	30	29	29	29	27	30	28	26	28	29	26	27
SUS Score	70	60	65	60	67.5	77.5	77.5	77.5	77.5	80	70	70	70	57.5	70	62.5

5.1.7 Accessibility Level Results of Norwegian University Websites

The participants were given immediate tasks to answer six accessibility questions with two further sub-questions after they user testing. The accessibility tasks were prepared based on the documentation provided by (W3c, 2017a) to assess the essential web accessibility in a simpler way. These tasks are designed to check the quick and easy accessibility issues rather than definitive as suggested by the documentation. A further human evaluation may also be needed to reevaluate the accessibility barriers of the webpages since it presents an essential checks of web accessibility only.

Table 5.5, Table 5.6, Table 5.7, and Table 5.8 explain the overall accessibility responses which the participants answered based on the online questionnaire from the google form. However, some of the questions prepared in this study were not designed for all groups of screen reader users and they were asked to skip the question. For instance, one of the questions was related to the accessibility aspect of resizing text or zooming in/out text via keyboard shortcut. This doesn't make sense to

some group of disability, especially blind students and therefore, these questions were skipped by the such kind of participants. Moreover, the different group of users were informed beforehand they could omit any question if they weren't confident enough to answer it. The collected data was further converted into percentage based on the responses provided by the number (**n**) of users answered the particular question.

Table 5.5 Overall Accessibility Response of the University of Tromsø (UiT)

<table>
<tr><th>Accessibility Questionnaires</th><th colspan="6">Overall Response of UiT</th></tr>
<tr><td rowspan="2">1</td><td colspan="3">Yes</td><td colspan="3">No</td></tr>
<tr><td colspan="3">100% (n=16)</td><td colspan="3">0% (n=0)</td></tr>
<tr><td rowspan="2">2</td><td>Most of the images had alternative texts but they weren't all quite meaningful.</td><td>Most of the images didn't have alternative texts.</td><td>Most of the images have alternative texts but only some were meaningful.</td><td>Most of the images had alternative texts and they all had meaningful text.</td><td>I didn't have to scan any images.</td><td>Only some images had missing alternative text.</td></tr>
<tr><td>25% (n=4)</td><td>6.3% (n=1)</td><td>6.3% (n=1)</td><td>50% (n=8)</td><td>6.3% (n=1)</td><td>6.3% (n=1)</td></tr>
<tr><td rowspan="2">3</td><td colspan="3">Yes</td><td colspan="3">No</td></tr>
<tr><td colspan="3">40% (n=6)</td><td colspan="3">60% (n=9)</td></tr>
<tr><td>4</td><td colspan="2">The font size of the web pages was visible enough for me.</td><td colspan="2">I had to use the keyboard shortcut to increase/decrease some font size within the pages.</td><td>N/A</td></tr>
</table>

	26.7% (n=4)	33.3% (n=5)	40% (n=6)
5	Yes		No
	43.8% (n=7)		56.2% (n=9)
6	Yes		No
	75% (n=12)		25% (n=4)
6.1	Yes		No
	85.7% (n=12)		14.3% (n=2)
6.2	No Errors while submitting the form.		There were errors, but they were easily findable.
	78.6% (n=11)		21.4% (n=1)

Table 5.6 Overall Accessibility Response of University of Stavanger (UiS)

Accessibility Questionnaires	**Overall Response of UiS**			
1	Yes		No	
	100% (n=16)		0% (n=0)	
2	Most of the images had alternative texts but they weren't all quite meaningful	Most of the images didn't have alternative texts.	Most of the images had alternative texts and they all had meaningful text.	Only some images had missing alternative text.
	43.8% (n=7)	6.3% (n=1)	43.8% (n=7)	6.3% (n=1)
3	Yes		No	
	12.5% (n=2)		87.5% (n=14)	
4	The font size of the web pages was visible enough for me.	I had to use keyboard shortcut to increase/decrease some font size within the pages.	N/A	
	30.8% (n=4)	23.1% (n=3)	46.2% (n=6)	
5	Yes		No	
	37.5% (n=6)		62.5% (n=10)	
6	Yes		No	

	81.25% (n=13)	18.75% (n=3)
6.1	Yes	No
	93.3% (n=14)	6.7% (n=1)
6.2	No Errors while submitting the form.	There were errors, but they were easily findable.
	80% (n=13)	20% (n=3)

Table 5.7 Overall Accessibility Response of University of South-Eastern Norway (USN)

Accessibility Questionnaires	**Overall Response of USN**	
1	Yes	No
	86.7% (n=13)	13.3% (n=2)
2	Most of the images had alternative texts but they weren't all quite meaningful.	Most of the images had alternative texts and they all had meaningful text.
	68.75% (n=11)	31.25% (n=5)
3	Yes	No
	25% (n=4)	75% (n=12)
4	The font size of the web pages was visible enough for me.	I had to use the keyboard shortcut to increase/decrease some font size within the pages. N/A
	88.9% (n=8)	11.1% (n=1)
5	Yes	No
	37.5% (n=6)	62.5% (n=10)
6	Yes	No
	56.25% (n=9)	43.75% (n=7)
6.1	Yes	No

	78.6% (n=11)	21.4% (n=3)
6.2	No Errors while submitting the form.	There were errors, but they were easily findable.
	86.7% (n=13)	13.3% (n=2)

Table 5.8 Overall Accessibility Response of University of Adger (UiA)

Accessibility Questionnaires	**Overall Response of UiA**		
1	Yes		No
	93.75% (n=15)		6.25% (n=1)
2	Most of the images had alternative texts but they weren't all quite meaningful	No image to Navigate.	Most of the images had alternative texts and they all had meaningful text.
	18.75% (n=3)	18.75% (n=3)	62.5% (n=10)
3	Yes		No
	18.75% (n=13)		81.25% (n=13)
4	The font size of the web pages was visible enough for me.	I had to use keyboard shortcut to increase/decrease some font size within the pages.	N/A
	46.7% (n=7)	13.3% (n=2)	40% (n=6)
5	Yes		No
	68.75% (n=11)		31.25% (n=5)
6	Yes		No
	68.75% (n=11)		31.25% (n=5)
6.1	Yes		No
	92.85% (n=13)		7.15% (n=1)
6.2	No Errors while submitting the form.		There were errors, but they were easily findable.
	92.85% (n=13)		7.15% (n=1)

Chapter 6 Statistical Analysis of Results

6.1 Automated Tools Analysis

6.1.1 Wave Tool Report of Four University Web Pages

Figure 6.1 illustrates the total accessibility errors, alerts, and contrast errors generated by WAVE automated tools after evaluating four Norwegian University Websites. The potential errors, probable alerts, and contrast issues are aggregated together from three web pages, i.e., home page, contact page, and study program page of each university.

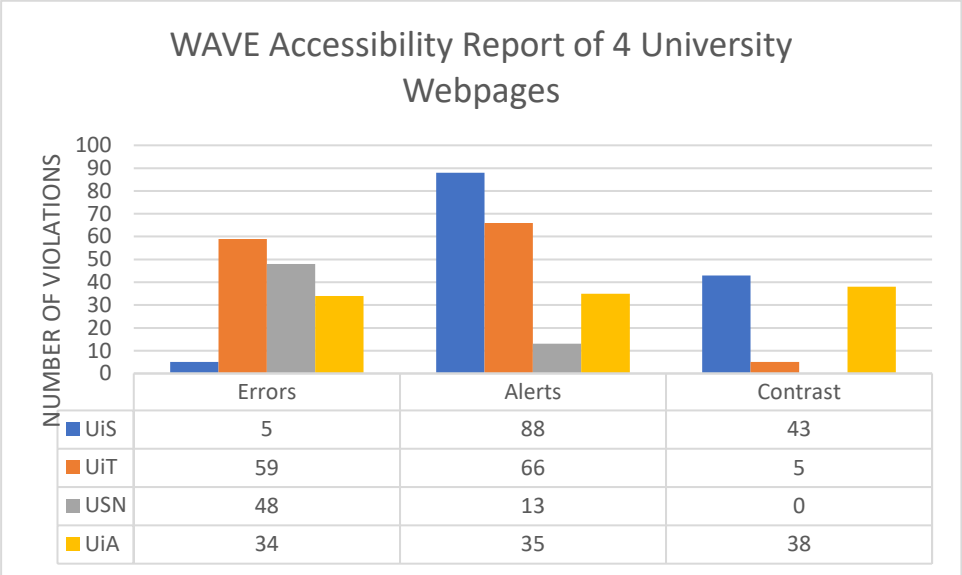


Figure 6.1 WAVE Accessibility Report of University Web Pages

6.1.2 Total Validator Tool Report for Each University Web Pages

Similarly, *Figure 6.2* describes the total accessibility errors and warnings generated by Total Validator automated tools of four Norwegian University Websites. The total precise errors and total probable warnings are calculated adding the respective issues of three web pages; home page, contact page, and study program page of each university websites. As we can see, the errors and warnings of the University of Tromsø webpages are relatively higher than that of the other three websites.

