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A Universally Designed Electronic Norwegian Dictionary

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Preface

This thesis entitled ‘A Universally Designed Electronic Norwegian Dictionary’ is submitted as a part of the Master in Universal design of ICT at the OsloMet – Oslo Metropolitan University (Storbyuniversitetet- in Norwegian), Norway. The research work involved design and user testing of a universally designed prototype of an electronic Norwegian dictionary. The motivations behind choosing this project are my interest and previous experience in web development as well as learning the Norwegian language. From this research I learned and got the depth knowledge of universal design, and accessibility and usability guidelines.

First of all, I would like to thank my supervisor, **Dr. Pietro Murano** for his time, support and guidance throughout this research work. I am grateful to all the participants for their invaluable time and feedback in the development and testing of the prototype.

I extend my sincere gratitude to my family for their continuous inspiration and encouragement. My special thanks to Sturla Berg-Olsen, Senior Advisor at The Language Council of Norway, who on behalf of Nynorsksordboka og Bokmålsordboka (https://ordbok.uib.no/) provided me permission to include the screenshots of the online dictionary portal in this thesis.

Lastly, I cannot attempt to mention by name everyone who helped me during my master’s degree. Nevertheless, to each and every one of them I would like to convey my appreciation.

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Abstract

Following the concepts of universal design as well as guidelines of accessibility and usability are important parts of the website design for wide range of users, and an online dictionary is not an exception to these requirements. The information regarding whether the online dictionaries are universally designed is still lacking. This study was designed to develop a prototype of a universally designed electronic Norwegian dictionary. The study followed an experimental approach starting with testing of a widely used trustworthy online Norwegian dictionary named Nynorskorboka og Bokmålsordboka (https://ordbok.uib.no/); developing a prototype following WCAG 2.1 and usability guidelines of universal design and finally user testing to compare these two electronic dictionaries for usability issues. A total of 20 participants were recruited for user testing. The automated evaluation of the current Nynorskorboka og Bokmålsordboka generated several accessibility issues indicating lack of universal design. The findings from this study shows that the universally designed prototype is significantly different than the existing online dictionary both in terms of improved satisfaction and reduced number of errors while using. Furthermore, the result also suggests that universal design of website makes a huge difference in the access and use.

Keyword: Universal design, Norwegian dictionary, Accessibility, Usability, WCAG 2.1

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List of acronyms

AMP - Accessibility Management Platform

API - Application programming interface

CSS – Cascading Style Sheets

EU - European Union

HCI - Human-computer Interaction

HHS - Health and Human Services

HTML – Hypertext Markup Language

IBM - International Business Machines Corporation

ICT - Information and Communications Technology

IOS – iPhone Operating System

JAWS - Job Access With Speech

NVDA - NonVisual Desktop Access

PHP - Hypertext Preprocessor

RAM - Random-access memory

SPSS - Statistical Package for the Social Sciences

UCD - User-centred design

UiB - University of Bergen

US - United States

W3C - World Wide Web Consortium

WAI - Web Accessibility Initiative

WAVE - Web Accessibility Evaluation Tool

WCAG - Web Content Accessibility Guidelines

WebAIM - Web Accessibility in Mind

Chapter 1. Introduction

With the increasing use of internet for various purposes like banking, social media, education, information etc., it is obvious that the use of electronic dictionary over the traditional dictionary in printed form is also increasing day by day. The achievement and future potential of human-oriented electronic dictionaries are well established which suggest that electronic dictionaries have several advantages over the printed form including but not limited to low cost or free access; ability of storing large amount of information without requirement of physical space; accessibility of information by a simple search function and cross-references; accessibility from any device irrespective of location; simultaneous use by large number of users in real-time; and ability for continuous update and editing the content (de Schryver, 2003; Dimitrova, Koseska-Toszewa, Dutsova, & Panova, 2009).

Each and every field of study, whether it is medicine, pharmacy, engineering, Information and communication technology (ICT), language studies or economics etc, has its own electronic dictionary in different languages; which indicates that these electronic dictionaries have wide range of diverse users. However, there are not sufficient studies or data available per today that suggest the available electronic dictionaries are designed as per the requirements of universal design concept (Connell et al., 1997). In other words, it means that the online dictionaries available today may or may not be deemed useful for diverse user groups especially for the disabled groups.

The concept of universal design suggests that the appearance, content, availability and usability of online product or environment must fulfill certain principles and guidelines for the product to be universally acceptable (Connell et al., 1997; Leavitt & Shneiderman, 2006; W3C, 2018), and electronic dictionaries are not an exception to these requirements.

Therefore, this study was designed with following objectives:

a. To test currently available electronic Norwegian dictionary for universal design.
b. To develop a prototype of a universally designed electronic Norwegian dictionary.

c. To compare the currently existing electronic Norwegian dictionary with the newly developed prototype of universally designed electronic Norwegian dictionary for usability issues.

The Norwegian language has two different writing standards: Bokmål and Nynorsk meaning book language and new Norwegian respectively. According to the Norwegian Language Council (Språkrådet in Norwegian) about 10% of the country's population uses Nynorsk as writing language mostly in the western Norway whereas 90% of the population uses Bokmål as writing language (Språkrådet, 2019). There are several online Norwegian language dictionaries available. Among these, the 'Nynorskordboka og Bokmålsordboka[1]' (hereafter called 'ordboka' in this thesis) is the most widely used electronic dictionary for Norwegian language since it is the most recommended dictionary in schools in Norway as well as Norwegian language courses to learn vocabulary of Norwegian words.

The orboka is co-owned by the University of Bergen and the Norwegian Language Council. The Norwegian Language Council is responsible for maintaining the official orthographies of Bokmål and Nynorsk standards, whereas the University of Bergen is responsible for ICT and technical support, development of the dictionary portal, and for editing the dictionaries in accordance with the official orthographies. Grammatical information of both standards comes from the Norwegian word bank called the Norsk Ordbank (Universitetet i Bergen & Språkrådet, 2017).

Even though there are other online Norwegian dictionaries available, the main reason for selecting orboka for this study is its trustworthiness, since the contents in the dictionary are provided by the Norwegian Language Council. The dictionary provides meaning in either Nynorsk or Bokmål alone or both together if selected to show the meaning in both standards at once (by choosing 'begge' function). When the meaning of a word is searched in both standards at once, the meanings are provided side by side in two columns, along with the meaning history, grammatical forms and examples. Moreover, it is available both in web and app format and the search function is very advance and useful.

[1] https://ordbok.uib.no/

This thesis highlights the drawbacks of ordboka with respect to the universal design principles, accessibility guidelines and usability guidelines and accordingly presents an updated prototype of universally designed electronic Norwegian dictionary based on the contents of the ordboka, thereby answering the research question “How can an electronic Norwegian dictionary be universally designed for all the users?”.

The thesis is organized in six chapters as follows:

Chapter 1 gives the background information on research problem and introduction of the study.

Chapter 2 is the literature review section comprising of concept of universal design, web accessibility, and usability followed by the usability guidelines and web accessibility tools.

Chapter 3 is the method section defining the research approach, objectives and hypotheses, along with description of participants’ selection, data collection procedure and analysis method.

Chapter 4 presents the findings of the study, i.e. web accessibility results of ordboka and the statistical results of the comparison between ordboka and newly developed prototype.

Chapter 5 relates the research findings with the literature review section thereby answering the research question.

Chapter 6 concludes the thesis with key points from the study and future recommendations.

Chapter 2. Literature review

2.1 Concept of universal design

According to Center for Universal Design at North Carolina State University (Connell et al., 1997) the universal design has been defined 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”.

In other words, universal design is design of a product or an environment which is accessible and usable to the maximum extent as possible by diverse range of people. Persson, Åhman, Yngling, and Gulliksen (2015) have reported that even though universal design is known as design for all or universal access or inclusive design the main objective of this concept is to largely focus on increasing the accessibility of the interactive system for the widest possible range of use.

Universal design is not only for a certain group of people, but it is for all diverse groups. We will be or are vulnerable in some point of our life due to the age, physical or mental ability. These changes might create barriers and obstacle in accessing and using the product or environment. To overcome these barriers and obstacle, the concept of universal design helps to design a product that can be used in any vulnerable part of our life.

To achieve the universal design in the product and environment, 7 principles of universal design was developed the group led by Ronald Mace at the North Carolina State University (Connell et al., 1997). These principles are:

a. Principle 1: Equitable Use

This principle states that the design of a product should help diverse users to use the product equally and should be appealing by all users. For example, having high contrast for user having low vision and using in different surrounding like in sunlight and night might help the user with poor vision view the content more effectively.

b. Principle 2: Flexibility in Use

According to this principle the design should have the feature of customizing the product as per the user’s need and abilities. For example, having the customization feature to change the zoom size and color contrast.

c. Principle 3: Simple and Intuitive Use

The design of the product should be easy to use and understand by all the users even when users have less user experience or knowledge or language skills or current concentration level. For example, making webpage easy to use and find the required information so that even user who is using for the first time can easily understand.

d. Principle 4: Perceptible Information

The information in the product should be presented in proper color contrast and easy to understand. For example, the content should be in consequential order and every page should have the same layout design.

e. Principle 5: Tolerance for Error

The product should have elements to minimize hazard and errors. The product should have to feature to undo the errors. If errors are made, then the alert or the warning message should be notified to the user.

f. Principle 6: Low Physical Effort

The product should be used applying low physical efforts. For example, the content in the website should also be accessible by keyboard so that simple function like copy and paste can be done easily and quickly.

g. Principle 7: Size and Space for Approach and Use

The product should be used regardless of user's body size, posture, or mobility. For example, making the content of the website responsive so that it can be viewed properly in both large and small devices.

2.2 Concept of web accessibility

There are several definitions of web accessibly. Petrie, Savva, and Power (2015) defined web accessibility as:

“All people, particularly disabled and older people, can use websites in a range of contexts of use, including mainstream and assistive technologies; to achieve this, websites need to be designed and developed to support usability across these contests.”

Similarly, Persson et al. (2015) also defined the web accessibility as:

“The extent to which products, system, services, environments and facilities are able to be used by a population with the widest range of characteristics and capabilities (e.g. physical, cognitive, financial, social and cultural, etc), to achieve a specific goal in a specified context.”

In other words, web accessibility is the access or use of the content of the website without any barrier by wide range of users. To achieve the web accessible status for a website an internationally accepted guideline for web accessibility can be implemented (W3C, 2018).

2.3 Concept of usability

Nielsen (2012) defined usability as the quality attribute of the user interface which make easy to use for the users. Furthermore, Nielsen also stated that usability can be defined by five components namely learnability, efficiency, memorability, errors, satisfaction. Learnability means how easy it is to learn the basic thing for the first time. Efficiency defines how quickly the users can perform the task. Memorability means how easy it will it be to use the interface after certain period. Error is related to the number, severeness and recover of the errors. Lastly, satisfaction is how agreeable user are after using the interface.

A study was done related to defining usability as a quality of use or quality of experience by McNamara and Kirakowski (2005). The authors argued that usability as a quality of experience is conceptually vague and concluded that the usability should be defined as quality of use.

The need of usability has been justified because of the competitive environment which makes survival of the website very difficult (Nielsen, 2012). There are several factors like difficulty in using and reading the content; and failing to navigate the required information. In addition, failing to provide information of website in the home page might lead to users looking for alternative website.

2.4 Guidelines for web contents

2.4.1 Web content accessibility guidelines (WCAG)

The Web Content Accessibility Guidelines (WCAG) is published by Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C). WCAG is a set of

guidelines that helps to make web content accessible and usable to all the people regardless of disability. WCAG consists of 12 guidelines that are categorized in to 4 principles namely perceivable, operable, understandable, and robust (W3C, 2018).

Perceivable means that users must be able to perceive all the content on the website. Operable means that features, component, and navigation must be operable by the users. Understandable means the content provided on the website must be understandable. Lastly, robust means that the website should be able to access with various types of user agents like browsers and assistive technologies also. Each guideline has three levels of testable success criteria: A, AA, AAA (W3C, 2018). The latest version of WCAG is WCAG 2.1 published on June 5, 2018.

The Norwegian Government's regulations for the universal design of ICT solutions states that the net based solutions must fulfill the success criteria A and AA of WCAG 2.0 (Regjeringen.no, 2013).

A study conducted by Hanson and Richards (2013), exhibited the improvement in the accessibility of website. For the study, more than 100 top government websites from United States and United Kingdom were examined on the changes of accessibility from 1999 to 2012. The result concluded that websites had fulfilled more of the success criteria of WCAG because of the awareness of WCAG guidelines.

In an empirical study conducted by Power, Freire, Petrie, and Swallow (2012) about problems encountered by 32 blind users on 16 websites showed that problems were encountered by the users even when success criteria of WCAG 2.0 were fulfilled by the websites. The authors argued that even when the guidelines are implemented there will still be some problem that might cause problems for user indicating that WCAG alone does not cover all the problems.

Even the W3C (2018) has stated that WCAG 2.1 defines how to make web content accessible for wide range of disability including visual, auditory, physical, speech, cognitive, language, learning, and neurological disabilities but WCAG 2.1 does not ensure web content being completely accessible to the users with various types, degrees, and combinations of disabilities.

Fichten, Asuncion, Barile, Ferraro, and Wolforth (2009) have elaborated that as long as the development of software and hardware continues without considering the

accessibility for the disabled people, there will always be a problem in accessing web content. Therefore, universally designed website is a must so that it could be accessible by everyone. In order to make universally designed environment Granić and Ćukušić (2007) have suggested five different approaches: learner-centred design paradigm, context of use approach, individualized approach, pedagogical framework and guideline framework.

2.4.2 Usability guidelines

The research-based web design and usability guidelines (Leavitt & Shneiderman, 2006) were developed by the United States Department of Health and Human Services (HHS), in partnership with the United States General Services Administration. It consists of 209 guidelines to evaluate the web design and its usability for diverse users.

The guidelines were developed as an assisting tool for web site managers, designers, and other professionals related to creating and maintaining web sites. Each guideline is given 'Relative Importance' rating and 'Strength of evidence' rating from a scale of 1 to 5, where 1 being the lowest and 5 being the highest. The rating of relative importance shows how much the guideline is important to the success of website; whereas the rating of strength of evidence shows how much the guideline helps to achieve usability in the website. These ratings then can be used to prioritize the guidelines to be used while developing a website. (Leavitt & Shneiderman, 2006).

2.5 Web accessibility evaluation tools

Web accessibility evaluation tools are software or online services that help to determine whether web content has fulfilled the accessibility guidelines or not. It helps to identify the accessibility issues quickly. Web accessibility evaluation tools can be used in all phases of design and development process of a website (W3C, 2016). Web accessibility evaluation software verifies if the webpage is accessible or not by measuring the level of accessibility of a webpage (Fernandes, Lopes, & Carriço, 2011).

The World Wide Web Consortium (W3C) reccomends that evaluation of web accessibility provides assistance in making web page accessible (W3C, 2018). It has been argued that the browser web accessibility evaluation tools prioritize on

providing solutions to solve the accessibility issues discovered during the evaluation thereby making the website more user friendly (Fernandes et al., 2011). However, the web accessibility evaluation tools do not check all the aspects of the web; therefore, human judgment is required simultaneously.

2.5.1 Wave

The WAVE tool is a web accessibility evaluation tool (WAVE) developed by the Web Accessibility In Mind (WebAIM). This tool evaluates the accessibility of the page using WCAG 2.1, WCAG 2.0 and Section 508. WAVE tool is available as an extension in Firefox and Chrome and is an installable Application Programming Interface (API) engine. The WAVE tool has been extensively used along with other web accessibility evaluation tools to evaluate different websites (Akgül & Vatansever, 2016; Ismail & Kuppusamy, 2018; Sanchez-Gordon, Calle-Jimenez, & Lujan-Mora, 2015) because it not only helps to discover several issues and errors if any available during the evaluation of websites but also provides recommendations to solve the issues found (WebAIM, 2018).

2.5.2 SortSite

SortSite is a web site testing tool. This tool scans for the various quality issues that include:

1. Accessibility: checks for the accessibility issues using WCAG guidelines
2. Broken links: checks for the broken links and spelling errors
3. Compatibility: checks if all content of web site is compatible in different browser (Internet Explorer, Edge, Chrome, Firefox, Safari, Opera) and mobile operating devices like (Android and IOS)
4. Search Engine optimization: checks for Google and Bing webmaster guidelines
5. Privacy: checks the European Union (EU) and the United States (U.S.) laws
6. Web Standard: validates HTML and CSS
7. Usability: checks using Usability.gov guidelines

Moreover, this tool also analyses whether the web content is accessible different screen readers like: JAWS, NVDA, VoiceOver, WindowsEyes IE, Dolphin IE and SaToGo IE (PowerMapper, 2018).

A study conducted by Vigo, Brown, and Conway (2013), assessed six different automated evaluation tools namely AChecker, SortSite, Total Validator, TAW, Deque and AMP to determine their capabilities in evaluating web accessibility. WAVE was not used in this research since WAVE does not provide machine readable report. Among those six tools, SortSite was found to have more balanced approach with 30% of completeness and 95% of correctness.

Chapter 3. Research methodology

3.1 Research approach

3.1.1 Research objectives

The main aim of this study is to develop a universally designed electronic Norwegian dictionary. The study was designed with following research objectives:

a. To test currently available electronic Norwegian dictionary for universal design.
b. To develop a prototype of a universally designed electronic Norwegian dictionary.
c. To compare the currently existing electronic Norwegian dictionary with the newly developed prototype of universally designed electronic Norwegian dictionary for usability issues.

3.1.2 Research design

This study followed a mixed qualitative and quantitative research approach. The qualitative approach was used to analyze whether the ordboka and the new prototype is universally designed or not by testing its web content accessibility and usability via WAVE tool (WebAIM, 2018) and SortSite tool (PowerMapper Software, 2018).

