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Universal Design of ICT

Supporting content creators create accessible digital content in higher education

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Preface

My journey into the Universal Design of ICT domain started in 2014 when I wanted to know more about how to tell whether the web content I was working on was something that people could use. I discovered an online course called Universal Design for Digital Media created by Howard Kramer, who works at the University of Colorado Boulder, which was the first MOOC I attended. Inspired by this course, I realised that the piece I was missing that could complement my engineering background was learning more about Universal Design. Where could you study this subject in Norway? It turned out at Oslo and Akershus University College, which happened to my workplace. I enrolled on the Master's programme of Universal Design of ICT in the fall of 2015, and a new world opened up to me.

Life is what happens when you have other plans. Eight years went by in a flash. Now, the day previously very difficult to imagine is approaching fast.

The topic chosen for this thesis was inspired by seeing many people struggling with creating accessible digital content. I have tried encouraging colleagues to learn from relevant online courses, sent many e-mails with detailed instructions or links to appropriate resources and instructions on creating accessible digital content, or taught in person. Only to realise that after some time, it was forgotten. I wished many times that I had a single online guide I could refer to, knowing well that this would cover all the problems people had with creating accessible digital content and cater to different people's needs and preferences. Still, I could find no such single source. This led to the project "Supporting content creators in creating accessible digital content in higher education". At this point in the journey, I am still not in a situation where I have a single online guide which can cover all those needs, but now I have a better understanding of content creators' needs, expectations and preferences. I am at least a little closer to the goal.

To my dear wife and children who have endured my being absent sometimes, thank you for your patience and love.

To all of you who have participated as informants and participants in my master project, you won't be mentioned by name to protect your confidentiality. Still, you know who you are, and you have my thanks for spending your time and contributing to this essential project.

Many others who have supported me along the way are not mentioned here but still deserve thanks. I would also like to send my sincerest thanks to my supervisor, professor Weiqin Chen, who has stood by my side from the beginning to the end of this project. I have learned many things from you, and it was your guidance that made it possible to succeed.

Abstract

The recent growth of the digitalisation of education has increased the importance of digital accessibility. In higher education, faculty members and administrative staff are the main content creators who are responsible for creating and publishing digital content for both students and university staff. Literature shows that these content creators do not have the necessary knowledge to create accessible digital content. At the same time, there is an abundance of information available online about how to create accessible digital content. However, due to the lack of time, the content creators are often not able to find the necessary information for helping them with the accessibility task they have at hand. In this study we have adopted a human-centred approach to develop an online prototype aiming at assisting content creators to create accessible content where target users have been involved in the iterative design, development, and evaluation process. A summative evaluation was also conducted with a mixed-method approach, combining observation, survey, semi-structured interview, and document inspection. The results show that the online guide is helpful for faculty members and administrative staff to improve the accessibility of their digital content. Some usability issues have been discovered and additional features and content have also been suggested by the participants, which will be the focus of future work.

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Abbreviations and terms

Common terms and abbreviations used in this report.

ATAG	Authoring Tools Accessibility Guidelines
CMS	Content Management System
GUI	Graphical User Interface
HCI	Human-computer interaction
HCD	Human Centred Design
ICT	Information and Communications Technology
ISO	International Organization for Standardization
LMS	Learning Management System
MVC	Model View Controller (design pattern)
OOXML	Office Open XML – an XML based format for Office documents
OS	Operating System
PDF	Portable Document Format
SD	Standard Deviation
SUS	System Usability Scale
TOC	Table of Contents
UCD	User Centred Design (later it was called Human Centred Design)
UD	Universal Design
User	a person using a system
WCAG	Web Content Accessibility Guidelines
UX	User Experience
XML	Extensible Markup Language
XPath	XML Path Language
XSLT	Extensible Stylesheet Language Transformations

1. Introduction

Worldwide, it is estimated that about 15% or above 1 billion people of the world's population experience some form of disability (WHO, 2011). The convention on the rights of Persons with Disabilities (CRPD) Article 24 – Education addresses the rights of persons with disabilities to education with an emphasis on an inclusive educational system at all levels and lifelong learning, respecting human rights, freedoms and human diversity (UN Department of Economic and Social Affairs, 2015). Equal opportunity for education is also covered by Sustainable Development Goal (SDG) 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (UN Department of Economic and Social Affairs, n.d.).

Digitalization has changed people's lives and education. The pandemic has been a driver for the digitization of education. Since the end of 2019 with the advent of the global COVID-19 pandemic restricting our lives, many universities and other educational institutions around the globe have been forced to move many of their activities to either be partially or fully online. The recent rise of the digitalization of education has only increased the importance of digital accessibility (Lazar, 2021, Chen, et al, 2018). Many students who previously were experiencing barriers in the digital part of their education risk complete exclusion from the university experience after the education has gone mostly or completely digital (Lazar, 2021).

Digital technologies and content that students are exposed to include websites, e-books, content/learning management systems for courses, registration mechanisms, video and other multimedia content (Lazar, 2021), as well as learning materials and documents in various formats such as .docx and PDF, presentations such as PowerPoint files.

It is an ongoing effort to improve the support for accessibility in digital technologies. Mainstream word processors, presentation software, Web and e-book standards such as HTML, CSS, JavaScript, SVG and EPUB all have built-in accessibility features. But knowledge is required to take advantage of these accessibility features.

The Web Accessibility Initiative (WAI) has been working on making the web more accessible to people with disabilities. WAI has published several standards and recommendations for

making the web more accessible including the Web Content Accessibility Guidelines (WCAG) and the Authoring Tools Accessibility Guidelines (ATAG).

In the context of higher education, content creators include teachers and other administrative staff who are responsible for creating and publishing content for both students and university staff. Content creators use many different languages, platforms, devices, operating systems when creating content. They use both cloud-based as well as locally installed software when creating digital content. For instance, content creators use web/cloud-based content management platforms such as OpenEdx, WordPress, Canvas and Moodle etc, word processors such as Word, Libre Office Writer and Pages, presentation software such as PowerPoint, Impress and Sozi.

Although there is a wealth of information online about how to create accessible content, literature has shown that faculty members in higher education are in lack of awareness and knowledge of relevant laws, regulations and their requirements (Chen, et al, 2018), as well as knowledge about how to make digital materials accessible (Sanderson, et al., 2022), (Langørgen & Magnus, 2018). It has also been reported that they are interested in learning, but in lack of time (Langørgen & Magnus, 2018). It is therefore necessary to understand their challenges in creating accessible digital content to provide appropriate guidance and support in the process.

1.1 Research question

The primary goal of this thesis is to better support content creators to create accessible digital learning materials. To be able to come closer to this goal it's needed to gain a better understanding of content creators needs and challenges when creating accessible digital content, which is the second goal of this thesis. This leads us to the research question. The research question for this project is:

How to better support content creators in creating accessible digital in the educational context?

To answer this question, literature was studied to understand the state of the art and challenges in creating accessible digital learning materials, the needs, experience and knowledge of content creators as well as guidelines to support content creators creating

accessible digital learning materials were investigated through including digital content creators in a Human Centred Design approach of developing an online guide driven by content creators' feedback. The online guide was evaluated, and answers to the research question was sought using a mixed methods approach combining both qualitative methodology such as user testing with observation, semi-structured interviews, open ended questions in online surveys, as well as quantitative data collection such as the use of an online survey using the System Usability Scale, and a performing Heuristic Evaluation of digital content created before and after having access to the online guide.

2. Literature review

2.1 Universal Design (UD)

The late Ron Mace was the first to coin “Universal Design” in the 1990s. Mace and his colleagues at North Carolina State University, The Center for Universal Design, defined Universal Design as “The design of products and environments to be usable by all people, to the greatest extent possible, without needing adaptation or specialized design.”

Center for Inclusive Design and Environmental Access at University at Buffalo defines Universal Design as:

> Universal design means planning to build physical, learning and work environments so that they are usable by a wide range of people, regardless of age, size or disability status. While universal design promotes access for individuals with disabilities, it also benefits others. (Center for Inclusive Design and Environmental Access, n.d.)