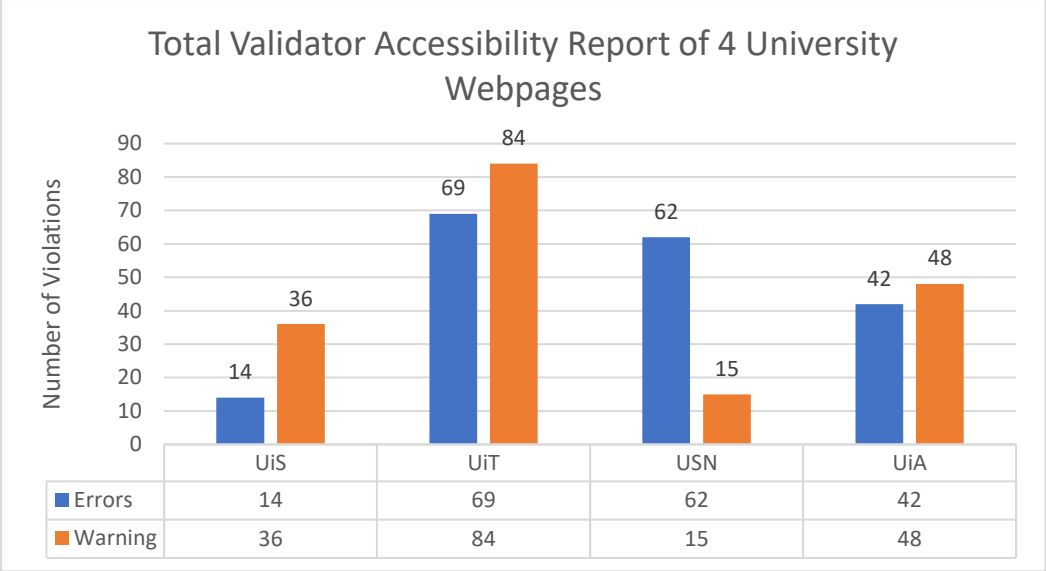


Figure 6.2 Total Validator Accessibility Report of University Web Pages

6.1.3 Statistical Interpretation of WAVE and Total Validator Tools

Table 6.1 further explains the average errors and standard deviation of reported issues generated by WAVE and Total Validator tools on four University websites. The WAVE automated tool reported the total errors of 146 while performing the accessibility evaluation check on four University websites. Moreover, WAVE reported 202 alerts which means the further expert review is necessary for a manual evaluation to check the conformance of these issues. There was also a total of 86 contrast errors on the University webpages as per WAVE tool evaluation.

In addition, the total validator tool outlined a total of 187 critical errors and 183 warnings of four University websites. The table represents that the number of errors reported by total validator is higher than that of WAVE tool. In contrast, the warnings reported by the WAVE tool for University websites is higher than the total validator tool. The mean of Total Validator tool is higher than the WAVE tool and the standard deviation of WAVE tool is higher than Total Validator tool. In contrast to the WAVE tool, the Total validator tool reported that the number of errors is relatively more significant than the reported warnings which need to be reduced to achieve successful accessibility.

Table 6.1 Mean and Standard Deviation of Automated Tools Report

Automated Tools	WAVE			Total Validator	
	Errors	Alerts	Contrast	Errors	Warnings
Total Errors	146	202	86	187	183
Mean	36.5	50.5	21.5	46.75	45.75
Standard Deviation	23.35	33.13	22.12	24.65	28.91

6.1.4 Statistical Interpretation of WCAG 2.1 checkpoints violated by automated tools

Table 6.2 explains the comparative accessibility checkpoints against WCAG 2.1 by two automated tools in percentage. Level A and Level AA conformance are distinguished based on the WCAG 2.1 criteria violated by Universities using automated tools.

Table 6.2 Percentile of accessibility issues reported by two automated tools

Checkpoint	**WAVE**	**Total Validator**
	Percentage	Percentage
Level A Conformance		
1.1.1	100	100
1.3.1	100	100
2.2.1	25	N/A
~~2.2.2~~	~~25~~	~~N/A~~
2.4.1	100	100
2.4.2	75	N/A
2.4.3	50	50

2.4.4	100	100
2.5.3	N/A	50
3.1.1	25	25
3.2.2	N/A	50
3.3.2	100	100
4.1.1	N/A	75
4.1.2	N/A	100
Level AA Conformance		
1.4.3	75	N/A
1.4.4	N/A	75
2.4.6	100	N/A

6.2 User Testing Analysis Overview

6.2.1 Usability Analysis of Norwegian University Websites based on questionnaire/survey (SUS)

After the usability tasks were performed with the participants, they were immediately provided with the online questionnaire to be filled out via online google form consisting of 10 item questions rating scale from 1 – 5 of difficulty level. Then the system usability score of each website was generated based on the response provided by the participants. **Figure 6**.3 illustrates that most of the participants rated the University of Adger (UiA) to be more usable than other University web pages while University of South-Eastern Norway (USN) comes to closer to UiA in terms of acceptance of usability.