The quantitative approach was conducted as an experimental research which is based on the scientifically way of data collection and analysis. It is the primary methodology for human-computer interaction (HCI) discipline (Gergle & Tan, 2014). For the experimental research, data related to design, usability and understandability of both ordboka and the prototype of the dictionary were evaluated to determine participant satisfaction and error rates. The data were analysed using a statistical test.

3.2 Automated evaluation

In order to develop a prototype, it was necessary to first analyze whether the most widely used currently available electronic Norwegian dictionary, i.e. ordboka is universally designed or not. The testing of ordboka was based on the WCAG 2.1 guidelines (W3C, 2018). The WAVE tool and SortSite tool were used to evaluate the content of ordboka.

For the evaluation of the ordboka following four pages were tested:

a. Home page: https://ordbok.uib.no/
b. Page with meaning of word ‘tur’ in Bokmål: https://ordbok.uib.no/perl/ordbok.cgi?OPP=tur&ant_bokmaal=5&ant_nynorsk=5&bokmaal=+&ordbok=begge
c. Page with meaning of word ‘prøve’ in Bokmål: https://ordbok.uib.no/perl/ordbok.cgi?OPP=Pr%C3%B8ve&ant_bokmaal=5&ant_nynorsk=5&bokmaal=+&ordbok=bokmaal
d. Page with meaning of word ‘språk’ in both Bokmål and Nynorsk (begge): https://ordbok.uib.no/perl/ordbok.cgi?OPP=+spr%C3%A5k&ant_bokmaal=5&ant_nynorsk=5&begge=+&ordbok=begge

The Google Chrome extension of WAVE was downloaded from chrome web store[2]. For all the selected pages of ordboka, evaluation was done by running the WAVE extension in each page. The report from the evaluation was analyzed and the screenshot was taken of all the evaluated pages. SortSite was downloaded from website of PowerMapper[3] and installed in the personal laptop. The website of the ordboka was loaded in the tool and evaluation check was conducted. Similar to the WAVE, all the selected pages were also evaluated using SortSite. The reports from the accessibility errors were analyzed which constituted the foundation for the next step of this research work, i.e. prototype designing.

The automated evaluation was used during each process of prototype design in order to trace the accessibility errors. The evaluation was repeated until the prototype was free from errors.

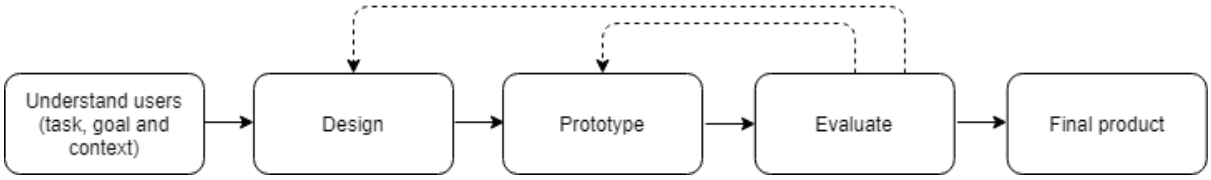
3.3 Prototype design

3.3.1 User centered design process

For the experimental research, a prototype of an electronic Norwegian dictionary was designed. The prototype was developed by using the User-centered design (UCD) which is an iterative design process (Figure 3-1) and every process focuses

[2] https://chrome.google.com/webstore/detail/wave-evaluation-tool/jbbplnpkjmmeebjpijfedlgcdilocofh?utm_source=chrome-ntp-icon
[3] https://www.powermapper.com/products/sortsite/

on the needs and requirement of users. The design process consists of understanding users (task, goal and context); designing concept; designing prototype and evaluating the prototype resulting in the final product (Petrie & Bevan, 2009).



(Source: (Petrie & Bevan, 2009))

Figure 3-1 User-centred design process

a. **Understand users (task, goal and context):** In this process, the existing dictionary ordboka was studied to check whether the requirements of the WCAG guidelines and Usability guidelines are fulfilled or not.
b. **Design:** For the concept design of the prototype, the content and the design of ordboka were studied. Alongside, other online dictionaries like Oxford dictionary[4] and Cambridge Dictionary[5] were reviewed for concept design.
c. **Prototype:** After the concept design was clear the prototype was designed using HTML, CSS, JavaScript and Bootstrap.
d. **Evaluate:** After design of each page, it was evaluated using the web accessibility evaluation tools i.e. WAVE tool and SortSite tool. The error and issues found by the tools were again designed to meet the guidelines of WCAG and usability guidelines.
e. **Final product:** After designing all the pages for the prototype and when no issues and error were found by the evaluation tools; the prototype was ready for further user testings.

For the new prototype; home page, page with meaning of word ‘tur’ (meaning *tour* in English) in Bokmål, page with meaning of word ‘prøve’ (meaning *test* in English) in Bokmål and page with meaning of word ‘språk’ (meaning *language* in English) in both Bokmål and Nynorsk using begge (meaning both in English) were designed.

[4] https://www.oxforddictionaries.com/
[5] https://dictionary.cambridge.org/

3.3.2 Guidelines for design

The prototype was designed following the WCAG 2.1 guidelines provided by W3C (W3C, 2018), and research-based web design & usability guidelines developed by HHS (Leavitt & Shneiderman, 2006). The WCAG provides guidelines on how to design each component of the web page. The designing process was mainly focused on the success criteria A and AA. However, WCAG does not have guidelines related to page layout and organizing and presenting the information in the web site; which was overcome by using the usability guidelines related to homepage, page layout, text appearance and content organization.

3.3.3 Technical features

3.3.3.1 Hardware

To design the prototype, Huawei MateBook D laptop was used. Laptop run in windows 10 with 64-bit operating system, 8GB RAM, Intel core i5 processor.

3.3.3.2 Software

Bootstrap: Bootstrap is an open source front-end HTML, CSS, and JavaScript framework to develop responsive, mobile-first website (Bootstrap, 2018). Bootstrap is used to develop a website quickly and for its feature of responsiveness, consistency and customizable (Rony & Rahman, 2016). To design the prototype bootstrap 4.1.3 version is used. For the layout and responsiveness class like container, row, section and ‘col-sm’ were used. For the search form ‘form-control’ and for the button ‘btn’ were used. Class table was used to display the table.

HTML: Hypertext Markup Language (HTML) is standard markup language for creating web pages (W3schools, 2019b). To design the prototype HTML version 5 is used.

CSS: Cascading Style Sheets (CSS) is style sheet language which describes how HTML elements are to be displayed on screen (W3schools, 2019a).

PHP: Hypertext Preprocessor (PHP) is open source scripting language (PHP-Group, 2019). It is mainly used to make the web content dynamic. For the design of the prototype php was used to make the content dynamic. The header, main content and footer were divided in to three parts to reduce the repetition of coding. Even though

the content was static, for the search function PHP was used to access different static pages.

JavaScript: JavaScript is a scripting language used to make web content interactive. For the feature like changing the zoom size of the page and contrast (font color and background color) of the page JavaScript is used. There are 3 options to change the zoom size of the screen. For the normal zoom size following code was used:

a. **Normal Zoom:** This function changes the zoom size in to 100%.
b. **Medium Zoom:** This function changes the zoom size in to 150%.
c. **Large Zoom**: This function changes the zoom size in to 200%.

These functions are triggered from the link present on the top left side of the prototype, as shown in the Figure 3-4. Similarly, to change the contrast of screen three options are provided.

a. **Black text on off-white background:** This function changes the font color into black and background into off-white. This is also the default color of the website.
b. **Black text on light yellow background**: This function changes the font color into black and background into light yellow.
c. **White text on dark grey background:** This function changes the font color into white and background into dark gray.

All of these functions are also triggered from the link present on the top left side of the prototype, as shown in the Figure 3-4.

3.3.4 Content

To design the new prototype three pages were selected form ordboka containing the word search ‘tur’ in Bokmål, ‘prove’ in Bokmål and ‘språk’ in both Bokmål and Nynorsk (begge). The reason behind retrieving the contents of these search words from the ordboka is that the focus of designing the prototype was on improvement of the design, accessibility and usability of the dictionary rather than improving the content. These three words were selected as content of the prototype because they are familiar and simple Norwegian words.

In the first design of the prototype the content were also provide in English so that non-Norwegian can also understand the content that would in return help them to learn Norwegian. The contents were translated using Google Translator. But it has been previously reported that the translation provided by the Google translate is not hundred percent accurate (Araujo, Reis, Pereira, & Benevenuto, 2016). Therefore, the English content in the prototype was removed.

3.3.5 Layout

The automated evaluation of ordboka presented several issued related to accessibility and usability that deviated from the requirements for the universal design guidelines. For example, when a word is searched in the ordboka, first history of the word with type of word (verb, adjective, or noun) is shown followed by list of meanings and sub-meanings. Each meaning may or may not have examples included. A word may have different history and different meaning under it. In Norwegian language, a word can be of different form like both noun and verb, or verb and adjective etc. For such kind of word; meanings in both forms are also provided in ordboka. Along with the history, meaning list and example of word, bending (different form of word) of the word is also present. These contents of the word meanings from ordboka are also presented in the new prototype. However, the layout of the ordboka seem to be more congested vertically, even though there was much more unused space on the right side, thereby making users to scroll down to view the content. These layout problems were the first priority to be adjusted in the prototype. The prototype layout design was an iterative process and in order to finalize the best layout; several layouts were designed and tested.

In the first design; the prototype was designed with dark background color with white font color. The meaning list was presented in vertical layout with grammatical forms (word bending) on the right side as shown in the Figure 3-2. However, the issues with this layout were similar to the ordboka including need for scrolling to view the meanings.

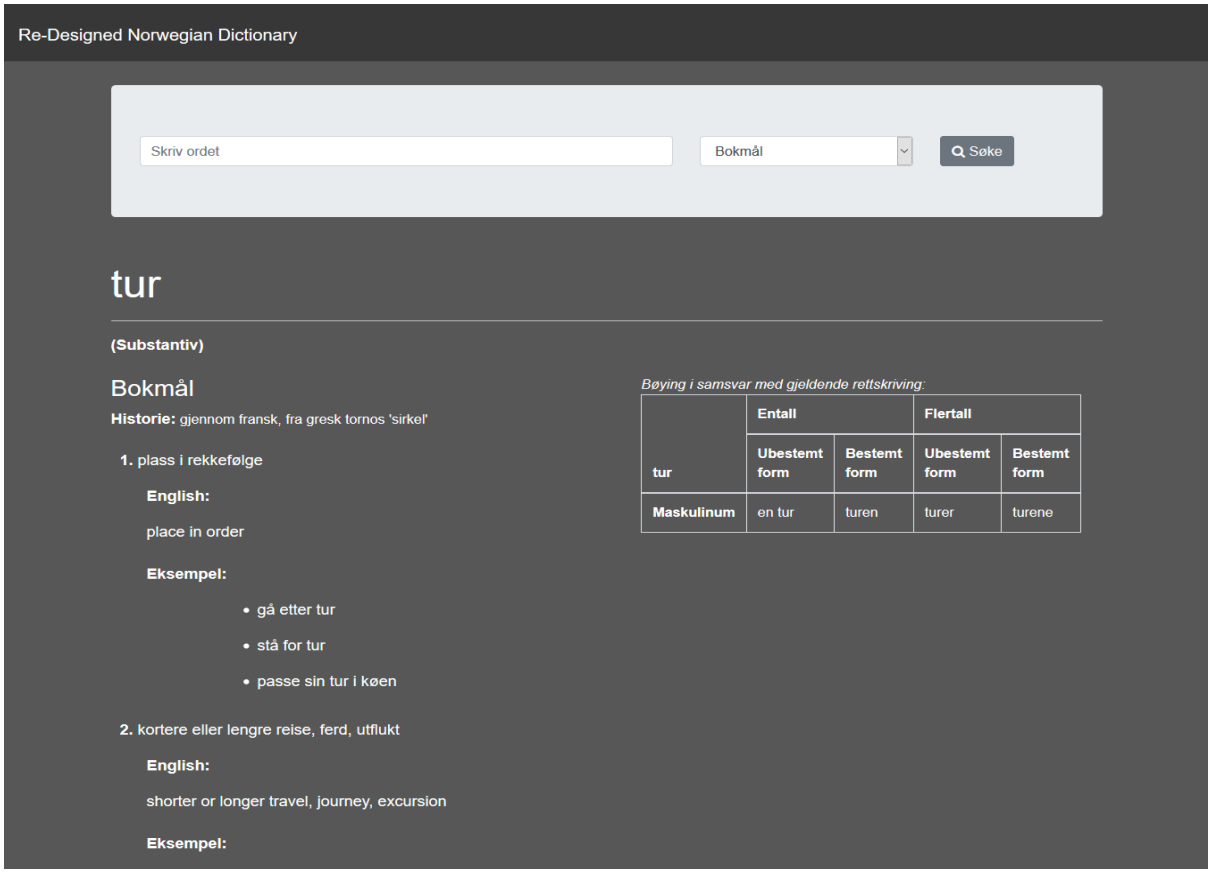


Figure 3-2 Screenshot of the first design of prototype showing the meaning of ‘tur’ in Bokmål

To solve this issue; another layout was designed with pagination as shown in Figure 3-3. The usability guidelines ‘8:4 Use Paging Rather Than Scrolling’ suggest that pagination function should be used instead of scrolling (Leavitt & Shneiderman, 2006). The issue of the contrast was solved by providing three different contrast views of the content. The selection of contrast color and the function are defined in section 3.3.6Color contrast.

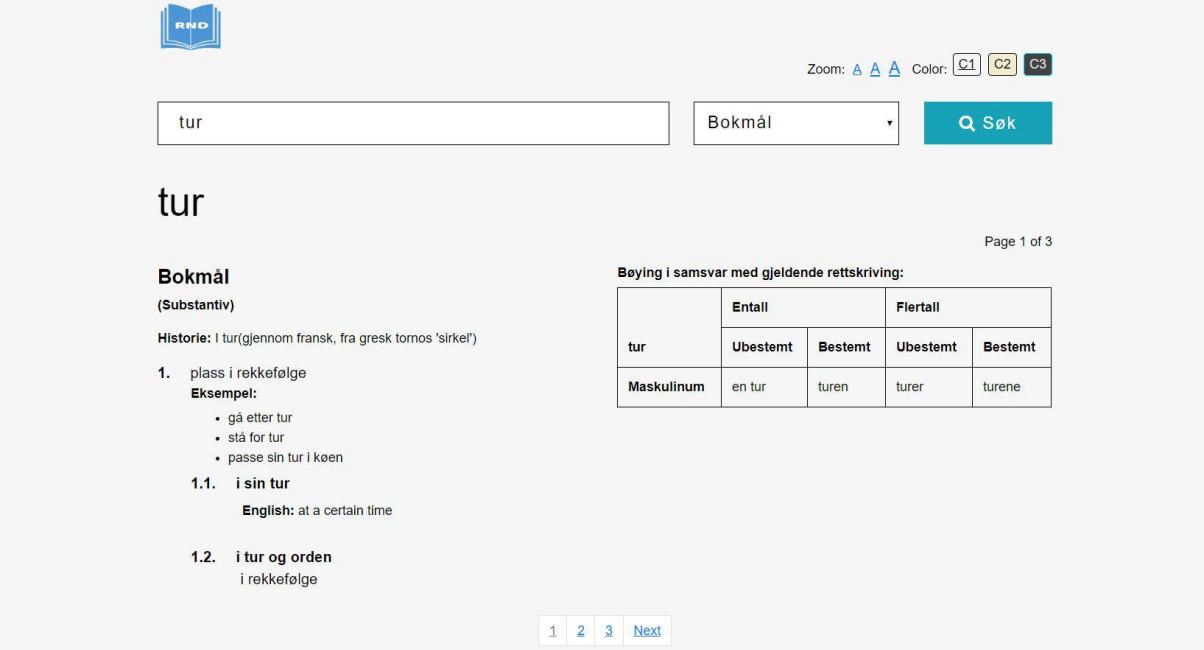


Figure 3-3: Screenshot of the prototype showing the meaning of ‘tur’ in Bokmål with pagination feature

The pagination function improved the layout to an extent, thereby requiring less scrolling. But it was thought that this might lead to frustration and annoying while searching the meaning because if the user does not find the required information in the first page then the user should click on the next page to find the information and so on. The problem seemed to be present even for the meaning list of 5 the pages was divided in to 3 pages to decrease pagination.

Lastly, a new design was made to reduce the scrolling and utilizing the screen space by displaying the meaning list in horizontal format as shown in the Figure 3-4. The contents are well-labelled in this prototype with meaningful sub-headings and bulleted list following the usability guidelines 12:3 format lists to ease scanning, and 12:4 display related items in lists (Leavitt & Shneiderman, 2006; Nielsen, 1997).