The Disability Act of 2005 has a slightly different wording of the definition of Universal Design (Centre for Excellence in Universal Design, n.d.-a):

1. The design and composition of an environment so that it may be accessed, understood and used
    a. To the greatest possible extent
    b. In the most independent and natural manner possible
    c. In the widest possible range of situations
    d. Without the need for adaptation, modification, assistive devices or specialised solutions, by any persons of any age or size or having any particular physical, sensory, mental health or intellectual ability or disability and
2. Means in relation to electronic systems, any electronics-based process of creating products, services or systems so that they may be used by any person.

2.1.1 The 7 principles of UD

In order to educate both designers and users about more usable products and environments (originally in the physical realm), and to evaluate existing designs as well as to guide the design process, a working group in North Carolina State University developed the 7 Principles of Universal Design in 1997 (Connell et al., 1997):

- Principle 1: Equitable Use
- Principle 2: Flexibility in Use
- Principle 3: Simple and Intuitive Use
- Principle 4: Perceptible Information
- Principle 5: Tolerance for Error
- Principle 6: Low Physical Effort
- Principle 7: Size and Space for Approach and Use

The details of the different principles of UD as described by (Connell et al., 1997) have been included below:

2.1.1.1 UD Principle 1: Equitable Use

The design is useful and marketable to people with diverse abilities:

a) Provide the same means of use for all users: identical whenever possible; equivalent when not.
b) Avoid segregating or stigmatizing any users.
c) Provisions for privacy, security, and safety should be equally available to all users.
d) Make the design appealing to all users.

2.1.1.2 UD Principle 2: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities:

a) Provide choice in methods of use.
b) Accommodate right- or left-handed access and use.
c) Facilitate the user's accuracy and precision.
d) Provide adaptability to the user's pace.

2.1.1.3 UD Principle 3: Simple and Intuitive Use

The use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level:

a) Eliminate unnecessary complexity.
b) Be consistent with user expectations and intuition.
c) Accommodate a wide range of literacy and language skills.
d) Arrange information consistent with its importance.
e) Provide effective prompting and feedback during and after task completion.

2.1.1.4 UD Principle 4: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities:

a) Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
b) Provide adequate contrast between essential information and its surroundings.
c) Maximize the “legibility" of essential information.
d) Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
e) Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

2.1.1.5 UD Principle 5: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions:

a) Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
b) Provide warnings of hazards and errors.
c) Provide fail-safe features.
d) Discourage unconscious action in tasks that require vigilance.

2.1.1.6 UD Principle 6: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue:

a) Allow the user to maintain a neutral body position.
b) Use reasonable operating forces.
c) Minimize repetitive actions.
d) Minimize sustained physical effort.

2.1.1.7 UD Principle 7: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility:

a) Provide a clear line of sight to important elements for any seated or standing user.
b) Make reach to all components comfortable for any seated or standing user.
c) Accommodate variations in hand and grip size.
d) Provide adequate space for the use of assistive devices or personal assistance.

2.1.2 Adaptation of the 7 principles of UD in ICT

While these principles originally were developed with the design of physical environments and physical objects in mind, The Principles of Universal Design have later been adapted to Information and Communication Technology (ICT).

The University at Buffalo's Center for Inclusive Design and Environmental Access expanded Universal Design's original focus to also include social participation and health and wellness and developed the 8 Goals of Universal Design.

2.1.3 UD design goals

Center for Inclusive Design and Environmental Access (Center for Inclusive Design and Environmental Access, n.d.) developed the 8 Universal Design Goals:

2.1.3.1 Body Fit

Accommodating a wide range of body sizes and abilities

2.1.3.2 Comfort

Keeping demands within desirable limits of body function and perception

2.1.3.3 Awareness

Ensuring that critical information for use is easily perceived

2.1.3.4 Understanding

Making methods of operation and use intuitive, clear and unambiguous

2.1.3.5 Wellness

Contributing to health promotion, avoidance of disease, and protection from hazards

2.1.3.6 Social Integration

Treating all groups with dignity and respect

2.1.3.7 Personalization

Incorporating opportunities for choice and the expression of individual preferences

2.1.3.8 Cultural Appropriateness

Respecting and reinforcing cultural values, and the social and environmental contexts of any design project

2.2 Diversity

Instead of polarising and putting tags on persons as “able bodied” or “disabled”, it is better to recognize that people are diverse in many ways. Diversity means how people differ. Diversity can be categorized in different types. *Internal Diversity* relates to characteristics related to a person that a person didn’t choose for themself. For instance age, assigned gender which might not be the same as gender identity, sexual orientation, gender identity, national origin, cultural identity, ethnicity, physical ability, mental ability etc. *External diversity* relates to characteristics related to a person which can change over time such as socioeconomic status, education level, personal interests, education, citizenship etc. Within an organization there is *organizational diversity* which relates to role, function or status within an organization. Finally, there is *diversity in world view,* such as political views, outlook on life and moral compass (Alliant International University, n.d.).

2.2.1 Understanding disability

Our understanding of the concept/phenomenon called *disability* is something that is evolving, and over the course of several decades, several models and views have emerged that try to explain it.

How are disabilities defined and categorized? The Accessibility for Ontarians with Disabilities Act (AODA) which became a law in 2005 categorizes disability in physical, sensory, learning, developmental, mental health disabilities as well as other invisible and episodic conditions (AODA, 2005).

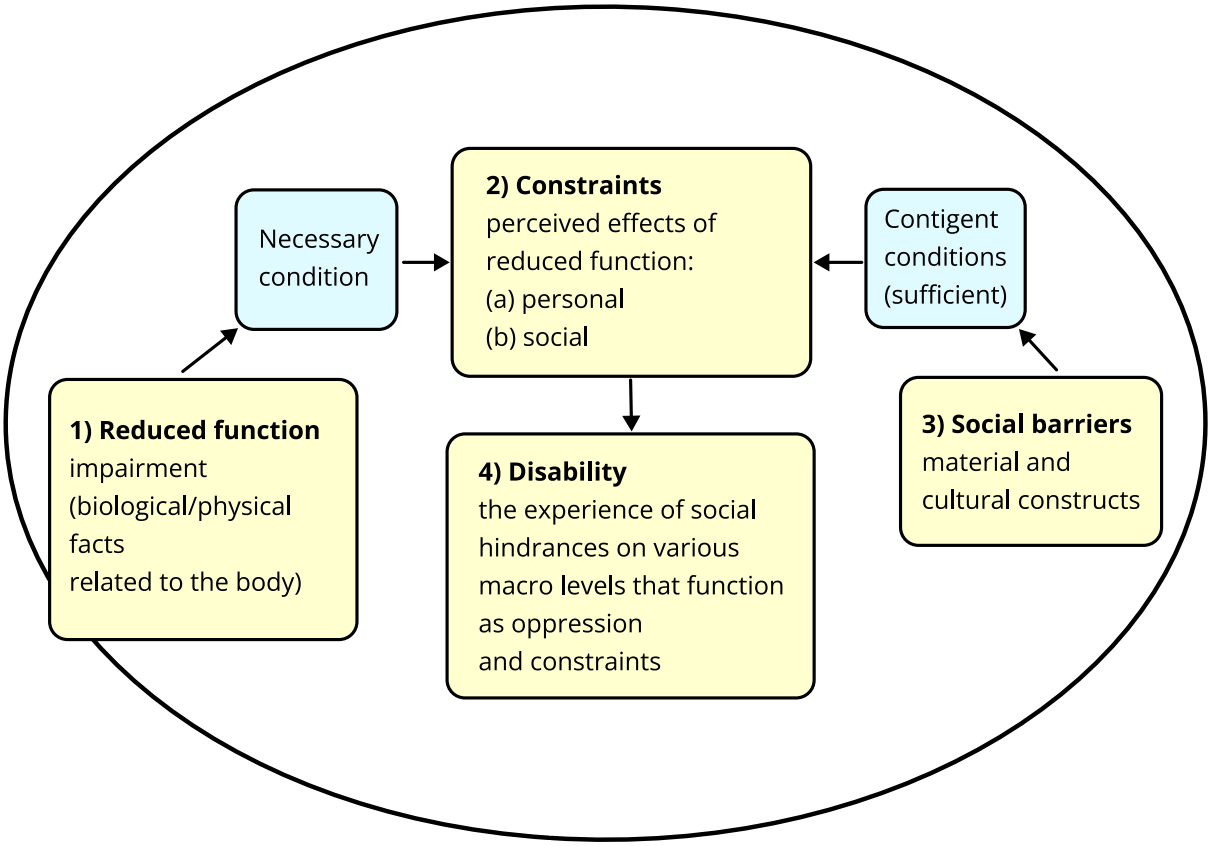
Originating from the medical field where disabilities are treated as a lack of body functions, the medical model of disability emerged. The medical model of disability views disability as a problem that belongs to the disabled individual, and that it is the disabled person's responsibility to resolve the situation (The AccessAbility Centre, n.d.). Currently this is now seen as an outdated view which puts too much responsibility on persons with impairments.