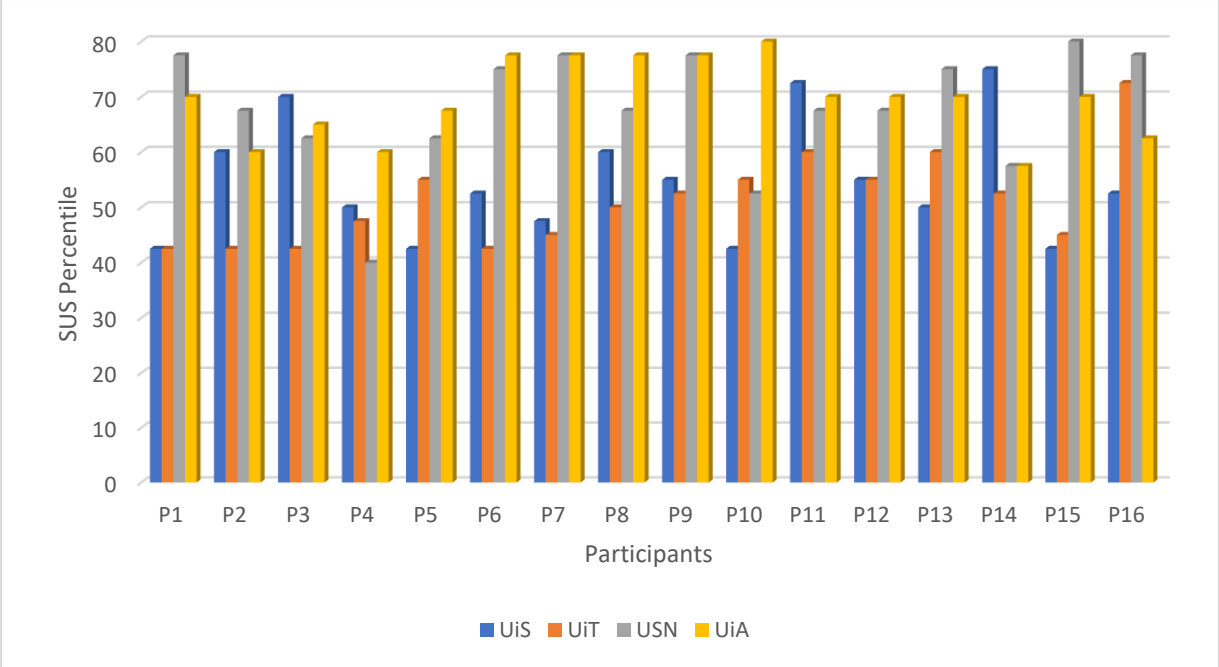
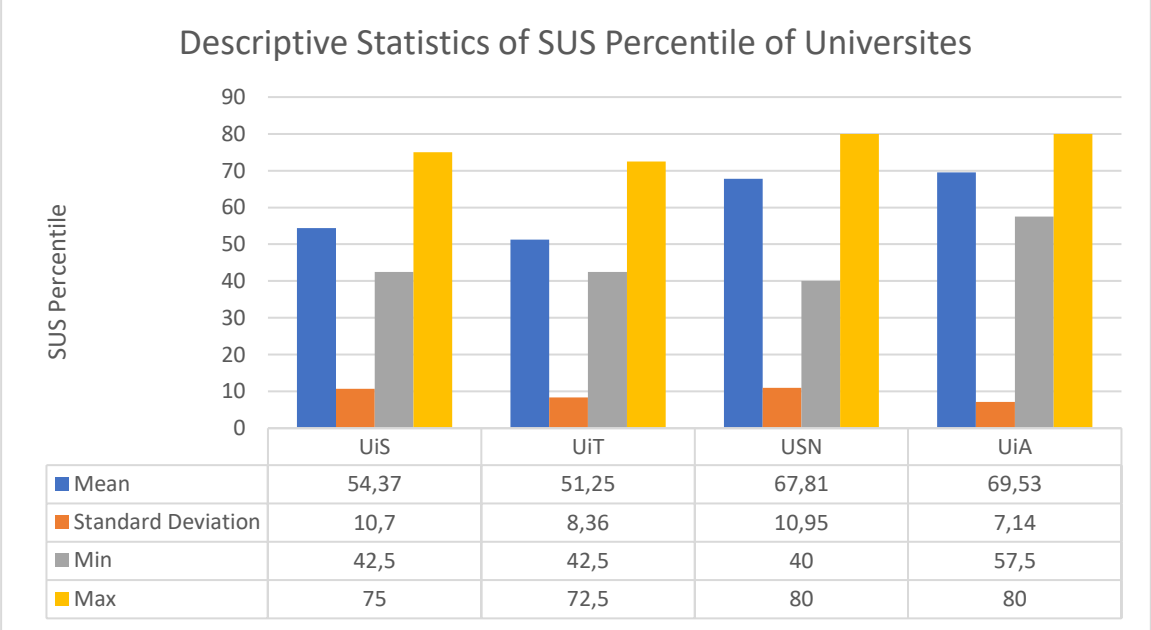


Figure 6.3 SUS rating of 16 participants for Norwegian University websites



	UiS	UiT	USN	UiA
Mean	54,37	51,25	67,81	69,53
Standard Deviation	10,7	8,36	10,95	7,14
Min	42,5	42,5	40	57,5
Max	75	72,5	80	80

Figure 6.4 Descriptive Statistics of SUS Percentile of Universities

Following the usability interpretation in the study (Brooke, 1996), the usability score rated by the participants shows that only University of Adger (UiA) website is acceptable against the usability principle and the remaining three University websites; Uis, UiT, and USN fall below average of usability scale i.e. 68, as

explained in Figure 6.4. The analysis of the usability scale in above figure further indicates that only USN comes close to the average usability scale (68) and UiS and UiT are below average when it comes to usability of the website.

6.2.2 Usability Analysis of the Norwegian University Websites based on the interview

After the online survey was performed with the participants based on user tasks, the participants were asked a further open-ended question to give their further opinion on the most commonly occurring issues or difficulty they encountered on University websites were:

1. Media: Video automatically playing and the page not having the option to pause the video. For visually impaired users, it messed up their eyesight.
2. Duplicate Page titles. Due to this, the users who relied on screen reader tools had difficulty distinguishing the pages.
3. Unstructured linked lists and headings. Due to this, screen reader tools had to scan the whole page to find the desired content which could have been.
4. The screen reader tool reading the web page contents in Norwegian Accents.
5. Poorly designed breadcrumbs which confuse the screen reader tools.
6. Browser compatibility issues of screen reader tool. Some participants had to switch to other browsers to complete some tasks when they couldn’t accomplish them in one browser.
7. The search form within the website not providing relevant results. Instead, when searched on a google search engine, they were able to accomplish the pertinent contents.

6.2.3 Accessibility analysis of Norwegian University websites based on the questionnaire

The participants were again immediately asked to perform another web accessibility online survey on four university websites via google form link after completing the usability survey. As mentioned in the above sections, the participants were asked 5 questions based on web accessibility documentation provided by W3c. We’ve thoroughly analyzed

6.2.3.1 Page Title Accessibility Analysis

The participants were asked if their screen reader failed to read the Page Title of the web page on the University while performing the tasks. The first thing screen reader tools read out loud is the page title when the user goes to any page (W3c, 2017a). Comparatively, all the participants responded that the page title was descriptive and meaningful enough accordance with the web page they have surfed for University of Tromso and University of Stavanger websites. However, 2 participants claimed, while browsing the University of South-Eastern Norway web pages, that the screen reader tool didn't read out the title of some webpages. In addition, 1 out of 16 participants complained the University of Adger didn't have a descriptive page title. To confirm these issues, we manually checked all 3 web pages (Home Page, Contact Page, and Study Program Page) of all 4 selected Universities. We then discovered that the all the webpage had clearly defined Page Title coded as *<title> </title>* in all webpages. We, then later, performed a follow-up checkup with the participants who were having difficulty with their screen reader finding the page title. As expected, the issue was due to the browser incompatibility with the screen reader tool. Trying with different updated browser paired with the screen reader tools they were using.

6.2.3.2 Image Text Accessibility Analysis

The 16 participants who relied on screen reader software were asked to provide a response to one of the questionnaires which were based on text alternative on the images including charts, pictures, illustrations, etc. as well. As mentioned in the above sections, all the usability and accessibility surveys/questionnaires were prepared based on the usability testing of the websites. Therefore, the users didn't necessarily have to scan through all the images to answer the question related to image text accessibility. Meaning, the users may have opted out or didn't have to scan the image or charts using screen reader while conducting the testing beforehand.

On average, 39% of the participants claimed that although the images had alternative texts, they weren't sure if they all contain the meaningful or appropriate alternative texts for the images based on 4 selected universities. In addition, 46.8% proclaimed that the text images had meaningful text when reading through webpages from screen reader tools. Alternatively, some participants responded that they didn't

have to scan through the images while performing the tasks via screen reader while very few claimed that the screen reader couldn't read out loud the text images on web pages.

6.2.3.3 Missing Heading or Structured heading Hierarchy Analysis

Almost every webpage has a heading and its sub-heading that highlights the necessary information about the website or the contents that are conveyed to the users. The headings can be typically be distinguished within the website as they are big and bold. However, for the non-visual users like visually impaired people, it is not possible to navigate the headings directly using the mouse. There is an availability of screen reader software, like JAWS and NVDA, which have inbuilt shortcuts to navigate through the different heading structure of the website (Deque University, 2013). That is why if the heading structures are clearly defined within a page, people who are solely dependent on screen reader do not struggle to navigate headings through the webpage.