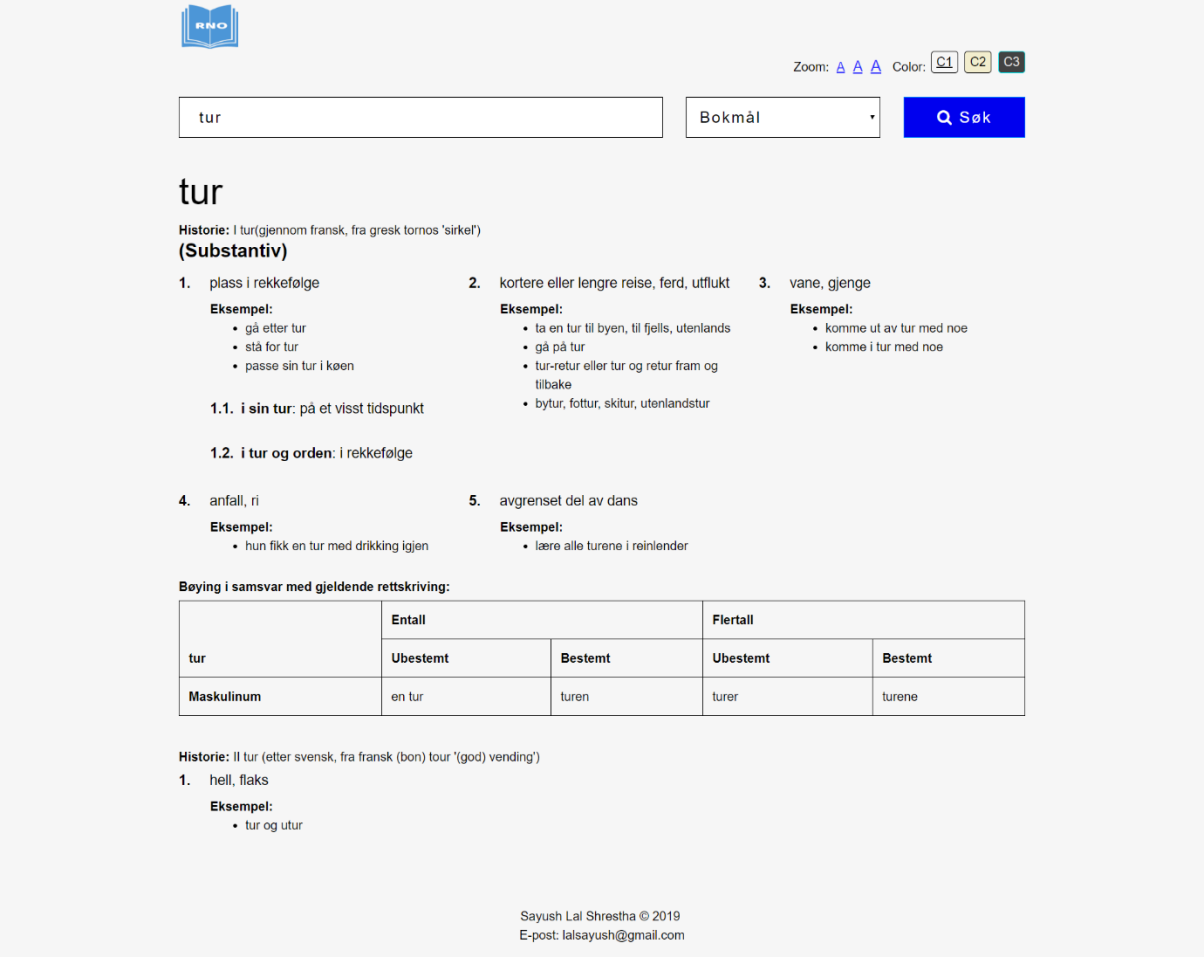


Figure 3-4: Screenshot of the prototype showing the meaning of ‘tur’ in Bokmål

This final layout with color contrast and layout was then used to design other pages.

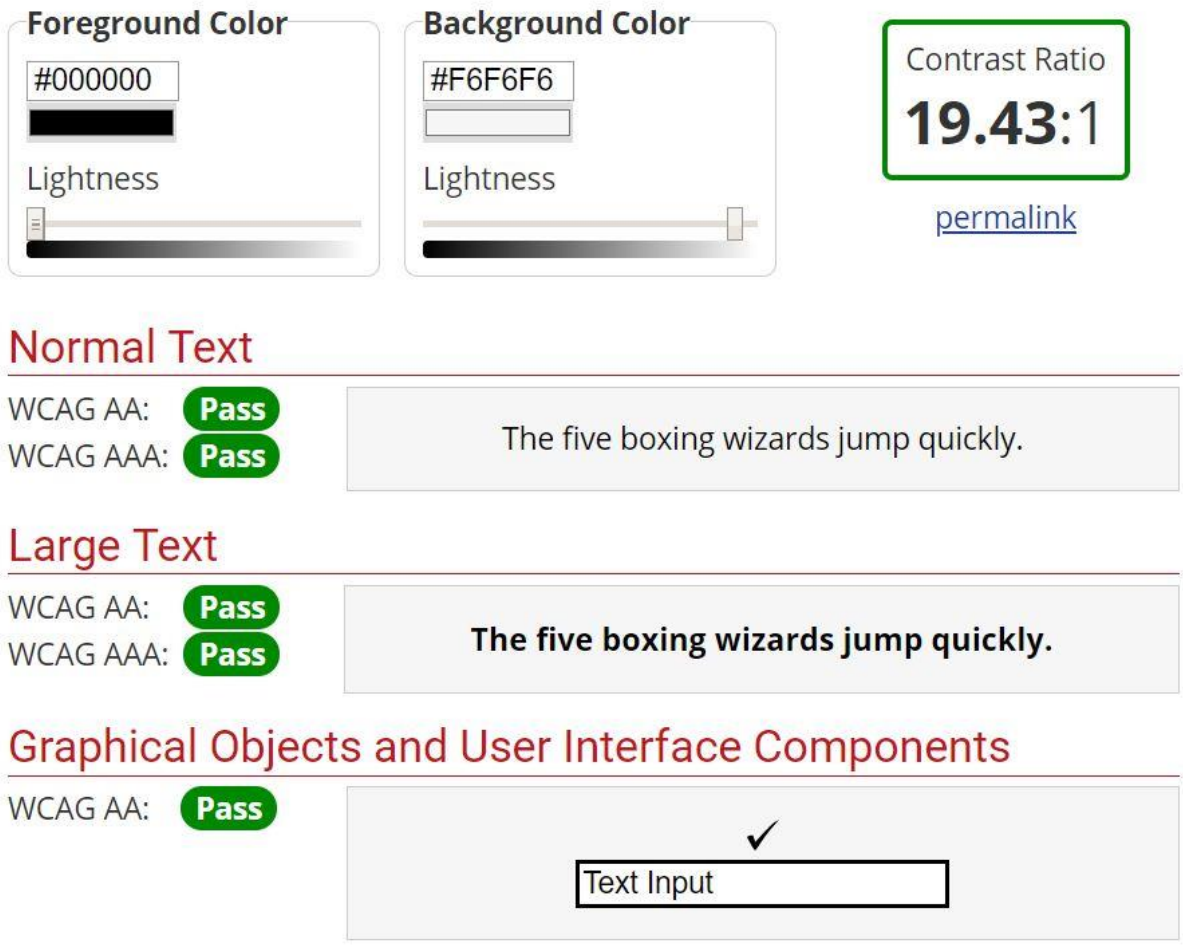
3.3.6 Color contrast

The readability of the text depends on the color of the text and the background (Hall, 2018). Therefore, it has been suggested to use the color that has high contrast between the font and the background (Hall, 2018). However, it has also been argued that the readability also depends on user perspective in choice of the text color and background color.

Accordingly, three types of color contrast are used in the new prototype. They are black color text on off white background, black color text on light yellow background, and white text on black background. A feature is added in the prototype which enables users to toggle between the contrast and choose the contrast that suites the needs of users to read the content. To verify that contrast used in the prototype, they were analysed using Color Contrast Checker (WebAIM, 2019).

a. **Black text** on off-white background: This contrast is the main contrast of the website. The contrast ratio is 19.43:1 which is greater than the minimum requirement (4.5:1) of WCAG 2.1 guideline. The contrast is checked using tool called Color Contrast Checker as show in Figure 3-5 (Source: (WebAIM, 2019))

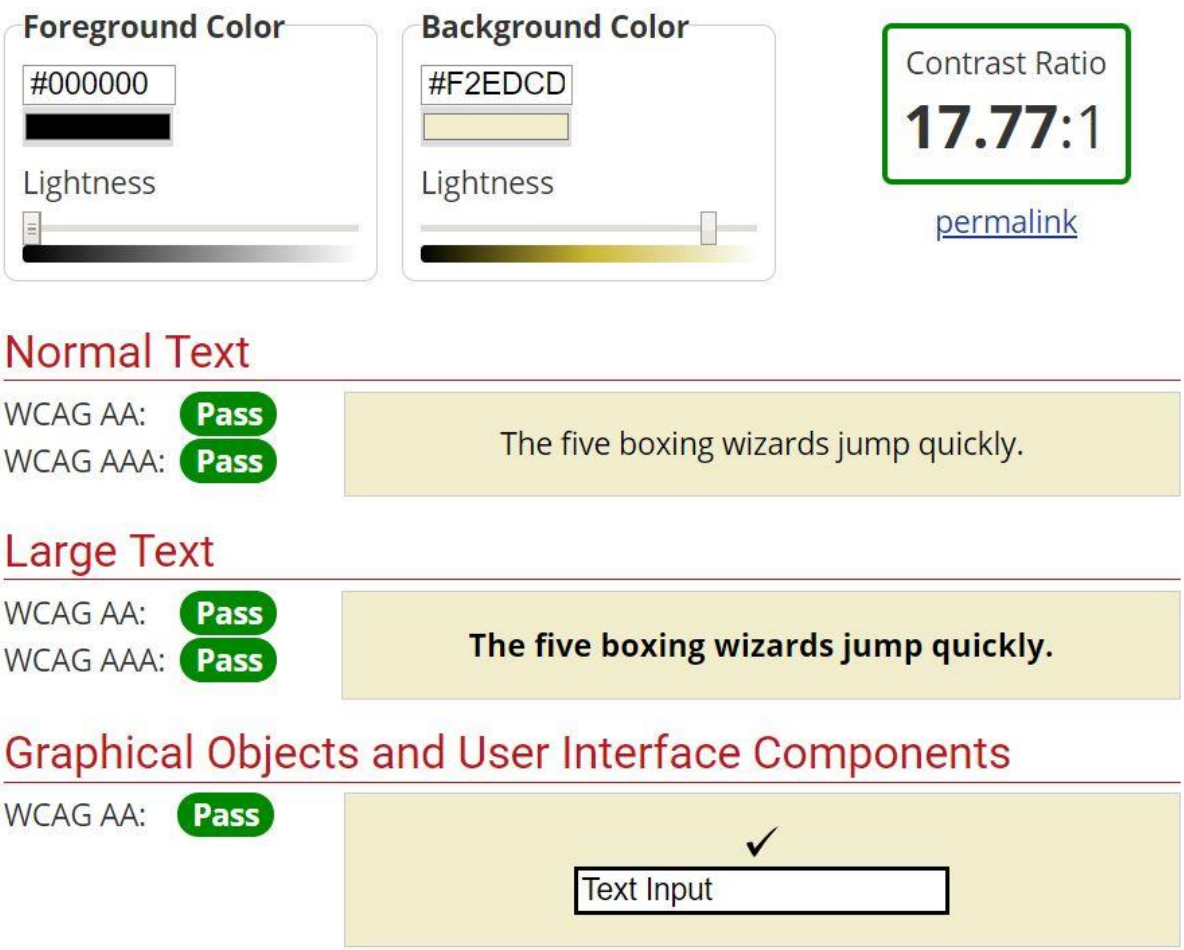
b. Figure 3-5



(Source: (WebAIM, 2019))

Figure 3-5: Report from WebAIM color contrast checker showing the contrast black text on off-white background has passed all the level.

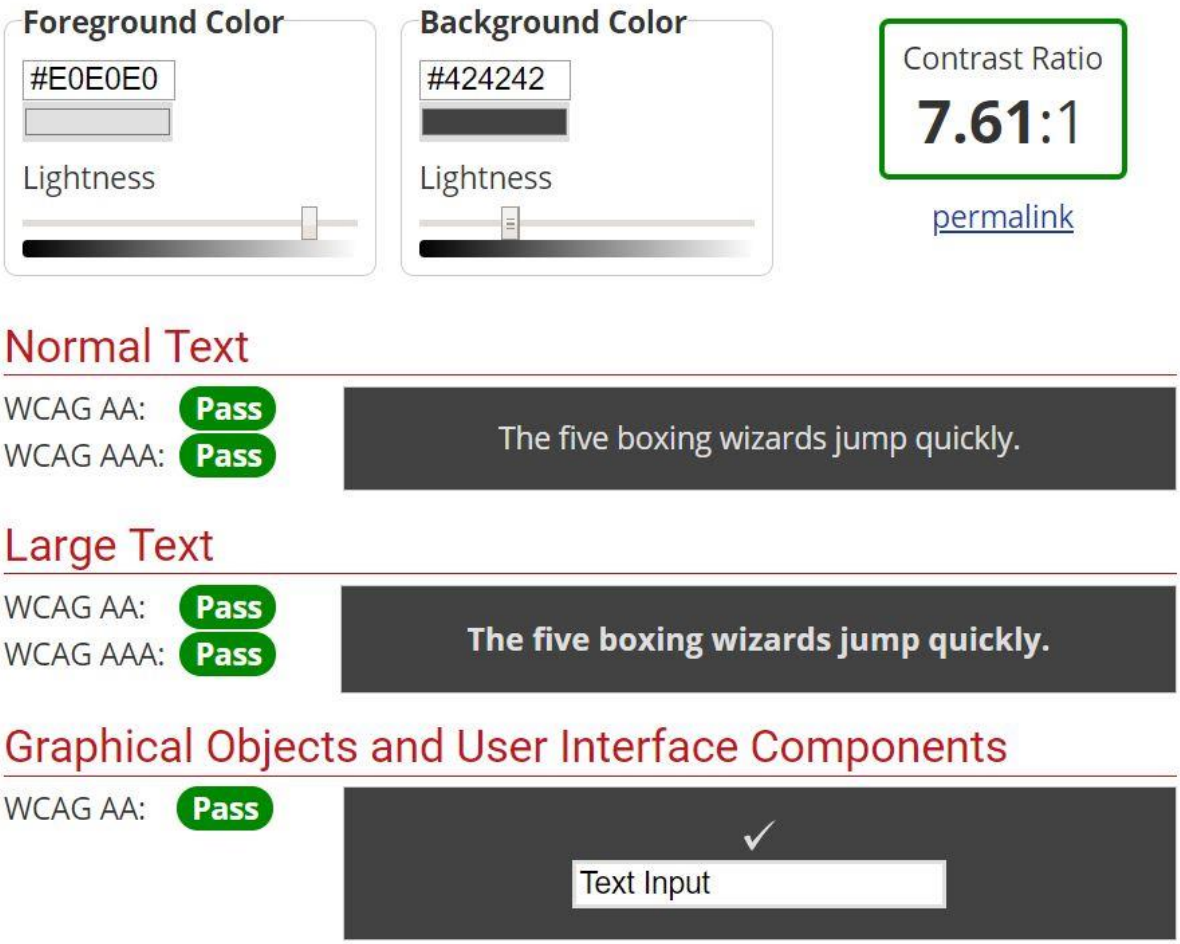
c. **Black text on light yellow background**: The contrast ratio is 17.7:1 which is greater than the minimum requirement (4.5:1) of WCAG 2.1 guideline. The contrast is checked using tool called Color Contrast Checker as show in Figure 3-6.



(Source: (WebAIM, 2019))

Figure 3-6 Report from WebAIM color contrast checker showing the contrast black text on light yellow background has passed all the level.

d. **White text on dark grey background:** The contrast ratio is 7.61:1 which is greater than the minimum requirement (4.5:1) of WCAG 2.1 guideline. The contrast is checked using tool called Color Contrast Checker as show in Figure 3-7.



(Source: (WebAIM, 2019))

Figure 3-7: Report from WebAIM color contrast checker showing the contrast white text on dark grey background has passed all the level.

3.4 User testing

After the finalization of prototype, it was ready for user testing. Within-group design was used to compare the accessibility and usability of the ordboka and prototype of the electronic Norwegian dictionary. The experimental design process included recruitment of participants, performation of pre-defined task in both ordboka and prototype, questionnaire survey to document comparison of the task performed by the participant and statistical analysis of the data collected in the survey.

3.4.1 Participants selection

A total of 20 participants were recruited from the OsloMet university. These participants include both native and non-native students. Following criteria were checked before recruiting the participant for the experiment:

a. Participant must have used and been familiar with ordboka before, so that there is no learning effect.
b. If not native to the Norwegian language, the participant must have at least completed A2 level of Norwegian language. The A2 level is the basic level of Norwegian language course and completing this level would ensure that they would be able to read and understand basic Norwegian language.
c. All the participants must have the basic IT skill.

The recruitment process started with an initial contact through email explaining the purpose of the study and task to be performed. If the participant agreed to participate, then the recruitment criteria were checked. A location was selected preferred by the participant self.

3.4.2 Consent for participation

The user testing started with first receiving consent from the participants both verbally and in written form. The participants were made clear that participation in the user testing was voluntary and they could withdraw from the testing at any time. All the details about the experiment were written in the consent form (Appendix A). Furthermore, the participants were also informed that their information will be confidential and will remain unidentified including during the data analysis. Participants were asked to check the on both the boxes saying, ‘to participate in user testing’ and ‘to participate in answering the questionnaires’. Only after the participant’s permission, the user testing was conducted.

3.4.3 Demographic survey

Before starting the tasks; participants were asked about their prior knowledge or experience of using ordboka including information regarding age, sex, and level of Norwegian langue for non-native participants. The response to these survey questionnaires (Appendix B) were recorded using Google form.

3.4.4 Experiment tasks

The tasks to be performed by the participants were focused on the design, usability, and understandability of both ordboka and the prototype of the electronic Norwegian dictionary. The tasks were as follows:

i. Search word ‘tur’ in either Bokmål or Nynorsk in both the dictionaries.
    a. Find in which dictionary it was easy to read the meaning list.

b. Find 3rd example of 2nd meaning.
c. Find the grammatical forms of the word (bøying).

ii. Search word ‘prøve’ in either Bokmål in both the dictionaries.
a. Find the noun (substantive) and verb meaning list
b. Find the sub-meaning of 1st meaning

iii. Search word ‘språk’ in both Bokmål and Nynorsk (begge) in both the dictionaries.
a. Find in which dictionary it is easy to read the meaning list.