The *social model of disability* which was presented by researchers in the field of disability studies challenged the medical model (Oliver, 1996 ; Shakespeare & Watson, 1997 ; Swain et al., 1993 as cited in Reindal, 2008). The social model of disability is more inclusive in that the main goal of the model was to break the linear and causal understanding of the individual/medical model of disability (Reindal, 2008) and it is thought that it is society that disables people due to designing everything to meet the needs of the majority of people who are not disabled (The AccessAbility Centre, n.d.). This view of disability recognises that society can do a lot to reduce and ultimately remove some of the disabling barriers. The social model of disability puts the responsibility of disabling barriers on society (The AccessAbility Centre, n.d.).

The *social relational model of disability* sees disability as a phenomenon that is imposed on an individual by hindrances or barriers in society *on top of* the social effects an impairment has for the individual (Reindal, 2008).

Figure 2.1

The interplay between reduced function and disability: a social relational model (redrawn from Reindal, 2008).



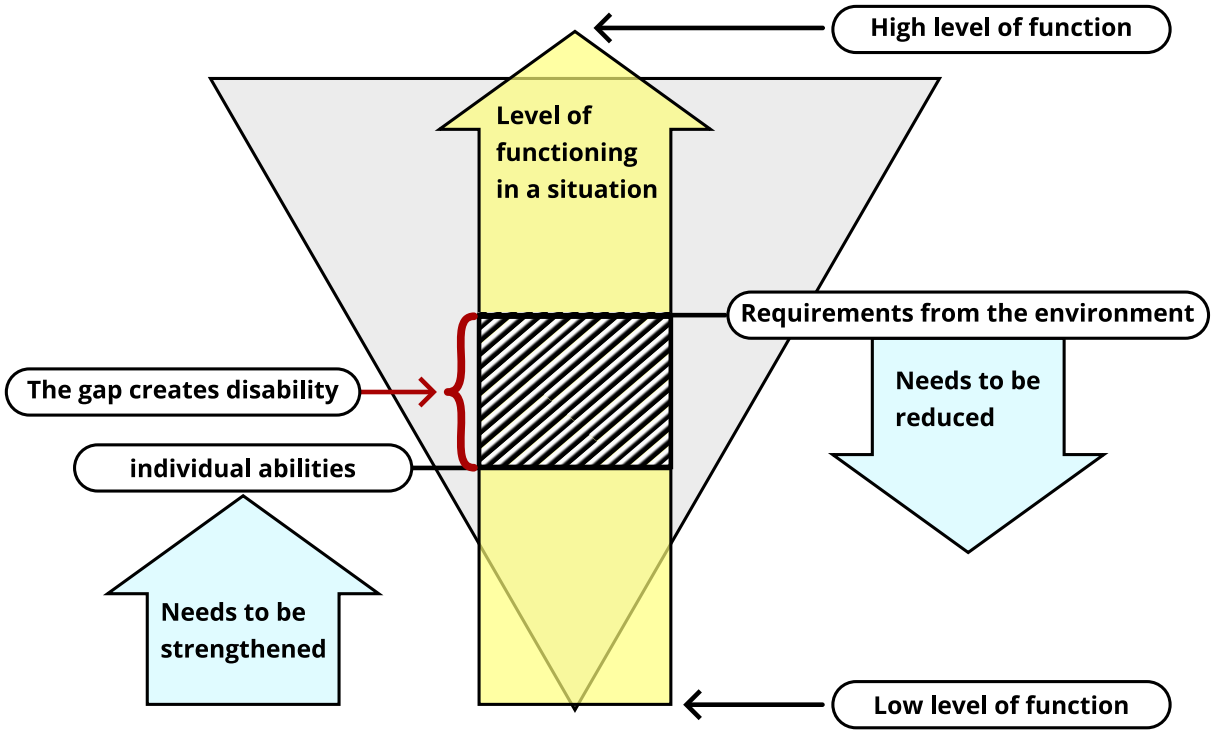
Note. According to the social relational model of disability, a *necessary condition* to 2) Constraints is 1) Reduced function/impairment which are biological/physical facts related to the body. 2) Constraints in this model are seen as the perceived effects of reduced function. They can be a) personal or b) social. When there is a sufficient amount of 3) Social barriers which can be either material or cultural constructs, Constraints can be experienced as 4) Disability. 4) Disability: the experience of social hindrances on various macro levels that function as oppression and constraints.

Disability can also be understood in the context of the Disability GAP model as the interaction between the demands from society and the abilities of the individual. This model was developed in the rehabilitation science field by Ivar Lie (Lie, 1996). Later the disability

gap model was presented as the political and professional understanding of “disability” in a white paper on Dismantling Disabling Barriers (Sosialdepartementet, 2003). In the Disability-GAP model, there are two challenges when bridging the disability-gap. One is to lower the demands from society which can be done through Universal Design, and the other is to empower or strengthen the individual, which could be done by training the individual in the use of assistive technology.

Figure 2.2

Redrawn Disability GAP model which was adapted by (Fuglerud, 2014) based on the white paper on Dismantling Disabling Barriers (Sosialdepartementet, 2003)



Note. The center vertical arrow pointing upwards in the model represents *Level of functioning in a situation*, where the lower part indicates *Low level of function* and the higher part represents *High level of function*. The *Level of functioning in a situation* relates both to *Individual abilities* as well as *Requirements from the environment*. If there is a gap between *Individual abilities and Requirements from the environment*, indicated as the *Requirements from the environment* requiring a higher level of functioning in a situation than *Individual abilities*' level of functioning in a situation, then according to this model there is a gap which creates disability. In this model there are two challenges to closing the gap which creates disability. One challenge is to *reduce requirements from the environment* which is illustrated with a downwards arrow. The other challenge is to *strengthen Individual abilities* which is illustrated with an upwards pointing arrow.

2.3 Relevant standards

2.3.1 Web Content Accessibility Guidelines (WCAG)

WCAG (Kirkpatrick et al., 2018) is an evolving set of guidelines developed through the W3C process which is made with the goal of providing a single standard for web content accessibility that meets the needs of individuals, organizations and governments internationally (Henry, 2021). It is being developed by the Accessibility Guidelines Working Group (AGWG), formerly known as the Web Content Accessibility Guidelines Working Group which is part of World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI). The current version at the time of writing is WCAG 2.0 which was published in 2008 and WCAG 2.1 which was published in 2018. WCAG 2.1 and later WCAG 2.2 which is expected in 2021 are backwards compatible, meaning the earlier versions of the standard are included word for word in the later versions. It is encouraged by W3C that we only need to consult the current/latest version when developing or updating content or accessibility policies. The newer versions of the standard don't deprecate the earlier versions of the standard but add success criteria which were not in the previous versions of the standard (Henry, 2021).