From the survey, 14 out of 16 participants reported that the heading structure was clearly defined, and it was easy to navigate headings through screen reader tools while opening the University of Stavanger web pages. The University of Tromso had the worst heading structure according to the survey response, as 6 out of 16 participants stated the wrong heading structure and some web page missing correct headings. In addition, while browsing the University of South-Eastern Norway website, 12 participants could easily navigate the headings using the keyboard shortcut and the remaining 4 participants struggled to discover the heading structure on their screen reader tools. Lastly, 13 out of 16 participants were satisfied on the website containing the structured headings and 3 participants had some difficulties finding headings on their screen reader tools while opening the University of Adger web pages.

6.2.3.4 Font Size Visibility or Text Resizing Analysis

Among 16 participants, there were six blind volunteers and ten partially blind people. One of the options within this questionnaire was regarding visibility of the text size, therefore, this could only be answered by the participants who could see the contents on the website. However, the blind participant could skip the responses and answer

with “N/A or not available” option. Therefore, only 10 participants’ data were recorded to analyze the accessibility of the selected university web pages.

While opening the University of Stavanger website, 4 visually impaired participants stated that the font-size of the text was visible enough to them within the page, while 3 participants reported that they had to use the keyboard short-cut to resize the text so that the contents would appear visible enough to them. Likewise, in the University of Tromsø webpage accessibility survey, 5 participants had difficulty perceiving the substantial text content, so they had to use keyboard short-cut to make the text size bigger. In addition, only 1 participant had an issue with conceiving the text content because the font-size was too small and 8 participants found the content large enough to read while opening the University of South-Eastern Norway web pages. Lastly, the University of Adger accessibility response showed that only 2 participants used the keyboard shortcut to increase the font-size of the text. While observing the participants, they were all able to increase/decrease the text size in all browsers and the design of the webpage didn’t change at all. This means, the page was designed responsive and increasing and decreasing the page content didn’t affect the content structure.

6.2.3.5 Keyboard Navigation Analysis

All participants were asked to answer if the keyboard navigation and visual focus on the webpage were accessible enough. Surprisingly, more respondents reported that UiS, USN, and UiT website were difficult to navigate from keyboard and 11 participants who opened UiA website claimed that the keyboard supported all the webpages with keyboard navigation with the tab key with the current screen reader tool out of 16 participants.

6.2.3.6 Search Form Accessibility Analysis

While observing the participants’ activities during user testing, we noticed that most of them went through the search form to accomplish some tasks. Only a few participants were able to complete tasks without having to go to the search form.

14 out of 15 respondents claimed that the University of Stavanger form was accessible, and 12 participants reported there was no issue submitting the form. 3 participants, however, discovered the errors on the form but they were easily traceable. In addition, out of 14 respondents on University of Tromso accessibility

survey, only 2 participants observed the inaccessibility of the form on the page using screen reader tools. Further, 11 participants claimed no errors submitting the form and remaining 3 participants reported that the errors in the form were easy to locate despite having issues on the form submission. The degree of accessibility of the form responded by the participants on the University of South-Eastern Norway had no significant difference to that of the University of Tromsø. Lastly, the 13 out of 14 participants based on response stated that the form was accessible enough and remaining 1 reported the inaccessibility of the form while surfing through the screen reader tool.

6.2.4 Accessibility analysis of Norwegian University websites based on the interview

After participants completed accessibility questionnaire online, they were asked open-ended questions to provide their personal feedbacks related to accessibility issues on Norwegian University websites based on experience. Below are some remarkable accessibility problems they encountered while using screen reader tools:

1. Poor heading structure.
2. Poor link list structure.
3. Ambiguous links.
4. Screen reader incompatibility in the browser itself.
5. Inaccessible keyboard navigation.

Chapter 7 Discussion

In this section, the discussion of the significant findings of the study, comparison of the outcomes with the previous related studies, future recommendations, and limitations of the study are presented based on automated evaluation results and user analysis.

Additionally, the first section elucidates the summary of key findings of the study related to the research questions. The second section describes the implications of the results. The third section compares and contrasts the findings of this study with the previous studies.

7.1 Summary of The Key Findings

In this section, the summary of the significant findings of this study based on usability and accessibility evaluation of the selected Norwegian University webpages are briefly discussed. The main aim of this study is to discover the most common accessibility and usability issues; the screen-reader users experience while interacting with the contents provided by the Norwegian University web pages. To meet the desired objective, this study,

1. Measured the level of web accessibility conformance on Norwegian University webpages against WCAG 2.1 guidelines and user experience
2. Discovered the most common usability issues that screen reader users experienced on selected Norwegian websites
3. Determined the overall usability level of the four selected websites
4. Evaluated the level of results of two selected automated tools on assessing the selected web pages.

In this study, two evaluated methods, automated tools and user testing, were used to evaluate the accessibility and usability of Norwegian University websites. Two automated tools, WAVE and Total Validator were implemented to assess the accessibility of Norwegian University websites. Besides, online questionnaire and post-interviews were performed with 16 participants after user testing. The user testing consisted of 5 usability tasks and based on those tasks, the users were asked to respond via online usability and accessibility questions. Furthermore, the post-questionnaire with each participant was conducted for the analysis of qualitative data

and correlate the usability and accessibility results of quantitative data with the qualitative data. In addition, at least one or both tools determined that all the selected university webpages failed to meet the success criteria of WCAG 2.1 four principles; Perceivable, Operable, Understandable, and Robust.

In the second phase, the results from automated tools and user testing were analysed to answer the research question 2. *Which of the most common accessibility barriers screen reader students usually face while interacting with the different Norwegian University web pages from the user experience and automated tools?* From the analysis of automated tools results, the most common identified accessibility issues were described from high level to low level depending upon the issue reported by both automated tools on both websites:

High-Level Accessibility checkpoint issues

- Non-Text Area (*1.1.1*) – Both automated tools, WAVE and Total Validator, reported that the Level A conformance (1.1.1) checkpoints were violated by all four selected websites. At least one of the 3 selected web pages of each University were discovered missing “Non-text Area” checkpoint while analysing the automated tools.
- Info and relationship (*1.3.1*) – The two automated tools discovered that all the selected University websites failed to comply with Level A checkpoint *info and relationship*.
- Link Purpose (In Context) (*2.4.4*) – Both of the automated tools described that all four websites failed to meet the success criteria of Level A, 2.4.4, after analysing the collected data from automated tools.
- Labels or Instructions (*3.3.2*) – Failure of success criteria, Level A - 3.3.2, were detected by both selected automated tools in all University websites.
- Bypass Block (*2.4.1*) – The analysis report showed that, all four evaluated websites failed to meet Level A (2.4.1) success criteria from both automated tools.
- Heading and Label (*2.4.6*) - Total Validator and WAVE tools recorded that three university websites UiT, USN, and UiA failed to meet the Level AA success criteria - 4.4.2. Only the UiS website was discovered not passing

such conformance by the WAVE tool. However, Total Validator reported that UiS passed this checkpoint.

Low-Level Accessibility Checkpoint issues

- Focus Order (*2.4.3*) –WAVE tool reported two University websites, UiA and USN, failed to meet the success criteria Level A checkpoints while Total Validator detected UiS and UiA not passing this success criterion. This result is void since only common issues these tools detected meeting focus order checkpoint is University of Adger (UiA) website.
- Timing Adjustable (*2.2.1*) –After analysing the accessibility level of University webpages, only WAVE tool reported that the homepage of University of Tromso (UiT) didn't meet the Level A success criteria 2.2.1. Further, The WAVE tool failed to locate this issue in any webpage of other remaining 3 selected websites. In contrast, the total validator has shown no sign of such issue in any web pages of four evaluated websites.
- Page Titled (*2.4.2*) – Similarly, WAVE tool reported that three out of four Universities, i.e. UiS, UiA, and USN, didn't pass the Level A success criterion, 2.4.2. Total Validator failed to report such issue in any of the four websites.
- Label in Name (*2.5.3*) - Total Validator tool reported the Level A, 2.5.3, criterion issue on UiS and UiT University webpages and didn’t locate such problems on remaining two websites, i.e. USN and UiA. In contrast, WAVE didn’t discover such issue in any of the four University web pages.
- Language of Page (*3.1.1*) - WAVE and Total Validator tools detected 3.1.1 Level A conformance issue on the homepage of University of Tromso website. Other selected pages on UiT and remaining other three University webpages weren’t identified to missing this checkpoint by any selected automated tools.
- On Input (*3.2.2*) - One of the selected webpages in University of South-Eastern Norway and all three selected webpages of University of Adger (UiA) were reported failing to meet Level A 3.2.2 checkpoint. This issue was detected by Total Validator tool only, while, WAVE tool confirmed that all evaluated University webpages passed this conformance.
- Parsing (*4.1.1*) - Total validator tool reported that at least one or more pages of 3 Universities, i.e. UiS, UiT, and USN had Level A Parsing issue. The

WAVE automated tool showed no sign of this error on any evaluated websites.