3.4.5 Post experimental survey

Based on the tasks performed by the participant the post questionnaires were designed. Questionnaires are 5-point Likert scale (1= Strongly disagree, 2= Disagree, 3= Neutral, 4= Agree and 5= Strongly agree). Likert scale is developed by Rensis Likert (Likert, 1932). Likert scale is a rating scale is used to measure the attitudes and opinions. 5-point Likert scale provides better quality of data compared to 7- or 11-point scale (Dawes, 2008; Revilla, Saris, & Krosnick, 2014).

Total of 8 questions were designed for the post experimental questionnaires (Appendix D). Questions 1 to 7 were related to tasks where participants compared the search result of word ‘tur’ and ‘prøve’ either in Bokmål or Nynorsk. Question 8 was related to task 5 in which the participants compared the search result of word ‘språk’ using begge functionality. The response to these questionaries were in a 5-point Likert scale where the rating 1 to 5 meant Strongly disagree, Disagree, Neutral, Agree and Strongly agree respectively. The responses to the post-experimental survey were recorded using Google form. After the completion of the survey, the participants were asked for any comments regarding improvement of the prototype followed by thanking the participants for participation.

3.5 Data analysis

The data collected from the user testing after performing the task were related to compare participant satisfaction and error rate while using the ordboka and the prototype. Since the test was done within same group, a related t-test also known as paired samples t-test was used to statistically analyze the data. In this statistical test, a comparison is made between the mean of two dependent variables measured across an independent variable in order to determine whether there is any significant

difference between the population means (Mayers, 2013). The paired t-test was calculated using IBM SPSS version 25 software.

The two main hypotheses were formulated relating to participant satisfaction and error rates. In total, two pairs of null hypotheses and alternative hypothesis were tested with paired t-test. The hypotheses were defined to test difference in number of errors; reading and scanning meaning; finding information or contents; and understanding layout design between the ordboka and the prototype. The hypotheses were formulated as follows:

Hypothesis 1:

Null hypothesis H_0: There will be no significant difference in number of errors performing the task in ordboka and new prototype of the dictionary.

Alternative hypothesis H_1: The number of errors performing the task in ordboka will be significantly greater than in new prototype of the dictionary.

Hypothesis 2:

Null hypothesis H_0: There will be no significant difference in satisfaction of participants in ordboka and new prototype of the dictionary.

Alternative hypothesis H_1: Participants will be significantly more satisfied in using the new prototype of the dictionary than ordboka.

This hypothesis was related to test whether the users would be more satisfied using the ordboka or the prototype. Also, this hypothesis was sub-divided into 8 hypotheses to test satisfaction in following:

a. Reading meaning list of search words
b. Scanning and finding required information
c. Opinion regarding cluttered content
d. Finding and navigating sub-meanings
e. Understanding layout design of the content
f. Finding grammatical forms of word (bøying)
g. Finding examples
h. Reading content of search word in both Bokmål and Nynorsk

The paired t-test deployed to test these hypotheses was tested for statistical significance at a significance level of 5%, i.e. 0.05. The rejection or acceptance of null hypothesis was justified by the calculation of p-value, where p-value less than 0.05 meant that the null hypothesis was rejected, meaning significance difference between ordboka and the prototype.

In addition, Cohen's d was calculated to find the effect size and power of each of the criteria under satisfaction and error tests. Cohen's d was calculated using Microsoft Excel using the following formula (Mayers, 2013):

$$d = \frac{Mean\ a - Mean\ b}{Pooled\ standard\ deviation\ (Sp)}$$

Pooled standard deviation was calculated by the formula below:

$$Sp = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2 \ldots + (n_k - 1)S_k^2}{n_1 + n_1 - k}}$$

Where n is the number of samples, k is number of conditions and S^2 is variance.

The effect size guidelines for Cohen's d is shown in Table 3-1 (Mayers, 2013).

Table 3-1 Effect size guidelines

Size	**Cohen's d**
Small	<0.25
Medium	0.25 – 0.4
Large	0.4 - ∞

Chapter 4. Results and analysis

This chapter presents the findings from the automated evaluation of ordboka and the statistical analyses of data collected from the participants

4.1 Evaluation of ordboka

The selected pages of the ordboka were evaluated using WAVE and SortSite tools. The pages under evaluation included homepage, page with meaning of word ‘tur’ in Bokmål, meaning of word ‘prove’ in Bokmål and meaning of word ‘språk’ using begge function, i.e. both Bokmål and Nynorsk together. The preliminary layout of the ordboka shows that the website is not accessible by assistive technology like screen reader. The content also seems to be cluttered with large white space and difficulty in reading. The automated evaluation of these pages failed several success criteria from WCAG 2.1 guidelines.

4.1.1 WAVE tool evaluation

The WAVE tool evaluation of home page of ordboka (Appendix E) showed 3 errors, 1 alert and 10 contrast errors under WCAG 2.1 guidelines (Table 4-1).

Table 4-1 Evaluation result of home page of ordboka from WAVE

Issue types	Issues	Failed success criteria
Error	1 Linked image missing alternative text	1.1.1 Non-text Content (Level A) 2.4.4 Link Purpose (In Context) (Level A)
	1 Missing form label	1.1.1 Non-text Content (Level A) 1.3.1 Info and Relationships (Level A) 2.4.6 Headings and Labels (Level AA) 3.3.2 Labels or Instructions (Level A)
	1 Document language missing	3.1.1 Language of Page (Level A)
Alert	No heading structures	1.1.1 Non-text Content (Level A) 2.4.4 Link Purpose (In Context) (Level A)
Contrast	Ten very low contrast	1.4.3 Contrast (Minimum) (Level AA)

Table 4-2 Evaluation result of page with ‘tur’ meaning in Bokmål from WAVE

Issue types	Issues	Failed success criteria
Error	5 missing alternative text	1.1.1 Non-text Content (Level A) 2.4.4 Link Purpose (In Context) (Level A)
	2 missing form labels	1.1.1 Non-text Content (Level A) 1.3.1 Info and Relationships (Level A) 2.4.6 Headings and Labels (Level AA) 3.3.2 Labels or Instructions (Level A)
	1 Document language missing	3.1.1 Language of Page (Level A)
Alert	1 JavaScript jump menu	2.1.1 Keyboard (Level A) 3.2.2 On Input (Level A)
Contrast	21 very low contrast	1.4.3 Contrast (Minimum) (Level AA)

In the WAVE evaluation of page where word ‘tur’ was searched in Bokmål (Appendix F); 8 errors, 1 alert and 21 contrast errors were found under WCAG 2.1 guidelines (Table 4-2). According to section 508, 27 device dependent event handler alerts were also found. Device depended event handler are the events that are not accessible by keyboard.

Similarly, the WAVE tool evaluation of the page with word search ‘prøve’ in Bokmål (Appendix G) showed 48 errors, 1 alert and 30 contrast errors under WCAG 2.1 (

Table 4-3). According to section 508, 66 device dependent event handler alerts were also found.

Table 4-3 Evaluation result of word search ‘prøve’ in ordboka from WAVE

Issue types	Issues	Failed success criteria
Error	45 missing alternative text	1.1.1 Non-text Content (Level A) 2.4.4 Link Purpose (In Context) (Level A)
	2 missing form labels	1.1.1 Non-text Content (Level A) 1.3.1 Info and Relationships (Level A) 2.4.6 Headings and Labels (Level AA) 3.3.2 Labels or Instructions (Level A)
	1 Document language missing	3.1.1 Language of Page (Level A)
Alert	1 JavaScript jump menu	2.1.1 Keyboard (Level A) 3.2.2 On Input (Level A)
Contrast	30 very low contrast	1.4.3 Contrast (Minimum) (Level AA)

In page with word search ‘språk’ in both Bokmål and Nynorsk (begge) the WAVE tool evaluation (Appendix H) found 58 errors, 2 alert and 39 contrast errors under the WCAG 2.1 guidelines (Table 4-4). According to Section 508, 125 device dependent event handler alerts were also found in this page.

The WAVE tool evaluation of these pages also found five reluctant title text each, meaning the tile text for the link and the link are same.

Table 4-4 Evaluation result of word search ‘språk in ordboka form WAVE

Issue types	Issues	Failed success criteria
Error	54 missing alternative text	1.1.1 Non-text Content (Level A) 2.4.4 Link Purpose (In Context) (Level A)
	3 missing form labels	1.1.1 Non-text Content (Level A) 1.3.1 Info and Relationships (Level A) 2.4.6 Headings and Labels (Level AA) 3.3.2 Labels or Instructions (Level A)
	1 Document language missing	3.1.1 Language of Page (Level A)
Alert	2 JavaScript jump menus	2.1.1 Keyboard (Level A) 3.2.2 On Input (Level A)
Contrast	39 very low contrast	1.4.3 Contrast (Minimum) (Level AA)

4.1.2 SortSite tool evaluation

The SortSite tool evaluation of homepage of ordboka (Appendix I) found 6 issues which were under Level A priority and 2 were found under Level AA priority (Table 4-5).

Table 4-5 Evaluation report of ordboka homepage from SortSite

Issues	Failed success criteria	Level
Table used for layout and role is not defined	1.3.1 Info and Relationships	A
Alternative text in missing in images	1.1.1 Non-text Content	A
No label in form control	4.1.2 Name, Role, Value	A
Image updated without updating its alternative text	1.1.1 Non-text Content	A
	4.1.2 Name, Role, Value	A
Language of the page not defined	3.1.1 Language of Page	A
Less contrast between text and background color	1.4.3 Contrast (Minimum)	AA
Specifying foreground colors without specifying background colors or vice versa	1.4.3 Contrast (Minimum)	AA

Similarly, 9 issues were found under Level A priority and 1 were found under Level AA priority (

Table 4-6) in the page with word ‘tur’ meaning in Bokmål using SortSite tool (Appendix J).

Table 4-6 Evaluation report of page with ‘tur’ meaning in Bokmål from SortSite

Issues Found	Failed success criteria	Level
Event handler (onclick) is not accessible by keyboard	2.1.1 Keyboard	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Table used for layout and role is not defined	1.3.1 Info and Relationships	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Link with no underline	1.4.1 Use of Color	A
Elements that used JavaScript to behave like link are not accessible by keyboard and screen readers	1.3.1 Info and Relationships	A
	2.1.1 Keyboard	A
	4.1.2 Name, Role, Value	A
No label in form control	4.1.2 Name, Role, Value	A
HTML layout table that does not make sense when linearized	1.3.2 Meaningful Sequence	A
Language of the page not defined	3.1.1 Language of Page	A
Less contrast between text and background color	1.4.3 Contrast (Minimum)	AA

The evaluation of page with ‘prøve’ meaning in Bøkmål using SortSite tool (Appendix K) found10 issues under Level A priority and 1 issue under Level AA priority (

Table 4-7).

Table 4-7 Evaluation report of page with ‘prøve’ meaning in Bokmål from SortSite

Issues Found	Failed success criteria	Level
Event handler (onclick) is not accessible by keyboard	2.1.1 Keyboard	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Table used for layout and role is not defined	1.3.1 Info and Relationships	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Link with no underline	1.4.1 Use of Color	A
Elements that used JavaScript to behave like link are not accessible by keyboard and screen readers	1.3.1 Info and Relationships	A
	2.1.1 Keyboard	A
	4.1.2 Name, Role, Value	A
No label in form control	4.1.2 Name, Role, Value	A
Page has duplicate IDs which cause problems in screen readers	4.1.1 Parsing	A
HTML layout table that does not make sense when linearized	1.3.2 Meaningful Sequence	A
Language of the page not defined	3.1.1 Language of Page	A
Less contrast between text and background color	1.4.3 Contrast (Minimum)	AA

10 issues were found under Level A priority and 1 issue was found under Level AA priority (

Table 4-8) in the page with ‘språk’ meaning in begge when tested using SortSite tool (Appendix L).

Table 4-8 Evaluation report of page with ‘språk’ meaning in Bokmål from SortSite

Issues Found	Failed success criteria	Level
Event handler (onclick) is not accessible by keyboard	2.1.1 Keyboard	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Table used for layout and role is not defined	1.3.1 Info and Relationships	A
Alternative text in missing in images	1.1.1 Non-text Content	A
Link with no underline	1.4.1 Use of Color	A
Elements that used JavaScript to behave like link are not accessible by keyboard and screen readers	1.3.1 Info and Relationships	A
	2.1.1 Keyboard	A
	4.1.2 Name, Role, Value	A
No label in form control	4.1.2 Name, Role, Value	A
Page has duplicate IDs which cause problems in screen readers	4.1.1 Parsing	A
HTML layout table that does not make sense when linearized	1.3.2 Meaningful Sequence	A
Language of the page not defined	3.1.1 Language of Page	A
Less contrast between text and background color	1.4.3 Contrast (Minimum)	AA

4.2 Participants distribuition

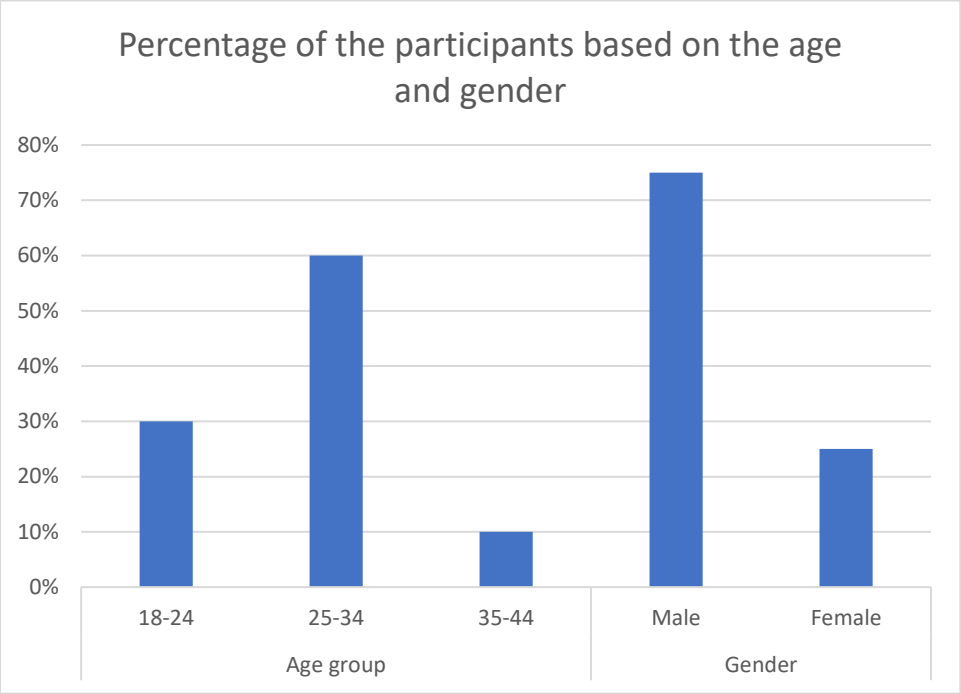


Figure 4-1: Chart showing percentage of the participants based on the age and gender

A total of 20 participants were recruited in this study for the user testing of both ordboka and the prototype. Among these participants 5 were female and 15 were males. The age distribution of the participants is presented in Chart showing percentage of the participants based on the age and gender (Figure 4-1).

There were 10 Norwegian participants and 10 non-Norwegian participants. When participants were asked about where they heard about the ordboka, the response was that 50% used this dictionary in school, 40% were recommended by Norwegian language teacher and 10% of the participants found out from the Google search (Figure 4-2).

Similarly, 85% of the participants used the dictionary in browser, 5% in app and 10% used both the platform: app and browser. Lastly, when participants were asked about, whether it was easy to use ordboka in the beginning where 60% of the participants found difficult to use the dictionary in the beginning and remaining 40% of the participant found easy to use the dictionary in the beginning.

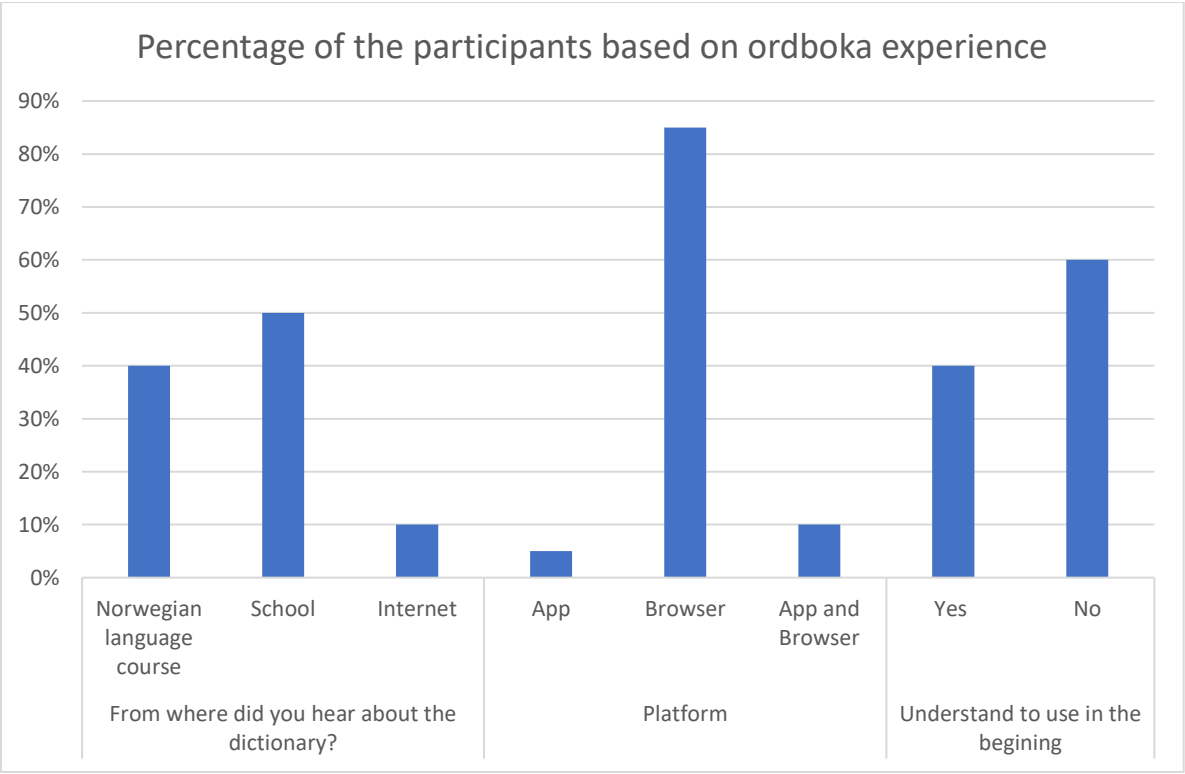


Figure 4-2 Chart showing percentage of the participants based on ordboka experience

4.3 Error comparison analysis

The types of errors were calculated in 4 different tasks: finding the examples from the searched word, finding the grammatical forms (bøying) of searched word, finding different meaning list of searched word, and finding sub-meaning list of searched word. The details of the t-test results and Cohen's d are presented in Table 4-9.