2.3.1.1 WCAG Principles, guidelines and success criteria

WCAG 2.0 and 2.1 has a set of guidelines, currently (12-13) which are organized under 4 principles: perceivable, operable, understandable and robust. These principles relate to the principles of UD.

WCAG principle "**perceivable**" relates to UD Principle 4: Perceptible information. Perception is about how humans perceive or sense content through different senses. In ICT this usually means sensing content through seeing, hearing and/or feeling/tactile. How people sense content will vary depending on needs, preferences and situation.

WCAG principle "**operable**" relates to UD Principle 2: Flexibility in Use, UD Principle 3: Simple and Intuitive Use as well as Principle 7: Size and Space of Approach and Use.

This WCAG principle is about supporting different interaction styles, having enough time to read and use the content, ease of navigating content, locating content and determining where the user is in the content and that the content does not cause seizures or other harmful physical reactions.

Many people do not rely on the mouse at all to interact with the web and instead use only a keyboard, or switches that emulate a keyboard. This type of interaction style requires keyboard access to all functionality including user interface components, form controls and other forms of input. Some notable requirements for *keyboard accessibility* include that all functionality that is available for the mouse, must also be keyboard accessible, keyboard focus must not get trapped in any part of the content, and finally that user agents, authoring tools and other tools should also provide keyboard support.

As some people need more time than others for there must be mechanisms to provide enough time for example by adjusting time limits, pause or stop blinking or scrolling content, suppress interruptions, re-authentication when a session expires without losing data.

As some people are sensitive to certain types of flashes, such content must be avoided. If it is still presented, users need to be warned before flashing content is presented, and alternatives must be provided. Also there needs to be mechanisms to switch off animations.

"Operable" also covers that users can easily navigate, find content and determine where they are is attributed to how well organized the content is. This means that content needs to be structured using clear titles and descriptive headings, that users should be informed of their current position both within a page and within a set of pages. Keyboard focus needs to be visible, and finally that the purpose of links is evident even if the link is viewed out of context on it's own.

WCAG principle "**understandable**" relates to UD Principle 1: Equitable Use and UD Principle 3: Simple and Intuitive Use.

WCAG principle "**robust**" relates to UD Principle 5: Tolerance for Error.

2.3.1.2 WCAG success criteria and conformance levels (A, AA, AAA)

Success Criteria of WCAG 2.0 and onwards are *testable statements* which define conformance to the WCAG 2.0 and onwards guidelines. For specific web content, the relevant success criteria, or tests if you think about it that way, will be either true (met) or false (not met). In addition, each success criterion will have a conformance level assigned to

it, which will be either single A (basic conformance to WCAG), double A (AA) or triple A (AAA) (Cooper et al., 2016).

2.3.2 Authoring Tools Accessibility Guidelines (ATAG)

While WCAG addresses content, ATAG addresses authoring tools which generate content.

2.3.3 User Agent Accessibility Guidelines (UAAG)

These guidelines are targeted to developers of user agents, that is software people use to access web content. This includes graphical browsers, voice browsers, mobile phone browsers, multimedia players, plug-ins and also some assistive technologies. web browsers, to aid in making the web more accessible for people with disabilities.

2.4 Laws, legislation and regulations

2.4.1 Convention on the Rights of Persons with Disabilities (CRPD)

CRPD doesn't define disability. In the preamble it is stated that disability is an evolving concept and also that disability is something that results in the interaction between persons with impairments and barriers they meet either in the environment or attitudes. This view is in line with the social-relational model of disability. CRPD doesn't create any new rights but recognizes that rights of persons with disabilities have not been protected well enough with previously existing conventions and legislation and gives states legal obligations to specifically protect rights of persons with disabilities. (CRPD). In Norway, Likestillings- og diskrimineringsombudet [Equality and discrimination ombudsman] are responsible to foresee that Norway complies with CRPD as well as the International Convention on the Elimination of All Forms of Racial Discrimination and the Convention on the Elimination of All Forms of Discrimination against Women (Likestillings- og diskrimineringsombudet [Equality and discrimination ombudsman], n.d.).

2.4.2 Legal requirements of UD of ICT and WCAG conformance

While the best deal for users would be if every success criteria is always met, local (national, state, or union) legislation or laws related to accessibility, universal design and/or anti

discrimination typically define which level of conformance that must be met as a bare minimum, and to what types of domains or in which scope the WCAG guidelines needs to be met. For instance, should private and public web pages have the same demands in WCAG compliance? What about internal and external content? What about documents that are not made public but stored in internal archives? What about self service machines or apps for handheld devices or TVs? These choices are important because if a success criterion and it's conformance level is required by law/legislation it is a strong driver to make sure it will be implemented.

In Norway, Regulation on Universal Design of Information and Communication Technology (ICT) of 2013 requires WCAG 2.0 compliance for both public and private sector for main solutions which are targeted towards the general public (Kommunal- og moderniseringsdepartementet [Ministry of Local Government and Modernization], 2013). It covers web solutions, including digital learning materials as well as self-service machines. Recently, as of May 28th 2021, Norway has adopted the EU's Web Accessibility Directive (WAD) for the public sector only. Inclusion of WAD in Norwegian legislation will require compliance of all new level A and AA success criteria of WCAG 2.1 (an additional 12 out of the total of the 17 success criteria which are new in WCAG 2.1). The new regulation will be in effect 1st of January 2022 with one year grace period to allow time to adjust meaning WCAG 2.1 will be enforced beginning January 1st 2023. The inclusion of WAD will not apply directly to the private sector, as today's requirements will continue (Tilsynet for universell utforming av ikt [The Audit for Universal Design of ICT], n.d.).

2.5 Digital content and modalities

Digital content comes in many file formats ranging from web-based content presented in text and structured HTML, with presentation styled in CSS, and possibly being made interactive either using native constructs of the HTML language, or by being supplemented with JavaScript. Multimedia such as bitmap images, Scalable Vector Graphics, audio and video are presented within web pages or e-books. Documents of various formats such as word processor documents, spreadsheets, presentations, are made available.

The different formats have different strengths, weaknesses and in relation to Universal Design, different requirements for being accessible for users considering user diversity. One

way of evaluating strengths and weaknesses of a file format is to consider which modalities the format supports. A sensory modality corresponds to the senses humans use when sensing information. Within ICT the most relevant senses are seeing (visual), hearing (audio) and tactile (touch). As users are diverse, the preferred or possible methods a user can interact with content will vary. Therefore it is important that it's possible to navigate the content efficiently and change the presentation of content depending on the user's preferences and that the content is compatible with assistive technology. For instance to present the content in several modalities. This is where the WCAG guidelines can guide content creators.

A note about the Portable Document Format (PDF), a fixed layout page format which still is widely used. This format solves the problem of consistent presentation of documents across systems. It was designed with printing on paper in mind and has later been extended with several accessibility features to make it work better with accessible technology. It does have a major accessibility drawback though when being used to read documents on electronic devices. A fixed layout format means the text won't necessarily reflow to fit the viewport, meaning it is hard to read documents on small devices or for users with visual impairments since zooming in makes it very hard to navigate.

2.6 State of the art research

2.6.1 Stakeholders related to accessibility in learning

There are several groups of stakeholders related to accessibility in learning, for instance students, teachers, administrative staff, software developers, learning management system providers, associations for people with disabilities.

It is argued that web developers are key to creating an accessible web but that it is a challenge to find people, who both have developer skills as well as an understanding of accessibility practices and the challenges faced by people with disabilities (Gay et al., 2017). This is a result of accessibility and disability awareness not often being integrated in computer science programs (Gay et al., 2017).