- Name, Role, Value (*4.1.2*) – All four evaluated Universities reported by Total validator discovered to have missing Level A conformance issue on 4.1.2 checkpoint.
- Contrast (minimum) (*1.4.3*) – Level AA checkpoint 1.4.3 affected UiS, UiT, and UiA websites except for USN. This means these three universities violated the minimum required contrast ratio of at least 4.5:1. The manual check is necessary to confirm this issue. This issue was reported by WAVE automated tool only.
- Resize Text (*1.4.4*) - The assistive technology, for instance, keyboard magnifier can resize the text without losing the content of functionality. When evaluating with the total validator tool, the websites of UiT, USN, and UiA were found to be missing the Level AA (Resize Text) checkpoint.

The finding on the accessibility of the Norwegian Website based on a pre-defined online survey in this study suggests that the keyboard navigation is the most common accessibility issue which the screen reader users experience while using Norwegian University webpages. In addition, poorly organization of the heading is another accessibility concern to look into Norwegian University websites.

After the user testing, the participants were asked to provide their feedback and opinions regarding the most common accessibility barriers they experienced while performing the tasks on each University websites. These are some remarkable common accessibility problems reported by the 16 screen readers participants:

- Poor heading structure.
- Poor link list structure.
- Ambiguous links.
- Screen reader incompatibility in the browser itself.
- Inaccessible keyboard navigation.

Additionally, after the completion of usability tasks on each University website, all the participants were given online questionnaire form to give their response immediately to rate the usability level of the websites via SUS questionnaire as shown in

Appendix D. The analysis of the usability level of four selected website showed that only one of the four evaluated websites, i.e. University of Adger (UiA), was usable as per rated by 16 participants. All three remaining websites fell below average usability.

Based on the follow-up interview with participants, the most notable usability issues the screen reader users experienced are as follows:

- Automatic Video Playing and no option to pause or stop the video.
- Duplicate Page titles.
- Unstructured link lists and headings - Navigation
- Poorly design of breadcrumbs - Navigation
- Irrelevant search results on the search form.
- Alteration of screen reader accent when switching the webpage to a different language.

Similarly, the data results from the automated tools were analyzed to answer research question 2. *To what level of compliance do the Nordic University websites meet the criteria for successful inclusive web design following WCAG 2.1 guidelines using automated tools?* The analysis confirms that none of the evaluated websites are fully compliant to WCAG 2.1 guidelines on both selected automated tools. The four sample sized university websites are not even fully compliant to Level A success criteria of WCAG 2.1.

Lastly, to test the correlation of two automated tools, the data reported by the selected tools on the evaluation of selected University web pages were analyzed to answer research question 3. *What is the degree of agreement between two automated tools for the assessment of the accessibility of selected Norwegian University web pages?* Identifying correlations and patterns among the results generated by WAVE and Total Validator automated tools suggests that there is an inconsistency between the results generated by two automated tools. Referring to **Table 6.1**, the average errors reported by the Total Validator tool is relatively higher than the WAVE tool (187 and 146 respectively) and conversely, the average warnings/alerts reported by the WAVE tool is relatively higher than that of Total Validator tool (202 and 183 respectively).

7.2 Discussion of the Key Findings with the Related Studies

In this section, the findings in this study are compared and discussed with the previous related studies.

7.2.1 Web accessibility Issues on Norwegian University Websites

This section identifies the patterns and relationships of the most common accessibility issues discovered on Norwegian University websites against the similar issues discovered on previous related studies. The most frequently discovered issues on all the selected webpages by both automated tools are discussed in this section. From the findings of two automated tools, all four universities had accessibility Level A checkpoint issues of 1.1.1. This “Non-Text Content” checkpoint has been found as the most commonly violated issue in other University websites (Alahmadi & Drew, 2017; Ismailova & Inal, 2018; Kurt, 2011, 2017; Verkijika & De Wet, 2018) as well. This issue is frustrating to people with disability, especially to screen reader users, therefore fixing this issue enables users to perceive the web content.

Likewise, the most violated checkpoints reported by two automated tools on Norwegian University websites were Level A checkpoints 1.3.1 and 3.3.2 which were also outlined as distinct issues in educational institute websites (Alahmadi & Drew, 2017; Ismail & Kuppusamy, 2018; Ismailova & Inal, 2018; Verkijika & De Wet, 2018). Level A checkpoint 1.3.1 (*info and relationship*) and checkpoint 3.3.2 (*labels or instructions*) should also be entailed to increase accessibility users relying on screen reader users.

In addition to checkpoints 1.1.1, 1.3.2, and 3.3.2, the Level A checkpoint 2.4.4 was violated by all four university websites and detected by both selected automated tools. Entailing this checkpoint ensures that all the links have a meaningful purpose and the potential users can understand the context of the links. This checkpoints issue has also been identified in studies (Ismail & Kuppusamy, 2018; Ismailova & Inal, 2018; Verkijika & De Wet, 2018).

Furthermore, 2.4.6 was the only Level AA checkpoint issue detected on all selected websites by WAVE tool only. This issue has also been a major issue in previous studies (Alahmadi & Drew, 2017; Ismailova & Inal, 2018; Verkijika & De Wet, 2018).

7.2.2 Variation in Results of Two Automated Tools

Using two automated tools (Wave and Total Validator), this study concluded that none of the selected University websites met the minimum WCAG accessibility guidelines. These both tools detailly reported the WCAG 2.1 success criteria and checkpoints. From Table 6.1, two tools reported inconsistent accessibility issues and warnings results of four University websites. In the study (Molinero & Frederick, 2006), the researchers conducted three automated tools to evaluate 50 websites to test the reliability of automated tools. Similar to this study, the study concluded that relying only on an automated tool is a risk to confirm the accessibility issue of the website since different tools had a substantially high difference in the accessibility results.

7.2.3 Usability Issues in Norwegian University Websites

The findings and results in this study showed that the Norwegian Universities need to look out for usability issues on the current context.

From the follow-up interview, the participants responded that navigation was the most reoccurring issue they experienced while opening the Norwegian University websites using screen reader tools. This issue acknowledges the earlier research (Lazar et al., 2007) which confirms that navigation issue is one of the most frustrating experiences screen reader users face using the web. Previously conducted studies (Hasan, 2014; Pearson, Pearson, & Green, 2007; Zhang, Dran, Blake, & Pipithsuksunt, 2000) also address the navigation issue to be considered in educational websites.

In addition, the participants experienced screen reader tool reading all the links and headings persistently annoying while browsing the web pages. In the study (Lazar et al., 2007; Menzi-Çetin et al., 2017; Tanyeri & Tüfekçi, 2010), the researchers also confirmed the users get frustrated when the pages read out loud every time the web page is loaded. Inclusion of the "*Skip*" link within a webpage is recommended by the study (Lazar et al., 2007) so that screen reader users can skip the unwanted links.

Incompatibility of screen reader software with the internet browsers was another common usability issue the participants complained during the testing. A few students were observed switching the browser to complete the task. This fails one of

the usability principles, i.e. *learnability*, coined by (Nielsen, 2003). This issue has been addressed in a few studies (Lazar et al., 2007; Menzi-Çetin et al., 2017).