Table 4-9 Paired samples t-test of errors

Error in finding	**Mean Difference**	**Std. Deviation**	**t**	**p-value**	**Cohen's d**
Examples	-1.450	0.686	-9.448	0.000	2.253
Grammatical forms	-1.550	1.234	-5.616	0.000	2.080
Meaning list	-0.421	0.507	-3.618	0.002	0.704
Sub-meaning list	-0.250	0.444	-2.517	0.021	0.294

The negative value of mean difference in the table above denotes that there were more chances of errors while using ordboka than the prototype, since the value in Likert scale given by the participants were lower in case of prototype

In the task where participants were asked to find the specific example of the search word, all participants were confused and had difficulties in finding examples in ordboka, whereas in the new prototype participants found the specific example easily because of the bullet listing and indentation.

Similarly, in finding the grammatical forms (bøying) of searched word, all the Norwegian participants could not find it in ordboka, even though they had been using this dictionary from the school. They randomly clicked on different links until it was found. In the prototype, the users found it easily, as the grammatical forms were located at the end of the page.

In finding different meaning list of searched word, participants were asked to find the noun meaning list and verb meaning list of word ‘prøve’. Errors were made by most of the non-Norwegian participants in ordboka. All participants could easily find it in the prototype because of the heading and the meaning list were specified.

While finding the sub-meaning of searched word some of the participants were confused and made error in the prototype but number of errors was less than in the ordboka. Some of the participants also found difficult in finding the meaning list in prototype because they got confused whether it was another example or sub-meaning.

The calculated p-value as mentioned in Table 4-9 above was lower than the significance level of 5%, and thus showing that the prototype was significantly less prone to errors than the ordboka.

The Cohen’s d value for the errors also suggests that the prototype has strong tendency to have less errors in finding examples, grammatical forms of words and meaning list, whereas the tendency to have less errors than in ordboka does not seem to be too effective while searching for sub-meaning in the prototype.

4.4 Satisfaction comparison analysis

The satisfaction of the participation in ordboka and new prototype were calculated in 8 different categories.

Category 1. Satisfaction in reading the meaning list of searched word
Category 2. Satisfaction in scanning and finding the required information
Category 3. Opinion regarding cluttered content of searched word

Category 4. Satisfaction in finding and navigating sub-meaning of searched word

Category 5. Satisfaction in understanding layout design of the content

Category 6. Satisfaction in finding grammatical forms of searched word

Category 7. Satisfaction in finding examples of searched word

Table 4-10 Paired samples t-test of satisfaction

Satisfaction in	**Mean Difference**	**Std. Deviation**	**t**	**p-value**	**Cohen's d**
Category 1	2.350	0.745	14.104	.000	2. 826
Category 2	2.300	1.081	9.516	.000	2.523
Category 3	-3.000	1.170	-11.469	.000	3.366
Category 4	2.500	1.235	9.050	.000	2.658
Category 5	2.800	1.105	11.332	.000	3.187
Category 6	3.500	0.513	30.512	.000	4.542
Category 7	2.800	0.951	13.161	.000	3.123
Category 8	1.850	0.489	16.907	.000	2.109

The positive value of mean difference in Table 4-10 denotes that the value given by participants for questionnaires related to satisfaction criteria were higher in prototype than the ordboka. The negative value in Category 3 relates to the cluttered option, in which the participants found the content in the ordboka more cluttered than in prototype.

The paired t-test showed that the calculated p-value was lower than the significance level of the study (i.e. 0.05 or 5%) in each of the criteria of satisfaction test, thereby suggesting that the participants were significantly satisfied by the layout and design of the prototype than the ordboka. The calculated Cohen's d values also represent that the prototype had a strong effect with respect to participants' satisfaction.

Chapter 5. Discussion

5.1 Need for universally designed prototype

Before starting to design the prototype of the dictionary, the existing dictionary ordboka was evaluated using two different evaluation tools: WAVE (WebAIM, 2018) and SortSite (PowerMapper Software, 2018). Evaluation was done of 4 different pages of ordboka: home page, page with meaning of word ‘tur’ in Bokmål, page with meaning of word ‘prøve’ in Bokmål and page with meaning of word ‘språk’ in both Bokmål and Nynorsk (begge). The findings from the evaluation tools suggest that the ordboka violated many guidelines of WCAG 2.1 (W3C, 2018).

The error and alerts found in the report generated by WAVE while testing the home page of ordboka were also found in other pages. All the pages with the meaning search had the same errors and alert, the only difference being the number of errors and alerts. Out of all the errors, maximum number of missing alternative text was found. From overall pages used for evaluation, 9 failed success criteria of WCAG 2.1 were generated. Out of the 9 Success Criteria, 7 Success Criteria were level A and remaining 2 were level AA.

Similarly, in the report generated by SortSite of different pages of ordboka issues under Priority A and Priority AA found in the home page were also found in other pages. The comparison of the reports generated by WAVE and SortSite, showed same numbers of issues, but the issues were different. SortSite generated more detailed report than WAVE. Issues like table used for layout and role is not defined, page has duplicate IDs which cause problems in screen readers and HTML layout table that does not make sense when linearized were only found in SortSite. All the issues found in WAVE were also found by SortSite.

Despite being most widely used and trustworthy online Norwegian dictionary as of today, the dictionary developed and co-owned by the Norwegian Language Council and the University of Bergen does not comply with Norwegian government’s requirement of universally designed net based ICT solutions (Leavitt & Shneiderman, 2006; Regjeringen.no, 2013; W3C, 2018). Therefore, there was necessity of developing a new prototype of an electronic Norwegian dictionary that is universally designed.

5.2 Superiority of the prototype

The main goal of the designing the new prototype was to improve the accessibility and usability of the content of the existing dictionary and not to improve the content. Even though the ordboka was not universally designed, but the contents of the ordboka formed the backbone of this prototype. Prototype was designed based on the principles of universal design (Connell et al., 1997) following the WCAG 2.1 (W3C, 2018) and usability guidelines provided by HHS (Leavitt & Shneiderman, 2006). With the help of these guidelines the final prototype of the dictionary has additive functions like keyboard compatibility and accommodates screen readers, specified heading, label and sections, contrast customization, page zoom customization and browser and device compatible that is missing in the ordboka.

Although, the prototype design followed the universal design concept and guidelines, the superiority of the prototype was deemed incomplete without the user testing. The findings from the user testing suggest that the new prototype is superior to the ordboka in many aspects including finding examples of search word, grammatical forms, sub-meanings and different meaning both in terms of user satisfaction and the amount of errors made.

After the user testing the findings from the data analysis suggest that usability components (Nielsen, 2012) were fulfilled by the new prototype. Regarding learnability, participants understood the layout of the prototype easily. Even though the task were not timed, observation of the task performed by the participants suggest that task was performed faster in the prototype than in ordboka; hence showing efficiency in prototype. Since, participants were able to learn the design layout and perform the task faster in prototype, this suggest that the memorability exist in the design of the prototype. Comparing the number of errors in performing tasks in ordboka and new prototype proved that there is a significant difference.

It has been justified from this study that following the universal design guidelines and principles while developing an electronic dictionary has improved the success criteria (Hanson & Richards, 2013). The universally designed electronic Norwegian dictionary prototype has the tendency to have much lesser extent of error and improved satisfaction than the existing ordboka which is not universally designed However, the prototype still lacks some features that could have improved

participants' tendency of making errors while searching for sub-meaning, indicating that despite strictly following the guidelines while developing web content, there may always be a little chance of having problems when a diverse group of users are using same product (Power et al., 2012).

5.3 Limitation of the study

As mentioned earlier, this study focuses on developing a prototype of a universally designed electronic Norwegian dictionary. However, due to time constrains, only few words were selected for redesign. Norwegian language has a huge vocabulary with meaning in both Bokmål and Nynorsk. There is lot more to do in near future which is both time-taking and challenging. In addition, this study does not include design of homepage for the prototype, though it is one of the criteria in the universal design guidelines.

Chapter 6. Conclusion

The need and importance of universally designed web content has been a must in the present-day despite of content, language or form, because of the diverse users and competitive environment. This applies also to the online dictionaries available. The concept of universal design is not new, however there are lacking information regarding whether online dictionaries are universally designed or not. Though proper reasons are not available, lack of studies related to testing of online dictionaries for universal design might be because, online dictionaries are mostly prioritized for content alone rather than the layout, design and user accessibility.

Despite being one of the most widely used and trusted online Norwegian dictionary, developed jointly by The Norwegian Language Council (Språkrådet) and The University of Bergen, the Nynorskorboka og Bokmålsordboka (called 'ordboka' in this thesis) lacks several features as required by the universal design guidelines. The ordboka itself violates the Norwegian government's requirement of universal design of ICT solutions, thereby indicating a need of a prototype of an electronic Norwegian dictionary that is universally designed.

This study presents a prototype of universally designed Norwegian dictionary based on the contents from the ordboka. The findings from this study suggest that the prototype is superior to the ordboka both in terms of satisfaction and minimizing errors while using the dictionary. The study further suggests that online dictionary should have a proper layout where user can change contrast according to the need; the content should be presented appropriately making use of screen space, thereby reducing scrolling and proper labeling of content, so that the users can easily find what they are looking for. In addition, user assistive tools are must to support use for disabled groups. Moreover, the study also suggests that following the guidelines of web content accessibility and usability are must, but not always enough while designing web contents.

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Appendices

Appendix A: Information letter

Are you interested in taking part in the research project "A Universally Designed Electronic Norwegian Dictionary?"

This is an inquiry about participation in a research project where the main purpose is to improve the usability and readability of existing Norwegian dictionary Nynorsksordboka og Bokmålsordboka (https://ordbok.uib.no) so that diverse users can access the content provided by this dictionary. In this letter, I will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

This is a master's thesis project. The main purpose is to improve the accessibility and readability of existing Norwegian dictionary so that diverse users can access the content provided by this dictionary. To improve the accessibility and readability of the dictionary a new prototype is designed to overcome the accessibility and readability issues found in the existing dictionary.

Who is responsible for the research project?

OsloMet – Storbyuniversitetet (OsloMet - Oslo Metropolitan University) is the institution responsible for the project.

What does participation involve for you?

In this user testing; task will be given to compare the existing Norwegian Dictionary and the new prototype of that dictionary. Before the task; some questions will be asked to find the knowledge of the dictionary. After the tasks are completed; a pre-defined set of questionnaires will be given to you where you give your opinion and perception by scaling from 1 to 5 where 1 is strongly disagree and 5 is strongly agree. It will take approx. 45 minutes for the whole session.

Participation is voluntary

Participation in the project is voluntary. If you chose not to continue, you can withdraw your consent at any time without giving any reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

No personal data from you will be collected in this user testing.

What will happen to your personal data at the end of the research project?

No personal data from you will be collected in this user testing.

Information form

I have received and understood information about the project “A Universally Designed Electronic Norwegian Dictionary” and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in experiment
- ☐ to participate in answering the questionnaires

Appendix B: Demographic questionnaires

1. Age group?
   - ☐ 18-24
   - ☐ 25-34
   - ☐ 35-44
   - ☐ 45-54
   - ☐ 55-64
2. Gender?
   - ☐ Male
   - ☐ Female
3. Ethnic origin? (native or non-native)
   - ☐ Norwegian
   - ☐ Non-Norwegian
4. Which level have you completed Norwegian language course? (For Non-native)
   - ☐ A2
   - ☐ B1
   - ☐ B2
   - ☐ C1
   - ☐ C2
5. In which platform (browser or app or both)? (multiple select)
   - ☐ Browser
   - ☐ App
6. From where did you hear about this dictionary?
   - ☐ Norwegian language course
   - ☐ School
   - ☐ Family
   - ☐ Friends
   - ☐ Other: _____
7. How often do you use the dictionary?
   - ☐ Daily
   - ☐ Once a week
   - ☐ Once a month

- ☐ Only when needed

8. For what purpose did you use Norwegian dictionary? (multiple select)
   - ☐ Meaning
   - ☐ Examples
   - ☐ Bøying
   - ☐ Synonyms
   - ☐ Other: _____
9. Was it easy to use and understand the content of the dictionary?
   - ☐ Yes
   - ☐ No

Appendix C: Observation sheet

Participation ID: _____ Date: _____

Start time: _____ End Time: _____ Duration: _____

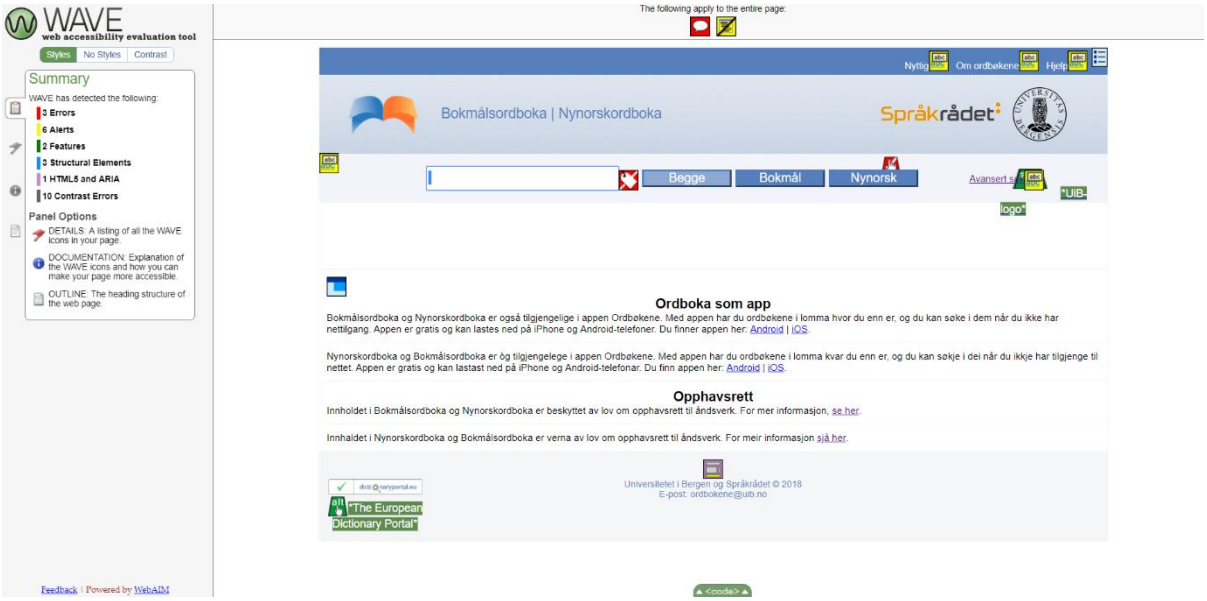
Task observation:

Ordboka	New Prototype
Task 1.a Remarks:	Task 1.a Remarks:
Task 1.b Attempts: ☐ ☐ ☐ ☐ Remarks:	Task 1b Attempts: ☐ ☐ ☐ ☐ Remarks:
Task 1.c Attempts: ☐ ☐ ☐ ☐ Remarks:	Task 1.c. Attempts: ☐ ☐ ☐ ☐ Remarks:
Task 2.a Attempts: ☐ ☐ ☐ ☐ Remarks:	Task 2.a Attempts: ☐ ☐ ☐ ☐ Remarks:
Task 2.b Attempts: ☐ ☐ ☐ ☐ Remarks:	Task 2.b Attempts: ☐ ☐ ☐ ☐ Remarks:
Task 3.a Remarks:	Task 3.a Remarks:

Appendix D: Post-questionnaires

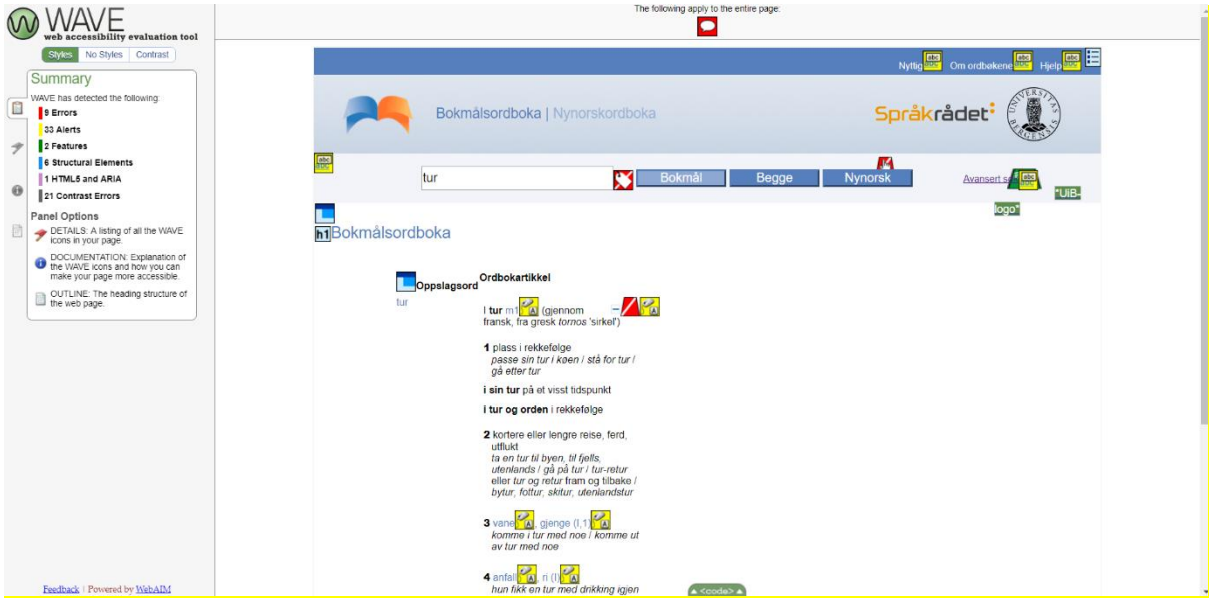
Questionnaires	Scale: 1= Strongly disagree, 2= disagree, 3= Neutral, 4= Agree and 5= strongly Agree	
	Ordboka	New Prototype
1. Meaning list is displayed with proper line spacing and is easy to read.	1 2 3 4 5	1 2 3 4 5
2. Content from the word search has proper heading and label that helps to scan and find the required information.	1 2 3 4 5	1 2 3 4 5
3. Content is cluttered and difficult to read.	1 2 3 4 5	1 2 3 4 5
4. Sub-meanings are numbered and easy to find and navigate.	1 2 3 4 5	1 2 3 4 5
5. The layout design of the content is easy to understand.	1 2 3 4 5	1 2 3 4 5
6. Bøying (forms of word) is easy to find.	1 2 3 4 5	1 2 3 4 5
7. Examples are easy to read and find.	1 2 3 4 5	1 2 3 4 5
8. When meaning of word is displayed in Begge (both Bokmål and Nynorsk), it is easy to read and understand.	1 2 3 4 5	1 2 3 4 5

Appendix E: Evaluation of home page of ordboka using WAVE



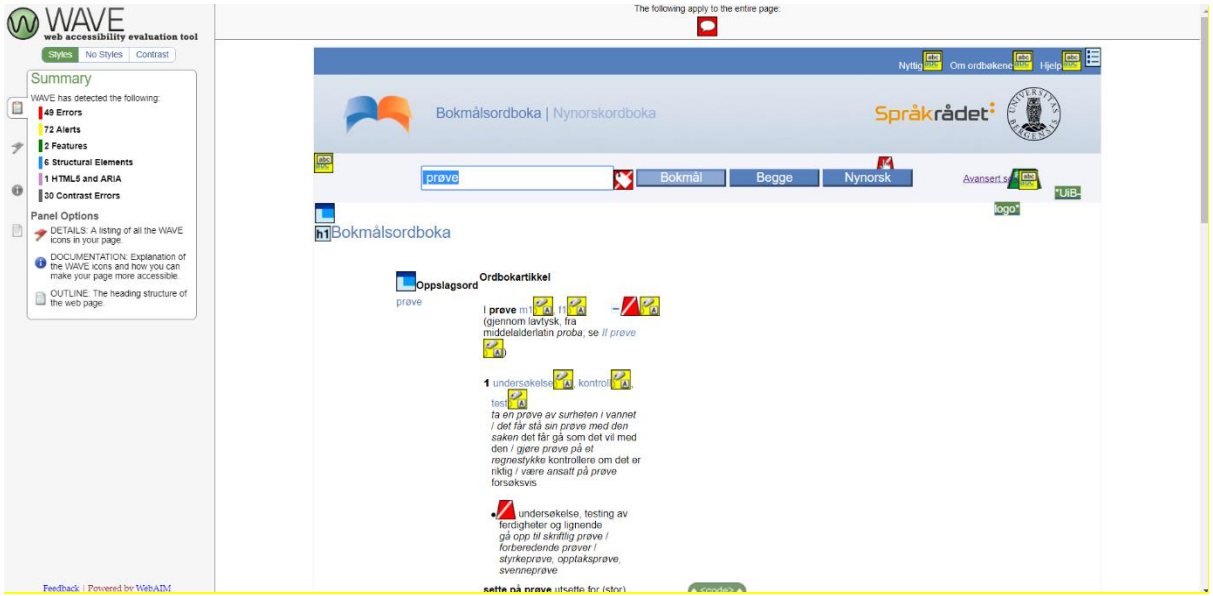
(source: (Universitetet i Bergen & Språkrådet, 2018))

Appendix F: Evaluation of page with ‘tur’ meaning in Bokmål of ordboka using WAVE



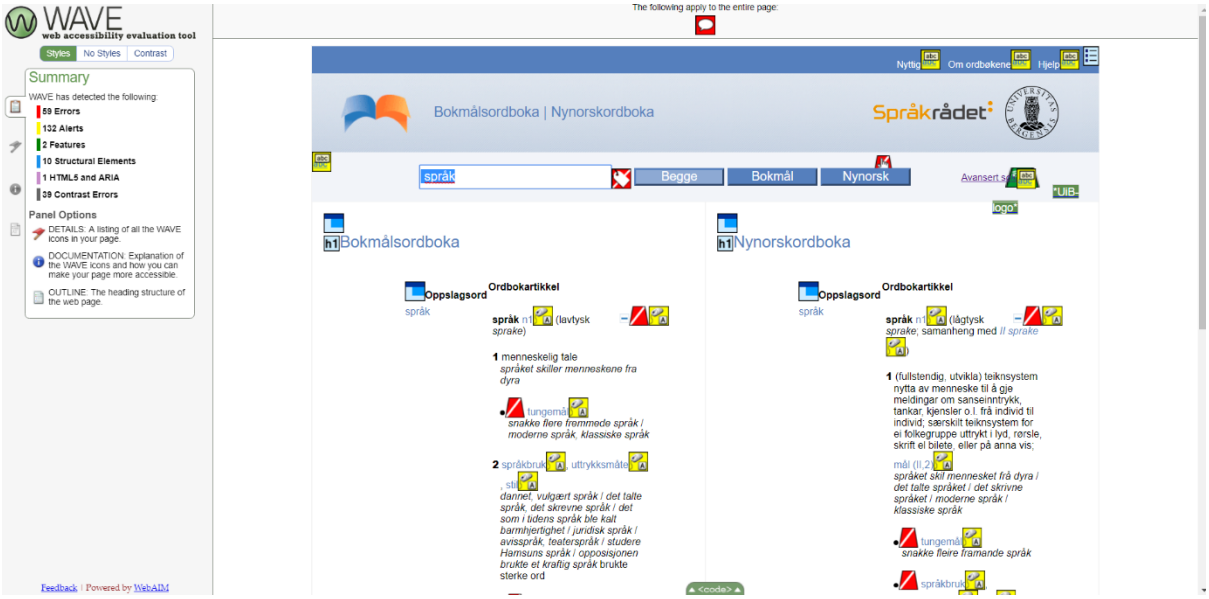
(source: (Universitetet i Bergen & Språkrådet, 2018))

Appendix G: Evaluation of word search ‘prøve’ in bokmål of ordboka using WAVE



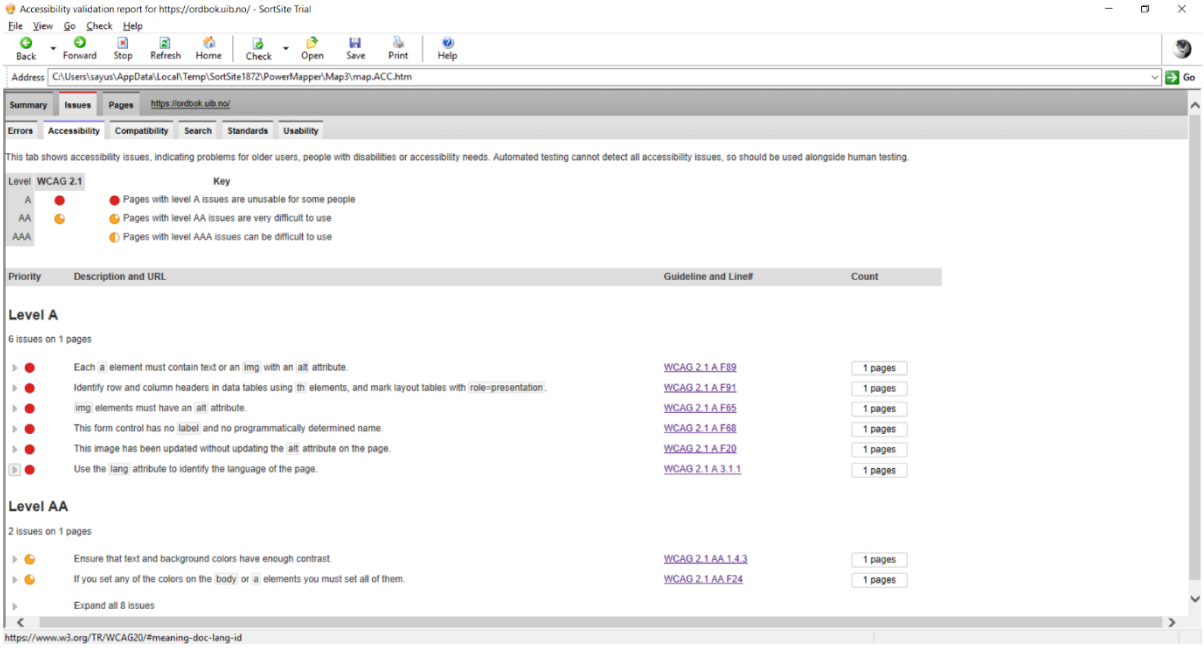
(source: (Universitetet i Bergen & Språkrådet, 2018))

Appendix H: Evaluation of word search ‘språk in both bokmål and nynorsk (begge) of ordboka using WAVE

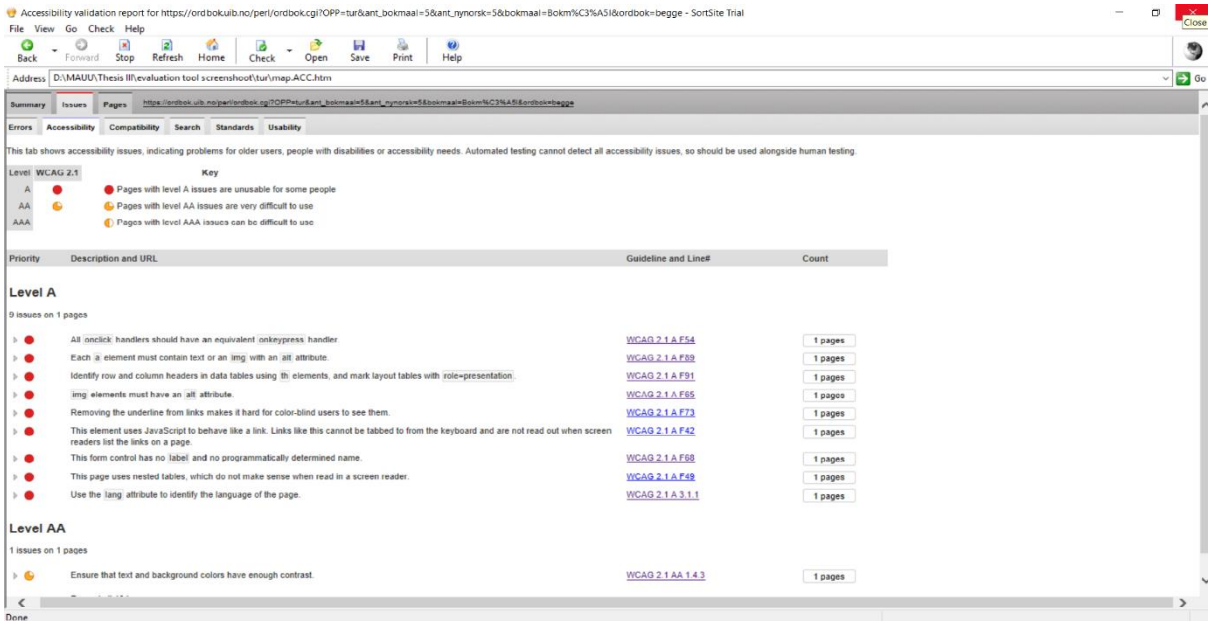


(source: (Universitetet i Bergen & Språkrådet, 2018))

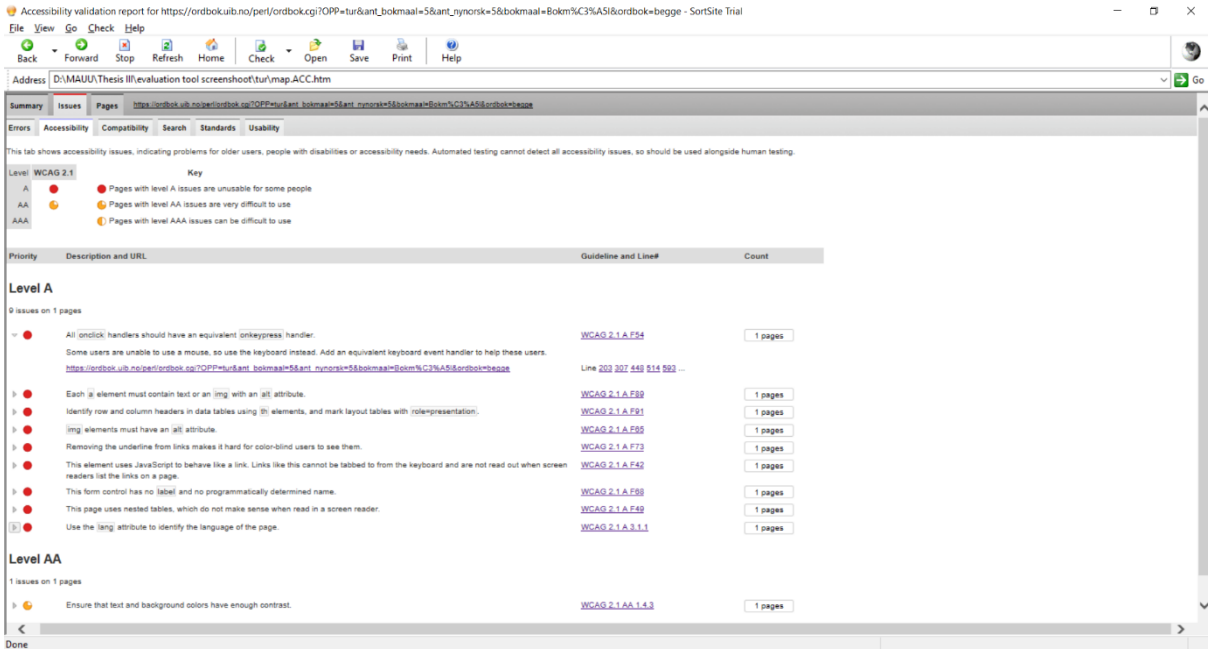
Appendix I: Evaluation of ordboka homepage using SortSite



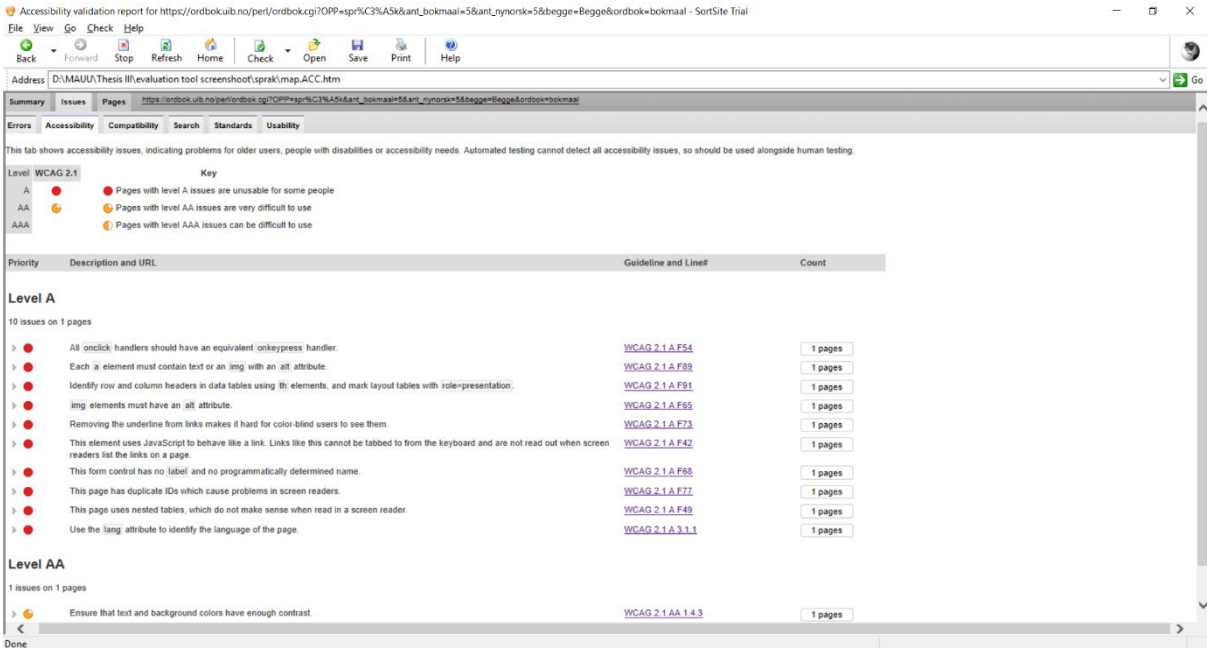
Appendix J: Evaluation of page with ‘tur’ meaning in Bokmål of ordboka using SortSite