2.6.2 Increasing digital accessibility

Participants with web developer background who took part in the MOOC called Professional Web Accessibility Auditing Made Easy found that experiencing barriers and challenges of people who were blind (simulated by turning off the monitor) was a difficult, eye-opening and emotional experience which had a lasting change in the way they looked at web accessibility. This was the activity that had the highest impact in the course (Gay et al., 2017). The feature most of the participants found useful was the Web Accessibility Auditing Toolkit which they assembled throughout the course. The perceived usefulness of the interactive discussion forum, however, was mixed. Previous research has suggested three types of learner engagement in MOOC courses. The first described as active engagement such as participating in all forum activity, posting, submitting quizzes and other assessments. The second is described as passive engagement such as being limited to viewing, subscribing or voting on the forum posts and viewing lectures. The third being described as disengaged which is associated with decreased posting, viewing of forum posts or voting (Gay et al., 2017). Three key elements of the accessibility MOOC that were reported to work well. The first key element being thorough and well written content which included a variety of sources and, both included in the course as well as external resources, and multimedia content. Another key element which was reported to work well was having different engaging activities to keep the participants interested and active during the course. The last key element reported, and the most notable takeaway in the accessibility MOOC reported by the participants was the Web Accessibility Auditing Toolkit which the participants had assembled during the course (Gay et al., 2017).

2.6.3 Learner's perspective - barriers in education

Even with legislation in place to secure people's rights, prohibiting discrimination on the basis of disability, such as the Americans with Disabilities Act of 1990 in the US, people with disabilities continue to face barriers in higher education . A study by (Horn & Bobbitt, 1999), mentioned in (Burgstahler et al., 2000), revealed that students with disabilities are less likely to stay enrolled or to earn a post secondary degree compared to students without disabilities. In post-secondary institutions, obstacles to equitable participation are attributed to areas such as lack of adequate supporting systems, little access to successful

role models, lack of awareness of and access to technology which could be used to increase independence and productivity, negative attitudes and low expectations from faculty and staff which students with disabilities had to interact. A different study titled Changing America 1989 by The National Science Foundation task force reported that negative attitudes was the single most significant barrier faced by individuals with disabilities (Burgstahler et al., 2000).

2.6.4 Digital challenges for students with disabilities

Students with disabilities reported being frustrated and angry that they have to find so much more money, as well as spend so much more time than others just to get the same standard of education. Another recurring complaint was that students with disabilities had to spend much time and effort to make the system work for them - such as making sure the right individuals knew about their disability and negotiating or asking for arrangements. Several students with disabilities were dependant on helpers being available in various situations, and coordinating this was reported to generate extra stress (Holloway, 2001). Several of the challenges identified by (Holloway, 2001) could be attributed to *lack of digitization*. A literature study by (Kent, 2015) reported on digital challenges as well as advantages for students with disabilities in e-learning. With the understanding of disability in the light of the social model of disability impairments such as vision impairments, cognition impairments, manual dexterity impairments and hearing impairments (with the widespread use of audio and video) can be significantly disabling in the digital environment. (Ellis & Kent, 2011 ; Goggin & Newell, 2003 as cited in Kent, 2015). Other problems encountered by students with impairments which were reported in literature cited by (Kent, 2015) included “accessibility of websites and learning management systems, accessibility of digital video and audio and alternatives, inflexible time limits built into online exams, lack of accessibility in PowerPoint presentations, course material in inaccessible PDF formats and the lack of access needed for adaptive technologies” (Kent, 2015).

2.6.5 Coping strategies

How do students cope with disabilities and barriers in Higher Education (HE)? This has been discussed by (Langørgen & Magnus, 2018) who, in a nordic setting, reported that students don't always report having disabilities or facing barriers to staff in Higher Education, and instead choose to cope with these barriers by themselves at a huge cost of effort and time

investment. This, they argue, could be because students want to prove themselves worthy of their place in academia, don't want to burden the staff unnecessarily, and also because students don't always know their rights about accommodating needs or who to contact. This could mean that HE staff are not always aware of how much responsibility the students are taking. Findings from Norway and other nordic countries contrast findings from the United States where students were claiming their rights (Langørgen & Magnus, 2018). The authors question how HE institutions can design a system capable of embracing the diversity of learners without treating some students as special cases because of disability. While no easy answer to this question can be found, many of the obstacles could easily be solved by Universal Design (UD) of the technical and physical environment as well as the pedagogic approaches. But UD alone is not enough to bridge the gap and the authors point out that learners with disabilities need to be met as persons with valuable experiences, as well as needing some extra support (Langørgen & Magnus, 2018).

2.6.6 Teacher's perspective

To have an impact on the accessibility of online courses, it is important to understand what kind of people teach accessibility as part of their courses and what causes are preventing teachers from including accessibility in their fields of expertise. When surveying more than 14000 computer and information science faculties in the United States, one finding was that faculty staff who teach accessibility are more likely to have expertise in HCI, software engineering, twice as likely to be female, and are likely to know people with disabilities (Shinohara et al., 2018). In this study, participants reported lack of knowledge, lack of accessibility learning objectives and resources of how accessibility related to specific disciplines they were teaching. The data had some evidence about faculty cultures which may be ambivalent to accessibility. For instance, some participants reported that they could not understand how accessibility could be relevant at all in their discipline. Due to their findings the authors recommend investigating how accessibility is relevant to specific disciplines, creating materials which incorporate accessibility in specific modules and finally teaching faculty staff how to incorporate accessibility in their teaching (Shinohara et al., 2018).

In a Norwegian study of professional higher education within health care, social work and teaching, practice placement, typically 2-3 periods lasting 4-12 weeks were reported to add to the barriers of both students with disabilities as well as academic staff, lecturers and professional supervisors. This was reported to be true for both students with disabilities who need to disclose their impairments if they are to receive special arrangements, as well as for the staff who needs to make such arrangements (Langørgen et al., 2020). Academic staff, lecturers and professionals who serve as supervisors report having mixed feelings when working with students with disabilities due to conflicting roles and values (i.e. is it more important to help the student to complete the education, or is it more important to act as the gatekeeper, ensuring only professionals who are fit to do the job will be able to work in the profession). Other problematic areas include lack of knowledge of how to accommodate (i.e., how to accommodate, and how much accommodation is appropriate), time constraints, lack of sufficient institutional support as well as lack of openness regarding participating students with disabilities (Langørgen et al., 2020).

In a focus group study conducted with participants from 23 postsecondary institutions who were part of a project called Disabilities, Opportunities, Internetworking, and Technology (DO-IT), academic staff reported having mostly positive experiences having students with disabilities in their classroom when the students were open with their professor and classmates about their disability, also knowing what kind of accommodations they needed. Some comments from the focus group participants highlighted that it was a positive but at the same time a challenging experience to work with students with disabilities as it involved change and made them think about the way they worked. When asked about their negative experiences having students with disabilities in their classes, faculty often reported that negative experiences with students with disabilities were rare. But the experiences which were frustrating were situations such as when students with disabilities did not identify themselves as having disabilities, also when students were not able to tell faculty which accommodations work well for them. Also in situations where students with disabilities displayed an 'entitled' or negative attitude was experienced as difficult to work with. Finally, physical disabilities were reported to be challenging to accommodate due to architectural barriers (Burgstahler et al., 2000).

The same study also asked the participants about what types of courses and activities which had been especially difficult to provide appropriate accommodation. To this question, difficult activities identified by faculty members were computer-use-related, such as software exercises, presentations and flashing computer screens. Also, several activities were made difficult due to physical architectural barriers; activities such as field experiences, science labs as well as basic access to classrooms and other facilities at the institution. Another challenging area mentioned was the difficulty of making appropriate test accommodations for students with learning or psychological disabilities (Burgstahler et al., 2000).

2.6.7 Universally accessible instruction and learning frameworks

A thorough discussion of different frameworks for Universally Accessible Instruction and how they relate to each other is given by (McGuire, 2014), where Universal Design in Education (UDE), Universal Design for Instruction (UDI), Universal Design for Learning (UDL), Universal Design of Instruction (UDI), and Universal Instructional Design (UID) are discussed. Although each of these frameworks has its own principles and operational definitions, what is common is more important than how they differ. What they have in common is that these frameworks are about inclusive instructional environments that are also responsive to diverse learners (McGuire, 2014).