During the testing, it was also observed that most of the participants went to search engine sites to locate the desired information when they couldn't find using the internal search form of the website. Most of them were able to accomplish the tasks via the search engine when they couldn't achieve from the internal search form. Menzi-Çetin et al. (2017) detected similar usability barriers.

7.3 Recommendations for web and screen reader developers

This section describes the suggestions or recommendations web and software designers should take account into based on the findings on this study and previous related studies.

7.3.1 Importance of Manual Evaluation by Experts

Since the sampled results from two automated tools don't give accurate results while evaluating the same websites, manual evaluation by the expert is necessary for the identification and rectification of web accessibility issues. Completely relying on automated tests alone has negative effects as automated tools cannot fully check accessibility issues of the web pages (Kurt, 2011; Vigo et al., 2013). Additionally, evaluating with only one automated tool does not confirm the accessibility level of websites (Thatcher, Waddell, & Burks, 2002). Therefore, the results should be manually and detailly examined by the web accessibility experts to verify the findings of the automated tools.

7.3.2 Emphasis on usability improvement of websites to Designers

The findings from this study show that the degree of usability issues of the sample sized Norwegian University websites are higher than the accessibility degree. Therefore, the web designers should also consider improving the usability aspect of the websites as well but not only the accessibility aspect. Since web accessibility correlates with web usability, integrating usability techniques on the web can improve usable accessibility (W3c, 2016b). Based on the post-interview from visually impaired users, the following usability recommendations are suggested for the improvement of usability of Norwegian University websites:

- **Unique Page Titles**: The first thing screen reader tools read out loud is the page title of the webpage when the website is loaded. Page titles are the section within the HTML code which is written as a tag <*title*> </*title*> within <*head*> section of the HTML code. Although the page title is the element of accessibility, ambiguous page title may hurt the usability of the website. Duplicate page titles or poor description of the page title confuse screen reader user whether they have landed in the right place.
- **Design of structured link lists and headings**: Many screen reader tools has an inbuilt keyboard shortcuts features which help to navigate through the contents of the webpage in a non-visual way (Borodin et al., 2010). For instance, JAWS and NVDA screen reader software have a shortcut **keystroke** "H" to navigate through the next heading title within the webpage. Similarly, listing of all links or skipping through the links can also be prosecuted in a non-visual way using a short-cut keyboard press. Designing structured headings and link lists facilitate the screen reader users to navigate to the contents they want on a web page.
- **Screen reader compatibility with browsers:** Compatibility issue of screen reader software with different browsers is another complication people relying on screen reader tools commonly face. Even though the webpage is designed accessible as per the guidelines, the incompatibility of browsers with such assistive technology tool may still hinder the users from navigating the web contents with ease.
- **Internal Search form algorithm**: Instead of achieving the desired contents exploring through the search engines, i.e. Google, Yahoo, Bing, etc. designing a reliable and a discoverable search form algorithm improves the usability of the website. This way, the web users do not have to unnecessarily switch through the third-party search engine to identify the desired contents on the web page.

7.4 Limitation of the Study

Despite the findings and results, this study is still subject to some limitations which could be addressed in future research. Some of the limitations of this dissertation are described as follows:

7.4.1 Participant Selection

This research was conducted to evaluate the accessibility and usability of the Norwegian University Websites, particularly for screen reader users. However, we were only able to recruit fully blind and partially blind participants and other participant groups who relied on screen reader tools, i.e. motor impaired users, cognitive disorder, etc., were not involved in our study due to limited time and other factors. In addition, most of the participants were Nepalese, and only one visually impaired participant from Norway was involved in this study. It was because the Norwegian participants who had some kinds of visual impairments hesitated to took part in this study since the study was only in English. Therefore, we were obliged to recruit the participants remotely from Nepal. A remote study is error-prone and it is difficult to observe all the issues and session during the tasks by the testers (Jard, Jéron, Tanguy, & Viho, 1999). Further, since the usability and accessibility questionnaires were provided to the participants in English, some participants had trouble understanding some complex terms and the interviewee had to explain them by translating the terms used on the online survey.

7.4.2 Nature of the website

The accessibility and usability evaluation of the tested websites was performed using various methods in this study. Since the nature of all four tested websites are dynamic, their contents are frequently updated according to time and nature. Due to this, the results we concluded could differ when the evaluation of these websites are performed at a different time-span. Moreover, the evaluation was performed only on three webpages of each University website. If the analysis was presented on more pages, the results could have been differed.

7.4.3 Selection of Automated Tools

In this study, two automated tools, WAVE and Total Validator, was used to evaluate and report the accessibility issues of the University web pages. However, while assessing the same webpage, these two tools reported varied results. Inclusion of more evaluation tool or further manual evaluation may be needed to reaffirm the findings in this study.

7.4.4 Analysis of the study

Since this study used a mixed approach for data collection, the qualitative analysis was more time consuming and tedious compared to quantitative analysis. It was because the qualitative data consisted of both close-ended and open-ended questions and mapping them together took some time and needed critical thinking. Analysing open-ended questions is complicated and powerful because it is time consuming and special skills are needed to distinguish the quality and useful answers from the bad one (Lazar, Feng, & Hochheiser, 2017).

7.4.5 Assistive Technologies Used by Participants

During the test, the participants used only two screen reader tools, i.e. JAWS (56%) and NVDA (44%). Since the experiment was not controlled, and the results were based upon only two screen reader tools, the results might have affected if different assistive technologies were used.

Chapter 8 Conclusion and Future Implication

The main aim of this study was to discover the most crucial usability and accessibility issues that screen reader students frequently face on Norwegian University webpages. Based on a finding from the qualitative and quantitative analysis, this research concludes that the usability level of the higher educational websites is deficient. Likewise, it was also observed that none of the evaluated sites met the minimum WCAG 2.1 guidelines. Additionally, by analysing the results of two automated tools, it was noted that entirely relying on automated tools is not the best practice to discover the accessibility issues of the website. Therefore, manual assessment is needed for optimal results.

To make the website more usable and accessible, some aspects are needed to be considered to address the need for screen reader users. Based on the findings of the study, the most common usability issues Universities need to take account into are clear labelling of page titles, ease of keyboard access on navigation, presenting the breadcrumb easy to locate, and proper interface and results of search form design. In addition to that, the universities should also focus on accessibility aspects like organizing the heading and link structure, proper labelling of the headings and links, keyboard navigation, and most importantly, the screen reader developers should design the software compatible for the most browsers screen reader use.

8.1 Future Work and Implications

The remarkable findings in this study provide some contributions to the current level of accessibility and usability issues occurring in present-day Norwegian University websites. Despite this, there are still some limitations to this study and the implication of further research would further improve the areas of the current research limitations.

Firstly, only 4 University websites were evaluated to answer the findings of the research problems. In the future study, assessing large sampled universities would provide an accurate extrapolation. Secondly, usability testing was performed mostly remotely. Although this method possesses some positive exposure, there are still some drawbacks of remote usability testing (Nelson & Stavrou, 2011). In the future, this study aims to perform face-to-face interviews to gather the real time results. Thirdly, the findings in this study were solely based on two automated tools, i.e.,

WAVE and Total Validator. Surprisingly, the accessibility issues reported by these tools were inconsistent. In future research, the manual evaluation by the expert would also be included to determine and confirm the accessibility errors of the websites. Fourthly, the nature of the assessed websites was dynamic. Therefore, it will be significant that future work assesses the websites from time to time manually or using automated tools. Fifth, various types of disabilities who rely on screen reader tools to access the information on the web (WebAIM, 2017b). However, only one type of such disabilities, i.e., visually impaired students were recruited in this research to inspect the accessibility and usability issues of the website for screen reader users. Future study is definitely needed by including different types of disabilities to address the viewpoint of general screen reader users. Sixth, the nature of the assistive technology in this study was not controlled, and the findings were solely based on two screen reader tools. Regardless, future research could explore this limitation by involving other assistive technologies to reaffirm the conclusions.