Appendix K: Evaluation of page with ‘prøve’ meaning in bokmål of ordboka using SortSite



Appendix L: Evaluation of page with ‘språk’ meaning in both bokmål and nynorsk of ordboka using SortSite



Appendix M: Statistical data of error calculation

Table M-1: Paired samples statistics of error in finding examples

	Mean	Standard Deviation	Standard error
In New Prototype	0	0	0
In Ordboka	1.45	0.686	.153

Table M-2: Paired samples statistics of error in finding examples

Paired Differences					t	df	Sig.	d
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference					
			Lower	Upper				
-1.450	0.686	0.153	-1.771	-1.129	-9.448	19	0.000	2.253

Table M-3: Paired samples statistics of error in finding grammatical forms of word (bøying)

	Mean	Standard Deviation	Standard error
In New Prototype	0	0	0
In Ordboka	1.45	0.686	.276

Table M-4: Paired samples t test of error in finding grammatical forms of word (bøying)

Paired Differences					t	df	Sig.	d
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference					
			Lower	Upper				
-1.550	1.234	0.276	-2.128	-0.972	-5.616	19	0.000	2.080

Table M-5: Paired samples statistics error in finding meaning list

	Mean	Standard Deviation	Standard error
In New Prototype	0	0	0
In Ordboka	0.42	0.507	.116

Table M-6: Paired samples t test error in finding meaning list

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
-0.421	0.507	0.116	-0.666	-0.177	-3.618	18	0.002	0.704

Table M-7: Paired samples statistics of error in finding sub-meaning

	Mean	Standard Deviation	Standard error
In New Prototype	0.25	0.444	.099
In Ordboka	0.5	0.607	.136

Table M-8: Paired samples t test of error in finding sub-meaning

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
-0.250	0.444	0.099	-0.458	-0.042	-2.517	19	0.021	0.294

Appendix N: Statistical data of satisfaction calculation

Table N-1: Paired samples statistics of satisfaction in reading meaning list of searched word

	Mean	Standard Deviation	Standard error
In Ordboka	4.45	.51	.114
In New Prototype	2.1	.447	.100

Table N-2: Paired samples t-test of satisfaction in reading meaning list of searched word

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
2.350	0.745	0.167	2.001	2.699	14.104	19	.000	2. 826

Table N-3: Paired samples statistics of satisfaction in scanning and finding the required information

	Mean	Standard Deviation	Standard error
In New Prototype	4.5	0.513	.115
In Ordboka	2.2	0.894	.200

Table N-4: Paired samples t-test of satisfaction in scanning and finding the required information

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
2.300	1.081	0.242	1.794	2.806	9.516	19	.000	2.523

Table N-5: Paired samples statistics of opinion regarding cluttered content

	Mean	Standard Deviation	Standard error
In New Prototype	1.5	0.761	.170
In Ordboka	4.5	0.513	.115

Table N-6: Paired samples t-test of opinion regarding cluttered content

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
-3.000	1.170	0.262	-3.547	-2.453	-11.469	19	0.000	3.366

Table N-7: Paired samples statistics of satisfaction in finding and navigating sub-meanings

	Mean	Standard Deviation	Standard error
In New Prototype	4.25	0.716	.160
In Ordboka	1.75	0.851	.190

Table N-8: Paired samples t-test in finding and navigating sub-meanings

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
2.500	1.235	0.276	1.922	3.078	9.050	19	0.000	2.658

Table N-9: Paired samples statistics of satisfaction in understanding layout design of the content

	Mean	Standard Deviation	Standard error
In New Prototype	4.45	0.605	.135
In Ordboka	1.65	0.587	.131

Table N-10: Paired samples t-test of satisfaction in understanding layout design of the content

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
2.800	1.105	0.247	2.283	3.317	11.332	19	0.000	3.187

Table N-11: Paired samples statistics of satisfaction in finding grammatical forms of word (bøying)

	Mean	Standard Deviation	Standard error
In New Prototype	4.95	0.224	.050
In Ordbok	1.45	0.51	.114

Table N-12: Paired samples t-test of satisfaction in finding grammatical forms of word (bøying)

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
3.500	0.513	0.115	3.260	3.740	30.512	19	0.000	4.542

Table N-13: Paired samples statistics of satisfaction in finding example

	Mean	Standard Deviation	Standard error
In New Prototype	4.75	0.444	.099
In Ordboka	1.95	0.887	.198

Table N-14: Paired samples t-test of satisfaction in finding example

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
2.800	0.951	0.213	2.355	3.245	13.161	19	0.000	3.123

Table N-15: Paired samples statistics of satisfaction in reading content of search word in both Bokmål and Nynorsk (begge)

	Mean	Standard Deviation	Standard error
In New Prototype	4.45	0.51	.114
In Ordboka	2.6	0.681	.152

Table N-16: Paired samples t-test of satisfaction in reading content of search word in both Bokmål and Nynorsk (begge)

Paired Differences								
Mean	Std. Deviation	Std. error	95% Confidence Interval of the Difference		t	df	Sig.	d
			Lower	Upper				
1.850	0.489	0.109	1.621	2.079	16.907	19	0.000	2.109

Appendix O: Coding of prototype

header.php

```
<!DOCTYPE html>

<html lang="no">

<head>

        <title><?php echo $page_name; ?> Re-designed Norsk Ordbok</title>

        <meta charset="utf-8">

        <meta name="viewport" content="width=device-width, initial-scale=1">

        <link rel="stylesheet"
href="https://maxcdn.bootstrapcdn.com/bootstrap/4.1.3/css/bootstrap.min.css">

        <script
src="https://ajax.googleapis.com/ajax/libs/jquery/3.3.1/jquery.min.js"></script>

        <script
src="https://cdnjs.cloudflare.com/ajax/libs/popper.js/1.14.3/umd/popper.min.js"></scri
pt>

        <script
src="https://maxcdn.bootstrapcdn.com/bootstrap/4.1.3/js/bootstrap.min.js"></script>

        <!-- Load icon library -->

        <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/font-
awesome/4.7.0/css/font-awesome.min.css">

    <link href="css/main1.css" rel="stylesheet">

        <script src="js/main.js"></script>

</head>

<body>

  <div class="container">
```

```
<div class="col-sm-12">
  <nav>
    <span class="logo">
      <a title="Re-designed Norsk Ordbok" href="http://localhost/rnd/">
        <img src="logo.png" alt="logo of Re-designed Norsk Ordbok" class="logo_img">
      </a>
    </span>
    <div style="display: flex; justify-content: flex-end">
      <ul class="cutomize">
        <li>
          Zoom:
          <a href="#" class="normal" onclick="normal()" title="Enlarge the content of the page to normal size 100%">A</a>
          <a href="#" class="zoom1" onclick="zoom1()" title="Enlarge the content of the page by 150%">A</a>
          <a href="#" class="zoom2" onclick="zoom2()" title="Enlarge the content of the page by 200%">A</a>
        </li>
        <li>
          Color:
          <button class="color_change1" onclick="color_change1();" title="change the theme color">C1</button>
          <button class="color_change2" onclick="color_change2();" title="change the theme color">C2</button>
```

```
                    <button class="color_change3" onclick="color_change3();"
title="change the theme color">C3</button>
                </li>
            </ul>
        </div>
    </nav>
    <main>
    <div>
        <form class="search_form" action="search.php" method="post">
            <div class="row">
                <div class="col-sm-7">
                    <label for="search" class="visuallyhidden">Søk: </label>
                    <input type="text" id="search" class="form-control search_input"
placeholder="Skriv ordet" aria-label="Søk" name="search_text" value="<?php echo
$word;?>">
                </div>
                <div class="col-sm-3">
                    <label for="search_type" class="visuallyhidden">Søk type: </label>
                    <select id="search_type" class="form-control search_select" aria-
label="Søk type" name="search_type">
                        <option value="1" <?php if($word_type == 1){ echo "selected" ;}
?>>Bokmål</option>
                        <option value="2" <?php if($word_type == 2){ echo "selected" ;}
?>>Nynorsk</option>
                        <option value="3" <?php if($word_type == 3){ echo "selected" ;}
?>>Begge</option>
```

```
                </select>
            </div>
            <div class="col-sm-2">
                <div class="input-group-btn">
                    <button class="btn btn-primary search_button" type="submit">
                        <i class="fa fa-search"></i> Søk
                    </button>
                </div>
            </div>
        </div>
    </form>
</div>
```

tur_bokmaal.php

```
<?php
    $page_name = "tur | Bokmål | ";
    $word = "tur";
    $word_type = 1;
    include "header1.php";
?>
    <h1>tur</h1>

    <b>Historie:</b> <span class="history">I tur(gjennom fransk, fra gresk tornos 'sirkel') </span>
    <h2>(Substantiv)</h2>
    <div class="row">
        <div class="col-sm-4">
            <ol class="main_ol">
```

```
            <li class="meaning_list">
                <p class="meaning">plass i rekkefølge</p>
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>gå etter tur</li>
                    <li>stå for tur</li>
                    <li>passe sin tur i køen</li>
                </ul>
                <ol class="sub_ol">
                    <li class="meaning_list">
                        <p class="sub_meaning"><b>i sin tur</b>: på et visst
tidspunkt</p><br>
                    </li>
                    <li class="meaning_list">
                        <p class="sub_meaning"><b>i tur og orden</b>: i
rekkefølge</p><br>
                    </li>
                </ol>
            </li>
        </ol>
    </div>
    <div class="col-sm-4">
        <ol class="main_ol" style="counter-reset: item 1;">
            <li class="meaning_list">
                <p class="meaning">kortere eller lengre reise, ferd, utflukt</p>
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>ta en tur til byen, til fjells, utenlands</li>
                    <li>gå på tur</li>
                    <li>tur-retur eller tur og retur fram og tilbake</li>
                    <li>bytur, fottur, skitur, utenlandstur</li>
```

```
            </ul>
        </li>
    </ol>
</div>
<div class="col-sm-4">
    <ol class="main_ol" style="counter-reset: item 2;">
        <li class="meaning_list">
            <p class="meaning">vane, gjenge</p>
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list">
                <li>komme ut av tur med noe</li>
                <li>komme i tur med noe</li>
            </ul>
        </li>
    </ol>
</div>
<div class="col-sm-4">
    <ol class="main_ol" style="counter-reset: item 3;">
        <li class="meaning_list">
            <p class="meaning">anfall, ri</p>
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list">
                <li>hun fikk en tur med drikking igjen</li>
            </ul>
        </li>
    </ol>
</div>
<div class="col-sm-4">
    <ol class="main_ol" style="counter-reset: item 4;">
        <li class="meaning_list">
```

```
            <p class="meaning">avgrenset del av dans</p>
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list">
               <li>lære alle turene i reinlender</li>
            </ul>
         </li>
      </ol>
   </div>

   <div class="col-sm-12">
      <section>
         <h3>Bøying i samsvar med gjeldende rettskriving:</h3>
         <table class="table table-bordered">
            <thead>
               <tr>
                  <th scope="col" rowspan="2" id="type">tur</th>
                  <th scope="col" colspan="2" id="e">Entall</th>
                  <th scope="col" colspan="2" id="f">Flertall</th>
               </tr>
               <tr>
                  <th scope="col" id="uf1" headers="e">Ubestemt</th>
                  <th scope="col" id="bf1" headers="e">Bestemt</th>
                  <th scope="col" id="uf2" headers="f">Ubestemt</th>
                  <th scope="col" id="bf2" headers="f">Bestemt</th>
               </tr>
            </thead>
            <tbody>
               <tr>
                  <th scope="row" id="m1" headers="type">Maskulinum</th>
                  <td headers="m1 uf1">en tur</td>
```

```
                    <td headers="m1 bf1">turen</td>
                    <td headers="m1 uf2">turer</td>
                    <td headers="m1 uf2">turene</td>
                </tr>
            </tbody>
        </table>
    </section>
</div>
</div>
<br>
<b>Historie:</b> <span class="history">II tur (etter svensk, fra fransk (bon) tour '(god) vending') </span>
<div class="row">
    <div class="col-sm-4">
        <ol class="main_ol">
            <li class="meaning_list">
                <p class="meaning"> hell, flaks </p>
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>tur og utur</li>
                </ul>
            </li>
        </ol>
    </div>
</div>
<?php include "footer.php" ?>
```

prove_bokmaal.php

```
<?php
    $page_name = "prøve | Bokmål | ";
    $word = "prøve";
```

```
    $word_type = "1";
    include "header1.php";
?>
    <h1>prøve</h1>
    <h2>(Substantiv)</h2>
    <b>Historie:</b> <span class="history">gjennom lavtysk, fra middelalderlatin proba </span>
    <div class="row section">
        <div class="col-sm-4">
            <ol  class="main_ol">
                <li class="meaning_list">
                    <p class="meaning">undersøkelse, kontroll, test</p>
                    <p class="example"><b>Eksempel:</b></p>
                    <ul class="example_list">
                        <li>ta en prøve av surheten i vannet</li>
                        <li>det får stå sin prøve med den saken det får gå som det vil med den</li>
                        <li>gjøre prøve på et regnestykke kontrollere om det er riktig</li>
                        <li>være ansatt på prøve forsøksvis</li>
                    </ul>
                    <ol class="sub_ol">
                        <li class="meaning_list">
                            <p class="sub_meaning">undersøkelse, testing av ferdigheter og lignende</p>
                            <p class="example"><b>Eksempel:</b></p>
                            <ul class="example_list_sub">
                                <li>gå opp til skriftlig prøve</li>
                                <li>forberedende prøver</li>
                                <li>styrkeprøve, opptaksprøve, svenneprøve</li>
                            </ul>
                        </li>
```

```
                </ol>
            </li>
        </ol>
    </div>
    <div class="col-sm-4">
        <ol  class="main_ol" style="counter-reset: item 1;">
            <li class="meaning_list">
                <p class="meaning">innøving, forsøksvis framføring av et teaterstykke, en konsert eller lignende</p>
                <!--<p class="english_meaning" lang="en"><b>English:</b> rehearsal, experimental presentation of a play, a concert or the like</p>-->
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>holde prøver på et Ibsen-stykke </li>
                </ul>
            </li>
        </ol>
    </div>
    <div class="col-sm-4">
        <ol  class="main_ol" style="counter-reset: item 2;">
            <li class="meaning_list">
                <p class="meaning">del eller utvalg av noe brukt til å undersøke art, kvalitet og lignende</p>
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>ta prøver av drikkevannet</li>
                    <li>stikkprøve, vareprøve</li>
                </ul>
                <ol class="sub_ol">
                    <li class="meaning_list">
                        <p class="sub_meaning">bevis, eksempel</p>
```

```
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list_sub">
                    <li>gi en prøve på ferdighetene sine</li>
                </ul>
            </li>
        </ol>
    </li>
</ol>
</div>
<div class="col-sm-12">
    <section>
        <h3>Bøying i samsvar med gjeldende rettskriving:</h3>
        <table class="table table-bordered">
            <thead>
                <tr>
                    <th scope="col" rowspan="2" id="type">språk</th>
                    <th scope="col" colspan="2" id="e">Entall</th>
                    <th scope="col" colspan="2" id="f">Flertall</th>
                </tr>
                <tr>
                    <th scope="col" id="uf1" headers="e">Ubestemt</th>
                    <th scope="col" id="bf1" headers="e">Bestemt</th>
                    <th scope="col" id="uf2" headers="f">Ubestemt</th>
                    <th scope="col" id="bf2" headers="f">Bestemt</th>
                </tr>
            </thead>
            <tbody>
                <tr>
                    <th scope="row" id="m1" headers="type">maskulinum</th>
                    <td headers="m1 uf1">en prøve</td>
```

```
                    <td headers="m1 bf1">prøven</td>
                    <td headers="m1 uf2">prøver</td>
                    <td headers="m1 uf2">prøvene</td>
                </tr>
                <tr>
                    <th scope="row" id="f1" headers="type">femininum</th>
                    <td headers="f1 uf1">ei prøve</td>
                    <td headers="f1 bf1">prøva</td>
                    <td headers="f1 uf2">prøver</td>
                    <td headers="f1 uf2">prøvene</td>
                </tr>
            </tbody>
        </table>
    </section>
</div>

</div>

<br>
<h2>(Verb)</h2>
<b>Historie:</b> <span class="history">norrønt test, gjennom lav tysk, fra latin probar </span>
<div class="row section2">
    <div class="col-sm-4">
        <ol class="main_ol">
            <li class="meaning_list">
                <p class="meaning">granske, undersøke, kontrollere, teste</p>
                <p class="example"><b>Eksempel:</b></p>
                <ul class="example_list">
                    <li>prøve en ny bil</li>
                    <li>prøve et stoffs motstandsdyktighet mot kjemikalier</li>
```

```
                <li>prøve ut et medikament i dyreforsøk</li>
                <li>prøve elever i grammatikk</li>
            </ul>
            <ol class="sub_ol">
                <li class="meaning_list">
                    <p class="sub_meaning">som adjektiv i presens partisipp</p>
                    <p class="example"><b>Eksempel:</b></p>
                    <ul class="example_list_sub">
                        <li>et prøvende blikk granskende</li>
                    </ul>
                </li>
            </ol>
        </li>
    </ol>
</div>
<div class="col-sm-4">
    <ol class="main_ol" style="counter-reset: item 1;">
        <li class="meaning_list">
            <p class="meaning">innøve, framføre forsøksvis</p>
            <p class="example"><b>Eksempel:</b>
            <ul class="example_list">
                <li>teateret prøver nå (på) en ny komedie</li>
            </ul>
        </li>
        <li class="meaning_list">
            <p class="meaning">forsøke, søke, freste</p>
            <!--<p class="english_meaning" lang="en"><b>English:</b> try, seek,
tempt</p>  -->
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list_sub">
                <li>prøve lykken</li>
```

```
            <li>prøve fisken om fisken vil bite</li>
            <li>prøve (på) å komme tidsnok</li>
            <li>vi får prøve om vi ikke kan finne en utvei</li>
          </ul>
        </li>
    </ol>
</div>
<div class="col-sm-4">
    <ol class="main_ol" style="counter-reset: item 3;">
        <li class="meaning_list">
            <p class="meaning">utsette for motgang eller lignende</p>
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list">
                <li>Gud prøver sine barn</li>
            </ul>

            <ol class="sub_ol">
                <li class="meaning_list">
                    <p class="sub_meaning">erfare, bli utsatt for</p>
                    <p class="example"><b>Eksempel:</b></p>
                    <ul class="example_list_sub">
                        <li>få prøve litt av hvert</li>
                    </ul>
                </li>
            </ol>
        </li>
    </ol>
</div>

<div class="col-sm-12">
```

```
<section>
  <h3>Bøying i samsvar med gjeldende rettskriving:</h3>

  <table class="table table-bordered">

    <thead>
      <tr>
        <th scope="col" rowspan="2" id="vtype">prøve</th>
        <th scope="col" colspan="4" id="vp1">Perfektum partisipp</th>
        <th scope="col" rowspan="2" id="vp2">Presens partisipp</th>
      </tr>
      <tr>
        <th scope="col" id="vh" headers="vp1">Hankjønn/ hunkjønn</th>
        <th scope="col" id="vi" headers="vp1">Intetkjønn</th>
        <th scope="col" id="vb" headers="vp1">Bestemt</th>
        <th scope="col" id="vf" headers="vp1">Flertall</th>
      </tr>
    </thead>
    <tbody>
      <tr>
        <th scope="row" id="v3" headers="vtype">Verb 3</th>
        <td headers="vp1 vh">prøvd</td>
        <td headers="vp1 vi">prøvd</td>
        <td headers="vp1 vb">prøvde</td>
        <td headers="vp1 vf">prøvde</td>
        <td headers="vp2">prøvde</td>
      </tr>
    </tbody>
  </table>
```

```
            <table class="table table-bordered">
               <thead>
                  <tr>
                     <th id="v3type">prøve</th>
                     <th id="i">Infinitiv</th>
                     <th id="pre">Presens</th>
                     <th id="pret">Preteritum</th>
                     <th id="prep">Presens perfektum</th>
                     <th id="imp">Imperativ</th>
                  </tr>
               </thead>
               <tbody>
                  <tr>
                     <th id="vv3" headers="v3type">Verb 3</th>
                     <td headers="vv3 i">å prøve</td>
                     <td headers="vv3 pre">prøver</td>
                     <td headers="vv3 pret">prøvde</td>
                     <td headers="vv3 prep">har prøvd</td>
                     <td headers="vv3 imp">prøv</td>
                  </tr>
               </tbody>
            </table>
         </section>
      </div>
   </div>
<?php include "footer.php" ?>
```