Universal Design for Instruction (UDI) is discussed by (McGuire et al., 2003) and (McGuire & Scott, 2006). Here the principles of Universal Design (UD) that have roots from architecture and product development are mapped to instructional practises in higher education. The first 7 principles are similar to the 7 principles of UD, with the addition of principle 8, a community of learners for facilitating interaction and communication between learners and staff, and principle 9, instructional climate that is inclusive and welcoming, as well as promoting high expectations for all students (Black et al., 2014). While related to each other, UDI focuses more on the instruction side - being a framework for creating instructional content, setting goals, which methods to use, and assessments that work for anyone. Universal Design for Learning (UDL) on the other hand is a concept that focuses more on the learner (Black et al., 2014)

3. Methodology

This project consists of two main tasks, the first one is the design and development of the prototype of the online guide, the second one is the evaluation of the online guide with target users. For the design and development of the prototype, we have adopted the Human-Centred Design (HCD) approach (International Organization for Standardizatino [ISO], 2019). For the evaluation, a mixed methods approach was adopted (Shorten & Smith, 2017). This chapter will provide more details about these approaches.

3.1 Ethical considerations and application to NSD

Because it was necessary to record audio to be able to properly analyse the interviews, the project had to be submitted to Norwegian Centre for Research Data (NSD) for approval before data collection could begin. The project data collection was approved with some minor comments to consider after about a month of waiting time. NSD was a research institution whose purpose was to make research data more available by removing financial, legal, and practical barriers. However, since January 1st, 2022, NSD, along with Uninett AS and Unit – the Directorate for ICT and Joint Services in Higher Education & Research, merged into Sikt – Norwegian Agency for Shared Services in Education and Research. During a transition period, NSD's services are still available through the old NSD website. Sikt provides services such as shared infrastructure for education and Research, as well as information security and data protection.

3.2 Human-Centered Approach

Human-Centred Design is a design methodology revolving around involvement of representative users from an early stage when developing something. HCD revolves around 4 principles: 1) It's People-Centered, 2) Solve the right problems/the root causes, 3) Think of everything as a system, and 4) Do iterative work over small and simple interventions (ISO, 2019). The HCD approach is iterative and incremental in that the process is a repeating cycle of the system being tested by and evaluated by representative users doing representative tasks, followed by a relatively short development phase before being tested and evaluated again and so forth.

To develop something that is useable for end users, user involvement and feedback is of great importance throughout the development phase. Involving users, getting their feedback, and letting it drive the development of a system from an early stage can avoid the risk of spending a lot of time, cost and effort into developing something with poor usability and accessibility.

Human Centred Design is published as an ISO standard in ISO 9241-210:2019(en) titled "Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems. It has gone through a formal standardization process which is obviously a strength. Unfortunately, ISO-standards are locked down behind paywalls which prevents them from being as widely used as they should be, as exemplified by the article appropriately named "Tech spec experts seek allies to tear down ISO standards paywall" (Claburn, 2021). That aside, "Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems" which is published in (International Organization for Standardization, 2019) outline some important guidelines for user involvement in the development process such as requiring:

- the design to be based upon an explicit understanding of users, tasks and environments
- users to be involved throughout design and development
- the design to be driven and refined by user-centred evaluation
- the process should be iterative
- the design should address the whole user experience
- the design team includes multidisciplinary skills and perspectives

In this project HCD guidelines have been applied by involving representative users from an early stage and letting their feedback drive and guide the development. In the project, multidisciplinary perspectives are included with contributions such as discussions with, and feedback from my supervisor, peer students and project participants as well as the perspectives of authors in the referenced literature.

3.2.1 Prototype development through an iterative design process

An iterative development cycle as outlined in HCD development methodology is used throughout the whole development of the prototype. Initially we started out by talking

about the project and sketching down some ideas on paper as known as paper prototyping or low fidelity prototyping.

After the initial phase, the development phase is cyclic and follows the following HCD guidelines/main activities. Each of cycle choosing problems to work on, active development, and user testing and evaluation is called an iteration.

This process of doing relatively small increments of work, each iteration typically spanning 1-3 weeks of development, followed by getting user's feedback before continuing is a very powerful concept. The continued user feedback will serve as a reality check to ensure that the project developed will meet the requirements of users, and not just be something made for the developers.

3.3 Method for Evaluation

The method for evaluation of the prototype adopts a mixed method approach, combining qualitative and quantitative data collection.

Qualitative data were collected from observing user testing sessions, performing semi-structured interviews and by including open ended questions in evaluation survey.

Quantitative data were collected by having the participants fill out an online System Usability Scale (SUS) survey after having tested the online guide, and also by inspecting files before and after the participants accessed the online guide to try and improve the accessibility in the files.

The participants who evaluated the guide were split in two groups.

Group 2 participants participated in a user testing session while being observed, followed by filling out an online survey with the System Usability Scale (SUS), and finally a semi-structured interview, which was recorded and later transcribed for qualitative analysis.

Group 3 participants were asked to try and use the information in the online guide to try and improve the accessibility of a document or presentation of their choosing by relying on the online guide. These before and after files were uploaded to an online form at nettskjema.no, which also had the SUS survey, as well as some open ended questions which

covered the same topics as the interview guide used in the semi-structured interviews for group 2 participants.

More details about the data collection for evaluating the guide follow.

3.3.1 Qualitative methodology

When evaluating a system, it's important to include users' perspectives to be able to improve the system so that it performs better according to the users' needs and expectations. Qualitative data collection can give us greater insights in understanding the interaction betweeen users and the system and the users' needs and expectations because it enables us to get deep and detailed data. In this study qualitative data is collected through usability testing with observation using the think aloud protocol, semi structured interviews and the use of open-ended questions in a survey.

3.3.1.1 Usability testing and observation

Usability testing include representative participants, representative tasks, and representative environments, with participants' activities monitored by one or more observers (Lewis, 2006).

Observation during user testing means to see what participants are doing, how they are using the system being tested, what they succeed in doing as well as what they fail at doing, how they are reacting, what emotions, thoughts, or opinions they are expressing.

When deciding on how many users to test on, Jacob Nielsen of Nielsen Norman Group argues that around 5 users is enough because testing more users usually don't result in appreciably more insights. This number of 5 users was found after summarizing 83 usability consulting projects with varying amount of users participating in usability testing (Nielsen, 2012).

In this study, the goal with the usability testing and observation was to see how the participants used the website, to what degree the online guide met the user's expectations, goals and needs, as well as test the website's structure, organisation, user interface and getting feedback on the content as well.

Qualitative data such as audio were recorded using Nettskjema Dictaphone app, and observational notes were made on paper. The participants were asked to use the third iteration of the online guide to find relevant information about making accessible content that they were interested in, or that they were unsure of how to make accessible, or to just see what was there. The participants were encouraged to use the think aloud protocol and were given different tasks when testing the online guide to ensure both content, organisation and user interface were tested.

The participants were asked questions such as:

“Is there any type of content which you are unsure how to make accessible?”

“Is there any type of content which interests you?”

“Could you try to find this information?”

“Could you try and follow that link and see if that answers your question?”

After completing the task of finding the information they were looking for, some participants who didn’t explore the filtering functionality were asked questions such as:

“Did you notice that there is a filtering functionality?”
“Would you like to test it?”

During the testing the participants were encouraged to think aloud and to clarify their thoughts.

3.3.1.2 Semi structured interviews

A semi structured interview is a commonly used method for acquiring qualitative data about a person’s opinions and experiences. In this project, an interview guide was developed with different topics and questions that needs to be covered. The semi structured interview allowed for follow-up questions and in-depth discussion with the participants. The strengths of using semi structured interviews include being flexible, natural, and providing rich qualitative data. A semi-structured interview is flexible in the way that it can be adapted to the participant’s answers and reactions. The conversation flows naturally, allowing ideas and themes to emerge. Since the format is not as rigid as a structured interview, it feels more like a casual conversation and the dialogue can flow quite freely. Finally, semi-

structured interviews provide rich qualitative data about how real people experience what is being discussed. To allow the conversation to flow naturally in the interview it is advisable to record the interview (Lazar et al., 2009). This can be done only after getting the participant's consent.