In addition, despite the Anti-Discrimination and Accessibility Act and the regulations in Norway, the findings in this study concluded that the University websites are still not designed accessible and usable to a wide range of people. These regulations should be taken seriously into account by the designers and developers and the Universities as well. Further, the awareness program should also be organized among web designers and developers for the effective inclusion of web accessibility (Sierkowski, 2002a).

Chapter 9 References

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Appendices

Appendix A

Information Form

Research Topic: A comparative study on user experience and automated assessment of accessibility of Nordic educational institute website for blind user

Participant ID:

Interview Time: 45-60 minutes

The main aim of this research is to discover the potential accessibility and usability issues screen reader students commonly experience while browsing Norwegian University websites. All the information provided by the participant remain anonymous and you have free will to leave the study at any time. You are required to read all the conditions mentioned below in this form and sign the consent form.

1. There will be no record of video or audio of the participants.
2. The identity of the participant remains anonymous and the participants cannot be recognized by any means.
3. It is voluntary to participate in the research and the individual can withdraw from the dissertation at any time without any clarification.
4. The participant will not be directly benefitted from the involvement.

I have read all the conditions above and willing to participate.

Appendix B

Demographic Questionnaire

Participant ID: _____ **Date**: _____

1. What is your age?
   ☐ Under 18 ☐ 18-24 years old
   ☐ 25-34 years old ☐ 35-40 years old
2. Gender
   ☐ Male ☐ Female

3. What is the highest degree or level you have completed?
   ☐ High-school degree or equivalent ☐ Some colleges, no degree
   ☐ Bachelor's degree ☐ Master's degree

4. What type of disability you have?
   ☐ Completely Blind ☐ Partial Blind
   ☐ Motor Impaired ☐ Others _____

5. Which screen reader tool do you prefer use to interact with web browsers?
   _____

6. How many years of experience do you have using the screen reader tool/tools?
   _____

7. Do you own your personal computer / laptop?
   ☐ Yes ☐ No

Appendix C

Usability Tasks

a) **Open the University Website in your browser**: You want to browse the University website for application. The first University If you are unable to browse the URLs, you are provided with the link or external assistance is given at first.

b) **Open the website in English language**: You want to browse the University website English if you are international student or in Norwegian language if you are a native student.

c) **Find the study program in English:** From the homepage, you want to find the study program of your Interest (in Masters' or Bachelors). Please list down the study program (one or more) your interest.

d) **Identify the course requirement for admission:** You want to check if you meet the minimum criteria for the course admission. List down the minimum English language requirement score (IELTS) from the page for this course.

e) **Identify the contact information:** You want to contact the University via telephone. List down any one of the telephone numbers where you can contact the University.

Appendix D

SUS Questionnaire

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1. I think I would like to use this tool frequently.	□	□	□	□	□
2. I found the tool unnecessarily complex.	□	□	□	□	□
3. I thought the tool was easy to use.	□	□	□	□	□
4. I think that I would need the support of a technical person to be able to use this system.	□	□	□	□	□
5. I found the various functions in this tool were well integrated.	□	□	□	□	□
6. I thought there was too much inconsistency in this tool.	□	□	□	□	□
7. I would imagine that most people would learn to use this tool very quickly.	□	□	□	□	□
8. I found the tool very cumbersome to use.	□	□	□	□	□
9. I felt very confident using the tool.	□	□	□	□	□
10. I needed to learn a lot of things before I could get going with this tool.	□	□	□	□	□

Appendix E

Accessibility Questionnaire

1. Did you find there is any title that adequately and briefly describe the content of the web page?
   - ☐ Yes
   - ☐ No

2. While browsing the website, did you navigate any image? If yes, did you find any image/images missing alternative texts or were they meaningful?
   - ☐ Most of the images had alternative texts but they weren't all quite meaningful.
   - ☐ Most of the images didn't have alternative texts.
   - ☐ Most of the images had alternative texts and they all had meaningful text
   - ☐ Other _

3. Did any of the web page have missing heading?
   - ☐ Yes
   - ☐ No

4. While browsing the website, did you happen to increase/decrease the text size within the webpage setting from keyboard shortcut? If yes, were the web pages usable?
   - ☐ The font size of the web pages was visible enough for me.
   - ☐ I had to use the keyboard shortcut to increase/decrease some font size within the pages.
   - ☐ Not Available

5. Did the keyboard support all the webpages with keyboard navigation with the tab key with your current screen reader tool?
   - ☐ Yes
   - ☐ No

6. Did you find any form/ search form on the page?
   - ☐ Yes
   - ☐ No

   6.1 Were they all accessible to keyboard?
   - ☐ Yes
   - ☐ No

   6.2 Did you find any error while submitting the form? Were the errors easily findable?
   - ☐ No Errors while submitting the form.
   - ☐ There were errors, but they were easily findable

Appendix F

Post Web Accessibility Interview

1. What were the most remarkable accessibility issues you encountered while browsing the different webpages of University from screen reader?
2. What do you think the main reasons behind the occurrence of these issues?

Appendix G

WCAG 2.1 Criteria for Screen Reader Users

1. Perceivable

1.1 Text Alternative

- 1.1.1 Non-Text Content – Level A

1.2 Time-based media

- 1.2.1 Audio-only and Video-only (Pre-recorded) Level A
- 1.2.3 Audio Description or Media Alternative (Pre-recorded) Level A
- 1.2.5 Audio Description (Pre-recorded) Level AA

1.3 Adaptable

- 1.3.1 Info and Relationships Level A
- 1.3.2 Meaningful Sequence Level A
- 1.3.3: Sensory Characteristics Level A
- 1.3.4 Orientation Level AA

1.4 Distinguishable

- 1.4.1 Use of Color Level A
- 1.4.2 Audio Control Level A
- 1.4.3 Contrast (Minimum) Level AA
- 1.4.4 Resize text Level AA
- 1.4.5 Images of Text Level AA
- 1.4.10 Reflow Level AA (Added in 2.1)
- 1.4.11 Non-text Contrast Level AA
- 1.4.12 Text Spacing Level AA
- 1.4.13 Content on Hover or Focus Level AA

2. Operable

2.1 Keyboard Accessible

- 2.1.1 Keyboard Level A
- 2.1.2 No Keyboard Trap Level A
- 2.1.4 Character Key Shortcuts Level A

2.2 Enough Time

- 2.2.1 Timing Adjustable Level A

2.4 Navigable

- 2.4.1 Bypass Blocks Level A
- 2.4.2 Page Titled Level A
- 2.4.3 Focus Order Level A
- 2.4.4 Link Purpose (In Context) Level A
- 2.4.5 Multiple Ways Level AA
- 2.4.6 Headings and Labels Level AA
- 2.4.7 Focus Visible Level AA

2.5 Input Modalities

- 2.5.3 Label in Name Level A
- 2.5.4 Motion Actuation Level A

3. Understandable

3.1 Readable

- 3.1.1 Language of Page Level A
- 3.1.2 Language of Parts Level A

3.2 Predictable

- 3.2.1 On Focus Level A
- 3.2.2 On Input Level A
- 3.2.3 Consistent Navigation Level AA
- 3.2.4 Consistent Identification Level AA

3.3 Input Assistance

- 3.3.1 Error Identification Level A
- 3.3.2 Labels or Instructions Level AA
- 3.3.3 Error Suggestion Level AA
- 3.3.4 Error Prevention (Legal, Financial, Data) Level AA

4. Robust

4.1 Compatible

- 4.1.1 Parsing Level A
- 4.1.2 Name, Role, Value Level A
- 4.1.3 Status Messages Level AA

Appendix H

List of Tables

Table 0.1 Accessibility Evaluation of Home Pages of Norwegian Universities (WAVE)

Universities Homepage	Errors	Alerts	Contrast Errors
University of Stavanger (UiS) http://uis.no	1	42	27
University of Tromso (UiT) http://uit.no	12	7	4
University of South-Eastern Norway (USN) https://www.usn.no/	15	8	0
University of Adger (UiA) https://www.uia.no/	18	19	5