spraak_begge.php

```
<?php
   $page_name = "språk | Begge | ";
```

```
    $word = "språk";
    $word_type = 3;
    include "header1.php";
?>
    <h1>språk</h1>
    <div class="row">
        <div class="col-sm-6 border-right">
            <section>
                <h2>Bokmål</h2>
                <p><b>(Substantiv)</b></p>
                <b>Historie:</b> <span class="history">lavtysk sprake </span>
                <ol  class="main_ol">
                    <li class="meaning_list">
                        <p class="meaning">menneskelig tale</p>
                        <p class="example"><b>Eksempel:</b></p>
                        <ul class="example_list">
                            <li>språket skiller menneskene fra dyra</li>
                        </ul>
                        <ol class="sub_ol">
                            <li class="meaning_list">
                                <p class="sub_meaning">tungemål</p>
                                <p class="example"><b>Eksempel:</b></p>
                                <ul class="example_list_sub">
                                    <li>moderne språk, klassiske språk</li>
                                    <li>snakke flere fremmede språk</li>
                                </ul>
                            </li>
                        </ol>
                    </li>
                    <li class="meaning_list">
```

```
<p class="meaning">språkbruk, uttrykksmåte, stil</p>
<p class="example"><b>Eksempel:</b></p>
<ul class="example_list">
   <li>opposisjonen brukte et kraftig språk brukte sterke ord </li>
   <li>studere Hamsuns språk</li>
   <li>avisspråk, teaterspråk</li>
   <li>det som i tidens språk ble kalt barmhjertighet</li>
   <li>det talte språk, det skrevne språk</li>
</ul>
<ol class="sub_ol">
   <li class="meaning_list">
      <p class="sub_meaning">om spesielle</p>
      <p class="example_sub"><b>Eksempel:</b></p>
      <ul class="example_list_sub">
         <li>kodespråk, sifferspråk</li>
         <li>fingerspråk, døvespråk</li>
      </ul>
   </li>
   <li class="meaning_list">
      <p class="sub_meaning">om andre uttrykksmidler</p>
      <p class="example"><b>Eksempel:</b></p>
      <ul class="example_list_sub">
         <li>fuglenes, musikkens språk</li>
      </ul>
   </li>
   <li class="meaning_list">
      <p class="sub_meaning">bud, lærdom</p>
      <p class="example"><b>Eksempel:</b></p>
      <ul class="example_list_sub">
         <li>tallene taler sitt tydelige språk</li>
```

```
                    </ul>
                </li>
                <li class="meaning_list">
                    <p class="sub_meaning"><b>snakke samme
språk</b></p><br>
                    <span class="meaning">legge det samme i ord og begreper,
forstå hverandre</span>
                </li>
            </ol>
        </li>
        <li class="meaning_list">
            <p class="meaning">uttalelse</p>
        </li>
        <li class="meaning_list">
            <p class="meaning">i sammensetninger: sitat</p>
            <p class="example"><b>Eksempel:</b></p>
            <ul class="example_list">
                <li>hun fikk en tur med drikking igjen</li>
            </ul>
        </li>
    </ol>
    <h3>Bøying i samsvar med gjeldende rettskriving:</h3>
    <table class="table table-bordered">
        <thead>
            <tr>
                <th scope="col" rowspan="2" id="type">språk</th>
                <th scope="col" colspan="2" id="e">Entall</th>
                <th scope="col" colspan="2" id="f">Flertall</th>
            </tr>
            <tr>
                <th scope="col" id="uf1" headers="e">Ubestemt</th>
```

```
                    <th scope="col" id="bf1" headers="e">Bestemt</th>
                    <th scope="col" id="uf2" headers="f">Ubestemt</th>
                    <th scope="col" id="bf2" headers="f">Bestemt</th>
                </tr>
            </thead>
            <tbody>
                <tr>
                    <th scope="row" id="m1" headers="type">Nøytrum 1</th>
                    <td headers="m1 uf1">et språk</td>
                    <td headers="m1 bf1">språket</td>
                    <td headers="m1 uf2">språk</td>
                    <td headers="m1 uf2">språka</td>
                </tr>
                <tr>
                    <th scope="row" id="m2" headers="type">Nøytrum 2</th>
                    <td headers="m2 uf1">et språk</td>
                    <td headers="m2 bf1">språket</td>
                    <td headers="m2 uf2">språk</td>
                    <td headers="m2 uf2">språkene</td>
                </tr>
            </tbody>
        </table>
    </section>
</div>
<div class="col-sm-6">
    <section>
        <h2>Nynorsk</h2>
        <p><b>(Substantiv)</b></p>
        <b>Historie:</b> <span class="history">lågtysk sprake; samanheng med sprake</span>
        <ol  class="main_ol">
```

<li class="meaning_list">

(fullstendig, utvikla) teiknsystem nytta av menneske til å gje meldingar om sanseinntrykk, tankar, kjensler o.l. frå individ til individ; særskilt teiknsystem for ei folkegruppe uttrykt i lyd, rørsle, skrift el bilete, eller på anna vis; mål

Eksempel:

<ul class="example_list">

språket skil mennesket frå dyra

det talte språket

det skrivne språket

moderne språk

klassiske språk

<ol class="sub_ol">

<li class="meaning_list">

tungemål

Eksempel:

<ul class="example_list_sub">

snakke flere fremmede språk

<li class="meaning_list">

språkbruk, uttrykksmåte, stil

Eksempel:

<ul class="example_list_sub">

granske språket til Garborg

opposisjonen brukte eit kraftig språk sterke ord

<li class="meaning_list">

snakke same språket : leggje det same i orda og omgrepa, forstå kvarandreòg i ord som allmennspråk, barnespråk, fingerspråk, løyndespråk, særspråk, teiknspråk

<li class="meaning_list">

kortere eller lengre reise, ferd, utflukt

Eksempel:

<ul class="example_list">

bytur, fottur, skitur, utenlandstur

tur-retur eller tur og retur fram og tilbake

gå på tur

ta en tur til byen, til fjells, utenlands

<li class="meaning_list">

uttrykksmiddel som liknar språk

Eksempel:

<ul class="example_list">

desse tala taler sitt tydelege språk

fuglane, musikken har sitt eige språk

<li class="meaning_list">

fråsegn, utsegn

<li class="meaning_list">

i samansetningar: sitat, skriftord

Eksempel:

<ul class="example_list">

```
            <li>valspråk</li>
          </ul>
        </li>
      </ol>
      <h3>Bøying i samsvar med 2012-rettskrivinga:</h3>
      <table class="table table-bordered">
        <thead>
          <tr>
            <th scope="col" rowspan="2" id="ntype">språk</th>
            <th scope="col" colspan="2" id="ne">Eintal</th>
            <th scope="col" colspan="2" id="nf">Fleirtal</th>
          </tr>
          <tr>
            <th scope="col" id="nuf1" headers="ne">Ubunden</th>
            <th scope="col" id="nbf1" headers="ne">Bunden</th>
            <th scope="col" id="nuf2" headers="nf">Ubunden</th>
            <th scope="col" id="nbf2" headers="nf">Bunden</th>
          </tr>
        </thead>
        <tbody>
          <tr>
            <th scope="row" id="nm1" headers="ntype">Nøytrum</th>
            <td headers="nm1 nuf1">eit språk</td>
            <td headers="nm1 nbf1">språket</td>
            <td headers="nm1 nuf2">språk</td>
            <td headers="nm1 nuf2">språka</td>
          </tr>
        </tbody>
      </table>
    </section>
```

```
        </div>
    </div>
<?php include "footer.php" ?>
```

footer.php

```
                        </main>
                </div>
        <!-- Footer -->
                <div class="footer">
                    Sayush Lal Shrestha © 2019 <br>
                    E-post: lalsayush@gmail.com
            </div>
        </div>
</body>
</html>
```

search.php

```
<?php
        $search_text = trim(strtolower($_POST["search_text"]));
        $search_type = $_POST["search_type"];

        if($search_text == "språk" && $search_type == "1"){
                header("Location: http://localhost/rnd/bokmaal_spraak.php");
                die();
        }
        elseif ($search_text == "prøve" && $search_type == "1") {
                header("Location: http://localhost/rnd/bokmaal_prove.php");
                die();
        }
        elseif ($search_text == "språk" && $search_type == "2") {
                header("Location: http://localhost/rnd/nynorsk_spraak.php");
                die();
```

```
	}
	elseif ($search_text == "språk" && $search_type == "3") {
		header("Location: http://localhost/rnd/begge_spraak.php");
		die();
	}
	elseif ($search_text == "tur" && $search_type == "1") {
		header("Location: http://localhost/rnd/bokmaal_tur.php");
		die();
	}
	elseif ($search_text == "tur" && $search_type == "2") {
		header("Location: http://localhost/rnd/nynorsk_tur.php");
		die();
	}else{
		header("Location: http://localhost/rnd");
		die();
	}
?>
```

main.css

```
body{
	font-family: arial;
	font-size: 16px;
	position: relative;
	margin: 0;
	padding-bottom: 6rem;
	min-height: 100%;
	color: #000000;
	background-color: #F6f6f6;
}
```

```
a{
    text-decoration: underline;
    color: #3333FF;
}

.logo{
    font-size: 35px;
    font-weight: bolder;
    line-height: 0.8;
}

.logo_img{
    height: 70px;
    width: 80px
}

.logo a{
    color: #000000;
    text-decoration: none;
}

.logo a:hover{
    color: #000000;
    text-decoration: none;
}

.container{
  margin-bottom:30px
}
```

```
h1{
  font-size: 3rem;
}

h2{
    font-size: 1.5rem;
    font-weight: bold;
}

h3{
    font-size: 16px;
    font-weight: bold;
}


hr{
  display: block;
  height: 1px;
  border: 0;
  border-top: 1px solid #ccc;
  margin: 1em 0;
  padding: 0;
}

.cutomize li{
    display:inline;
}

.zoom {
    border-right: solid thin #ccc;
```

```
}

.normal{
    font-size: 16px;
    margin-left: 5px;
    text-decoration: underline !important;
    cursor: pointer;
}

.zoom1{
    font-size: 18px;
    margin: 0 6px 0 6px;
    position: relative;
    cursor: pointer;
}

.zoom2{
    font-size: 20px;
    margin-right: 10px;
    position: relative;
    cursor: pointer;
}

.color_change1{
    color: #000000;
    background: #F6f6f6;
    border: 1px solid #000000;
    cursor: pointer;
    position: relative;
    bottom: 6px;
```

```
    margin-left: 2px;
    text-decoration: underline;
    border-radius: .25rem;
}

.color_change2{
    color: #000000;
    background: #f2edcd;
    border: 1px solid #000000;
    cursor: pointer;
    position: relative;
    bottom: 6px;
    margin: 0 4px 0 4px;
    border-radius: .25rem;
}

.color_change3{
    color: #E0E0E0;
    background: #424242;
    border: 1px solid #00e1e8;
    cursor: pointer;
    position: relative;
    bottom: 6px;
    border-radius: .25rem;
}

.visuallyhidden {
    border: 0;
    clip: rect(0 0 0 0);
    height: 1px;
```

```
    margin: -1px;
    overflow: hidden;
    padding: 0;
    position: absolute;
    width: 1px;
}

.search_form{
    padding: 9px 0px 40px 0;
}

.search_input{
    width: 100%;
    padding: 25px;
    font-size: 20px;
    float: left;
    letter-spacing: 2px;
    color: #000;
    outline: none;
    border-radius: 0rem;
    transition: 0.5s all;
    border: 1px solid #000000;
}

.search_select{
    position: relative;
    width: 100%;
    font-size: 20px;
    float: left;
    letter-spacing: 2px;
```

```
    color: #000;
    outline: none;
    border-radius: 0rem;
    transition: 0.5s all;
    height: 52px;
    border: 1px solid #000000;
}

.search_button{
    width: 100%;
    border-radius: 0rem;
    font-size: 20px;
    letter-spacing: 2px;
    outline: none;
    padding: 10px;
    background-color: #00e;
}

.section1{
    border-bottom: 2px solid;
}

.section2{
    margin-top: 30px;
}

.bold_heading {
        font-weight: bold;
}
```

```
.english_word{
    font-size: 18px;
    margin-bottom: 10px
}

.meaning_list{
    //line-height: 2.5;
    margin-bottom: 30px;
    margin-top:5px;
    display: block;
}

.meaning{
    font-size: 18px;
    margin-left: 20px;
    display: inline;
}

.sub_meaning{
    font-size: 18px;
    margin-left: 5px;
    display: inline;
}

.example{
    margin-top: 8px;
    margin-bottom: 10px;
}

ol{
```

```
    counter-reset: item;
}

.sub_ol {
    margin-top: 30px;
}

.meaning_list:before{
  content: counters(item, ".") ".";
  counter-increment: item;
  margin-left: -40px;
  font-weight: bold;
  font-size: 18px;
}


.table th{
    border: #000000 solid 1px !important;
}

.table td{
    border: #000000 solid 1px !important;
}

.example_list{
    margin-left: 5px;
    margin-top: -10px;
    list-style-type: disc;
}
```

```
.english_meaning_sub{
    margin-left: 22px;
    margin-top: 8px;
    margin-bottom: 10px;
}

.example_list_sub{
    margin-left: 5px;
    margin-top: -10px;
    list-style-type: disc;
}

.wrapper_1:after {
  content: '';
    position: absolute;
    right: 0;
    border-right: 2px solid #cfc7c0;
    top: 0%;
    bottom: 0%;
}

.footer{
        position: absolute;
        right: 0;
        bottom: 0;
        left: 0;
        padding: 1rem;
        text-align: center;
}
```

main.js

```
//change the theme color of the page
function color_change1(){
        $("body").css({ "color": "#000000", "background": "#F6f6f6" });
}

function color_change2(){
    $("body").css({ "color": "#000000", "background": "#f2edcd" });
}

function color_change3(){
    $("body").css({ "color": "#E0E0E0", "background": "#424242" });
}

// change the size of the page
function normal(){
        $("body").css({ "zoom": "100%"});
}

function zoom1(){
        $("body").css({ "zoom": "150%"});
}

function zoom2(){
        $("body").css({ "zoom": "200%"});
}
```