Following the user testing session, participants were asked to participate in a short interview, and if they gave consent to the interview being recorded with the Nettskjema Dictaphone App.

After getting consent, the semi structured interview with audio recording started, following the interview guide in Appendix 3 (English) or Appendix 4 (Norwegian), depending on the participant's language preference.

The interview revolved around the participant's experiences and thoughts about working with universal design, accessibility, digital content, and their brief experience with the online guide. See the Appendix 3 and Appendix 4 for more details.

After completing the interview, the relevant parts of the conversation in the interview were transcribed and subjected to a thematic analysis.

It was planned to make use of only notes in the case some participants would like to participate in the interview but not give consent to audio recording of the interview.

Most interviews were conducted with a physical meeting at the participant's workplace, or in a meeting room, while some were done online via Zoom.

3.3.2 Quantitative methodology

3.3.2.1 Survey with System Usability Scale (SUS)

The System Usability Scale which is often referred to as SUS, is a widely used 10 question survey which can be used to quickly assess the overall usability of a system. Usually the questions asked are the same as in the original SUS survey, only changing the word "system" to an appropriate word referring to what is being evaluated. (Brooke, 1995).

Immediately after having tested the online guide, the participant was asked to compete an electronic survey about the usability of the online with an adapted version of the SUS survey.

The questions in the SUS survey are organized such that the questions are alternating between positive and negative statements about the system. For even questions (2,4,6,8,10), a high score indicates poor usability, while for odd questions (1,3,5,7,9), a high score indicates good/great usability.

After participants have completed the SUS survey, a SUS usability score can be calculated according to the formula: SUS score = ((sum of scores for odd questions - 5) + (25 – sum of scores for even questions))*2.5

3.3.2.2 Questions used in the SUS survey

The questions are the same as the ones in the original SUS scale (Brooke, 1995), but the word “system” was changed to “guide”:

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

For each of the questions in the SUS questionnaire, the participant were asked to rate their level of agreement.

Table 3.1

Level of agreement to each statement in the SUS questionnaire, and individual statement score used when calculating the SUS score.

Level of agreement of different statements in the SUS survey	Individual agreement score used when calculating SUS score
Strongly disagree	1
Disagree	2
Unsure/don't know	3
Agree	4
Strongly agree	5

3.3.2.3 Interpreting SUS scores

The scores from the individual statements in the SUS survey should not be compared across participants or systems, but the calculated SUS scores can be compared across participants, and SUS score averages can be compared between systems or between different user groups of the same system.

For the SUS score, a higher number corresponds to better experienced usability. The lowest possible score is 0, which is achieved by answering "strongly agree" to all negative statements (even numbers), and "strongly disagree" to all positive statements (odd numbers). Answering all the statements with the middle value of "unsure/don't know", will give a score of 50. The highest possible score, 100, is achieved by answering "strongly agree" to all positive/odd statements (1,3,5,7,9), and strongly disagree to all negative/even statements (2,4,6,8,10).

While it is obvious that a higher SUS score indicates better usability, to be able to interpret these numbers better, (Bangor et al., 2009) added an eleventh, 7 point lickert rating scale for 1000 SUS surveys (see Table 3.2), and also calculated mean SUS scores for nearly 3500 SUS surveys within 273 studies. They found that overall, for different interface types such as

web, cell phones, Interactive Voice Response (IVR), GUI, Hardware and TV, the mean SUS score was around 70, while the median score was around 70.5. The rating of the 7 point lickert rating scale had a very strong correlation to the SUS score (Bangor et al., 2009).

The placement of a SUS score in a Quartile is also another way of interpreting how well the usability of a system is interpreted. A SUS score in the beginning of the 3rd quartile would be perceived as better than about half of the systems (Bangor et al., 2009).

Table 3.2

Quartiles for SUS Study Mean Scores (n=273 studies) (Bangor et al., 2009)

Quartile	Lower Bound	Upper Bound
1	30.0	62.2
2	62.6	70.5
3	70.5	77.8
4	77.8	93.9

We can use the 7 point adjective scale in Table 3.4 to interpret meaning to the SUS scores.

Table 3.3

Descriptive Statistics of SUS Scores for Adjective Ratings, from (Bangor et al., 2009)

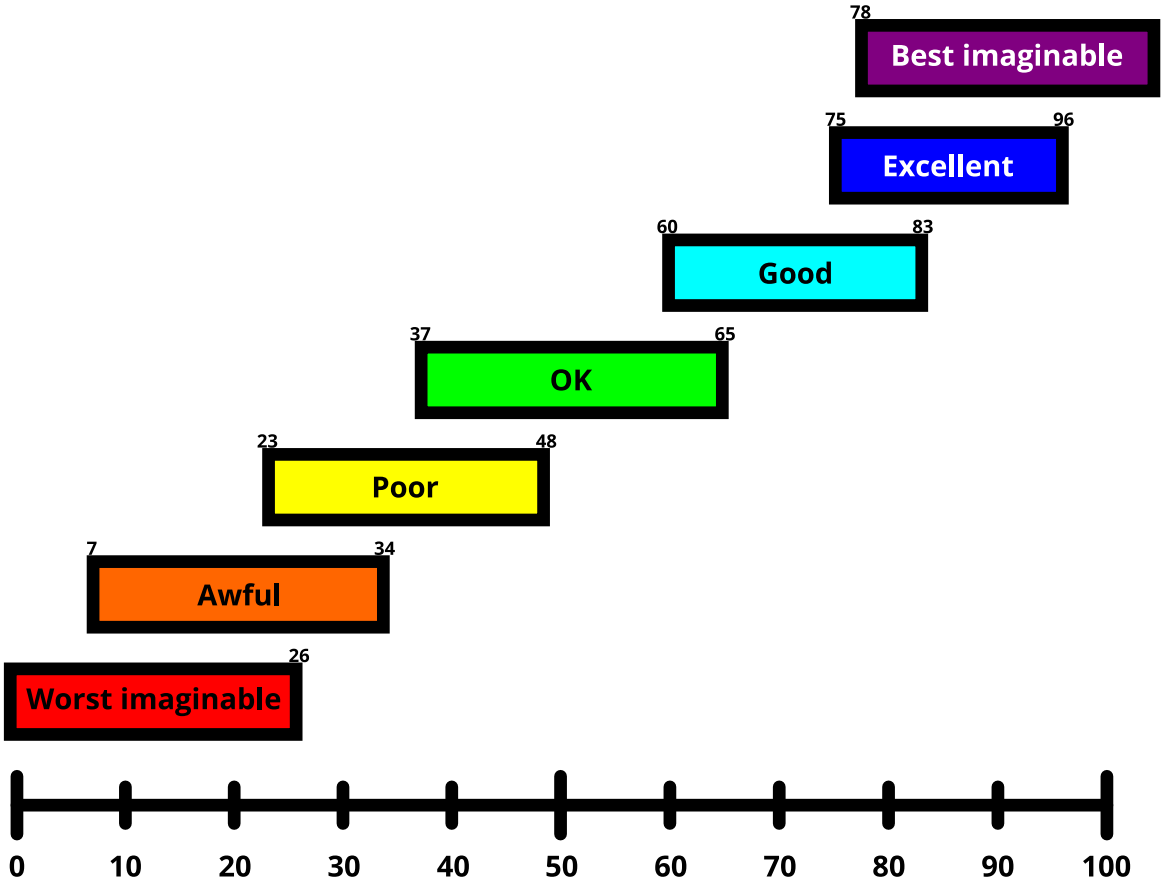
Adjective	Count	Mean SUS Score	Standard Deviation
Worst Imaginable	4	12.5	13.1
Awful	22	20.3	13.3
Poor	72	35.7	12.6
OK	211	50.9	13.8
Good	345	71.4	11.6

Adjective	Count	Mean SUS Score	Standard Deviation
Excellent	289	85.5	10.4
Best Imaginable	16	90.9	13.4

In *this* report an adjective is interpreted to be within range if the SUS score is within one SD of the Mean SUS Score in (Bangor et al., 2009.