Table 0.2 Accessibility Evaluation of Home Pages of Norwegian Universities (Total Validator)

Universities Homepage	Errors	Warnings
University of Stavanger (UiS) http://uis.no	8	8
University of Tromso (UiT) http://uit.no	0	2
University of South-Eastern Norway (USN) https://www.usn.no/	28	9
University of Adger (UiA) https://www.uia.no/	24	28

Table 0.3 Accessibility Evaluation of Program Taught in English Web Pages of Universities (WAVE)

Web Pages	Errors	Alerts	Contrast Errors
University of Stavanger (UiS) https://www.uis.no/studies/master-s-programmes-in-english/	1	22	8
University of Tromso (UiT) https://en.uit.no/education?studtype=4	39	42	1
University of South-Eastern Norway (USN) https://www.usn.no/english/academics/find-courses/#filter[educationalLevel]=Master	17	3	0
University of Adger (UiA) https://www.uia.no/en/study/search	9	10	25

Table 0.4 Accessibility Evaluation of Program Taught in English Web Pages of Universities (Total Validator)

Web Pages	Errors	Warnings
University of Stavanger (UiS) https://www.uis.no/studies/master-s-programmes-in-english/	1	22
University of Tromso (UiT) https://en.uit.no/education?studtype=4	39	42
University of South-Eastern Norway (USN) https://www.usn.no/english/academics/find-courses/#filter[educationalLevel]=Master	17	3
University of Adger (UiA) https://www.uia.no/en/study/search	9	10

Table 0.5 Accessibility Evaluation of Contact Page of Universities (WAVE)

Web Pages	Errors	Alerts	Contrast Errors
University of Stavanger (UiS) https://www.uis.no/om-uis/kontakt/	3	24	8
University of Tromso (UiT) https://en.uit.no/om/art?p_document_id=339795&dim=179034	8	17	0
University of South-Eastern Norway (USN) https://www.usn.no/om-usn/kontakt-oss/	16	2	0
University of Adger (UiA) https://www.uia.no/om-uia/finn-frem/kontaktinformasjon	7	6	8

Table 0.6 Accessibility Evaluation of Contact Page of Universities (Total Validator)

Web Pages	Errors	Warnings
University of Stavanger (UiS) https://www.uis.no/studies/master-s-programmes-in-english/	5	6
University of Tromso (UiT) https://en.uit.no/education?studtype=4	30	40
University of South-Eastern Norway (USN) https://www.usn.no/english/academics/find-courses/#filter[educationalLevel]=Master	17	3
University of Adger (UiA) https://www.uia.no/en/study/search	9	10

Table 0.7 WCAG 2.1 checklist issues on University of Stavanger (UiS) Web Pages (WAVE)

	Perceivable	**Operable**	**Understandable**	**Robust**
Home Page http://uis.no	1.1.1, 1.3.1, 1.4.3	2.4.6	3.3.2	N/A
Program Taught in English Page https://www.uis.no/studies/master-s-programmes-in-english/	1.1.1, 1.3.1, 1.4.3	2.4.2, 2.4.3, 2.4.4, 2.4.6,	3.3.2	N/A
Contact Page https://www.uis.no/om-uis/kontakt/	1.1.1, 1.3.1, 1.4.3	2.4.1, 2.4.3, 2.4.4, 2.4.6,	3.3.2	N/A

Table 0.8 WCAG 2.1 checklist issues on University of Stavanger (UiS) Web Pages (Total Validator)

	Perceivable	Operable	Understandable	Robust
Home Page http://uis.no	1.1.1, 1.3.1	2.4.1, 2.4.4, 2.5.3,	3.3.2	4.1.1, 4.1.2
Program Taught in English Page https://www.uis.no/studies/master-s-programmes-in-english/	1.1.1, 1.3.1	2.4.1, 2.4.3, 2.4.4, 2.5.3,	3.3.2	4.1.1, 4.1.2
Contact Page https://www.uis.no/om-uis/kontakt/	1.1.1, 1.3.1,	2.4.4, 2.5.3,	3.3.2	4.1.1, 4.1.2

Table 0.9 WCAG 2.1 checklist issues on the University of Tromso (UiT) Web Pages (WAVE)

	Perceivable	Operable	Understandable	Robust
Home Page http://uit.no	1.3.1	2.2.1, 2.2.2, 2.4.2, 2.4.6	3.1.1	
Program Taught in English Page https://en.uit.no/education?studtype=4	1.1.1, 1.3.1, 1.4.3	2.4.1, 2.4.3, 2.4.4, 2.4.6	3.3.2	
Contact Page https://en.uit.no/om/art?p_document_id=339795&dim=179034	1.1.1, 1.3.1,	2.4.1, 2.4.3, 2.4.4, 2.4.6,		

Table 0.10 WCAG 2.1 issues on University of Tromsø (UiT) Web Pages (Total Validator)

	Perceivable	Operable	Understandable	Robust
Home Page http://uit.no		2.4.1	3.1.1	
Program Taught in English Page https://en.uit.no/education?studtype=4	1.1.1, 1.3.1, 1.4.4,	2.4.1, 2.4.3, 2.4.4, 2.4.6, 2.5.3,	3.3.2	4.1.1, 4.1.2
Contact Page https://en.uit.no/om/art?p_document_id=339795&dim=179034	1.1.1, 1.3.1, 1.4.4,	2.4.1, 2.4.3, 2.4.4, 2.4.6	3.3.2	4.1.2

Table 0.11 WCAG 2.1 issues on University of South-Eastern Norway (USN) Web Pages (WAVE)

	Perceivable	Operable	Understandable	Robust
Home Page http://usn.no	1.1.1, 1.3.1,	2.4.1, 2.4.2, 2.4.4, 2.4.6		
Program Taught in English Page https://www.usn.no/english/academics/find-courses/#filter[educationalLevel]=Master	1.1.1, 1.3.1,	2.4.1, 2.4.4, 2.4.6	3.3.2	
Contact Page https://www.usn.no/om-usn/kontakt-oss/	1.1.1,	2.4.4		

Table 0.12 WCAG 2.1 issues on University of South-Eastern Norway (USN) Web Pages (Total Validator)

	Perceivable	**Operable**	**Understandable**	**Robust**
Home Page http://usn.no	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.3.2	4.1.1, 4.1.2
Program Taught in English Page https://www.usn.no/english/academics/find-courses/#filter[educationalLevel]=Master	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.2.2, 3.3.2,	4.1.2
Contact Page https://www.usn.no/om-usn/kontakt-oss/	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.3.2,	4.1.2

Table 0.13 WCAG 2.1 issues on University of Adger (UiA) Web Pages (WAVE)

	Perceivable	**Operable**	**Understandable**	**Robust**
Home Page http://uia.no	1.1.1, 1.3.1, 1.4.3	2.4.1, 2.4.4, 2.4.6,	3.3.2,	
Program Taught in English Page https://www.uia.no/en/study/search	1.1.1, 1.3.1, 1.4.3	2.4.1, 2.4.4, 2.4.6,	3.3.2,	
Contact Page https://www.uia.no/om-uia/finn-frem/kontaktinformasjon	1.1.1, 1.3.1, 1.4.3	2.4.1, 2.4.4, 2.4.6,	3.3.2,	

Table 0.14 WCAG 2.1 issues on University of Adger (UiA) Web Pages (Total Validator)

	Perceivable	**Operable**	**Understandable**	**Robust**
Home Page http://uia.no	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.2.2, 3.3.2	4.1.2
Program Taught in English Page https://www.uia.no/en/study/search	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.2.2, 3.3.2	4.1.2
Contact Page https://www.uia.no/om-uia/finn-frem/kontaktinformasjon	1.1.1, 1.3.1, 1.4.4	2.4.1, 2.4.4, 2.4.6	3.2.2, 3.3.2	4.1.2