Figure 3.1

Interpreting the SUS score in the adjective scale by (Bangor et al., 2009) by showing the bounds of Mean SUS Score plus/minus SD. The numbers refer to SUS scores. Worst imaginable: 0-26. Awful: 7-34. Poor: 23-48. OK: 37-65. Good: 60-83. Excellent: 75-96. Best imaginable: 78-100.



3.3.2.4 Heuristic review/accessibility inspection of created digital content

A heuristic review is an accessibility expert's analysis of the digital content by looking for common accessibility issues or barriers (Acosta-Vargas et al., 2019). In this project the heuristics which are used during the accessibility inspection, are based on WGAC 2.1 success criteria that are relevant to the document types inspected (text documents and presentations).

Participants in group 3 were asked to submit documents before and after having access to the online guide. Relying on the online guide, they were asked to try and improve the accessibility in their documents if they could find any accessibility issues. These documents were subject to a heuristic accessibility review of the digital content created.

Documents were checked using the built in Accessibility Checker in Microsoft 365 in addition to manual checks. The types of documents which will be inspected are word documents, PowerPoint presentations and PDF which are made from word source documents.

The files before and after group 3 participants used the online guide to try and improve the accessibility, were investigated for accessibility issues in a heuristic review (Acosta-Vargas et al., 2019).

4. Results

4.1 Participant recruitment

Teachers, researchers, administrative staff, and librarians from three Norwegian universities were recruited to participate in the study. See Table 4.1 for details.

Table 4.1

Gender balance in the study

Total	Female	Male
17	13	4

Table 4.2

Background information of the different participants.

Position type	Participants
Administrative	P3, P4, P7, P8, P15
Administrative and Teaching	P3
Teaching and Research	P1, P6, P9, P10, P11, P13, P14
Teaching	P16
Library	P2, P12, P16

Note. P1-P3 in Group 1 participated in early prototype development evaluation. P2 and P3 also participated in data collection pilots. P4-P9 in Group 2 participated in observed User Testing of iteration 3, semi structured interviews, and a SUS survey. P10-P17 in Group 3 participated in testing the guide by themselves to try and improve the accessibility of a document/presentation and a survey.

Table 4.3

Overview of the different groups' activities and number of participants in each group.

Group	Activities the participants took part in	Participants
Group 1	Evaluation and feedback of prototype in iteration 1 and 2 which was used when developing the next iteration.	P1, P2, P3
Group 1	Usability Testing Pilot, semi-structured interview Pilot and SUS survey pilot	P2, P3
Group 2	Usability Testing, semi-structured interviews and SUS survey	P4 – P9
Group 3	Submission of files for accessibility inspection before and after accessing the online guide to try and improve accessibility of digital content. Survey including SUS in addition to open ended questions about the online guide.	P10 – P17

Note. Two of the three participants in group 1 also participated in the pilot of usability testing, semi-structured interview and SUS survey.

These participants were recruited into three different groups. Three participants took part in group 1, where they evaluated the prototype after the first and second iteration. Six participants took part in group 2, who participated in a user testing session with observation, semi structured interviews, and a Systematic Usability Scale (SUS) survey. Finally, eight participants took part in group 3, where they tried to improve the accessibility in documents or presentations while relying on the online guide without being observed, as well as completing the SUS survey and some additional questions. The participants in group 3 submitted their documents or presentations before and after trying to improve the accessibility, for accessibility inspection.

4.2 Development of the online guide

4.2.1 Artifact and source code online

One of the results of this thesis is the development of an artefact – an online guide in the form of a website. This website, and the associated code is not submitted as a separate file submission but can be viewed online in a web browser. The online guide is hosted at the url: https://uuguiden.no

The project was source controlled with git from the beginning and the entire codebase can be viewed online on Github at the following url: https://github.com/eirikhanssen/uuguiden

If any readers are interested in how the website is built up, the most interesting files to look at in the Github repository are:

- The single page html application which is generated by an XSLT transform, and is used to serve the website at the website's url
- The CSS stylesheet responsible for the layout and presentation
- The JavaScript file responsible for the filtering logic and interaction which goes beyond what is offered by native HTML elements
- The XML file where all the content and relationships is defined
- The XSLT file which contains all the rules of creating the HTML view from the XML file where the content is stored.
- The shellscript which is used to regenerate the main HTML file by calling an XSLT Processor to transform the XML using the rules in the XSLT file.

At the time of submission this url runs iteration3 of the online guide, which is the version that has been extensively evaluated and written about in this thesis. At the time you read this text, the development might have moved on, but historical versions of the online guide can be viewed in the urls listed in the following subsection.

4.2.2 Historical live versions of the prototype

Different iterations/versions of the guide is available live to be tried out in a browser at:

- https://iteration1.uuguiden.no/ an early version
- https://iteration2.uuguiden.no/ an early version
- https://iteration3.uuguiden.no/ which is the version that was evaluated by users with observation and semi structured interviews
- https://iteration4.uuguiden.no/ where some of the feedback from the user testing and interviews has been implemented

4.2.3 Development methodology

An online guide for creating universally designed and accessible digital content was developed using an incremental and iterative HCD approach driven by user feedback as described in chapter 3.2.1 – Prototype development through an iterative design process.

4.2.4 Distributed versioning and source control with Git

When writing source code it is mandatory to use some sort of version control system (VCS) to be able to protect the work against several possible mishaps not limited to hardware failure and own mistakes. Git is a distributed VCS which provides a powerful way to track and compare versions, retrace errors, explore new approaches while retaining a full history of all changes that has been done (Ram, 2013). The following features makes the use of git excellent for source control and code management: backup of code on local development machines and a remote repository, all changes are logged making it is easy to check the development history to see what files were changed and where, when they were changed, what the developer was thinking of when changing files which is stored in a commit message. Git also supports branching the code to work on specific parts, tagging a specific point in the history which it is possible to check out code from.

From the beginning the developed website was source controlled using git, and the whole development code is available on Github on the following url: https://github.com/eirikhanssen/uuguiden

4.2.5 Architecture – Separation of concerns with Model View Controller (MVC) design pattern facilitated by XSLT

In the beginning, when the code base was small, and before introducing JavaScript logic programming was done in HTML and CSS. This approach was manageable in the beginning.

Expressing the relationships between topics and filter function directly in the HTML code which was necessary for the JavaScript logic to work became increasingly difficult to work with when just programming in HTML as the size of the codebase increased with more content. Therefore, the decision was made to express all the content, and the filtering relationships in a very simple xml-structure (the model or data representation), and then use XSLT logic (the controller) to transform the content into an HTML representation (the View).

4.2.6 MVC benefits

Strengths of using the MVC design pattern is the separation of content, view and logic, which allows each of them to be developed and tested independently.

After using this design pattern, changes to content or expressing relationships related to filtering the guide are done in the XML file filters-and-topics.xml, the HTML view of the guide is controlled by the XSLT stylesheet filters-and-topics.xsl

- See the XML file with the actual content, where the relationships to filters is expressed: https://github.com/eirikhanssen/uuguiden/blob/main/filters-and-topics.xml
- See the XSL file containing the rules for creating the HTML webpage: https://github.com/eirikhanssen/uuguiden/blob/main/filters-and-topics.xsl
- Running the command ./refresh-index.sh will update the website based on the content in the XML and XSL file: https://github.com/eirikhanssen/uuguiden/blob/main/refresh-index.sh

Refreshing the website after making changes to either content, relationships or the HTML transformation is done by running the script refresh-index.sh

This calls the saxon XSLT processor which needs to be installed on the system. This processor transforms filters-and-topics.xml to HTML code using the rules defined in filters-and-topics.xsl and updates index.html which is the displayed website.

This approach of separation of concerns, makes it very easy to continue adding more content to the guide and to express relationships between content and filter options which are done in the XML-file without having to worry about the HTML structure or the logic. At

the same time, making small or big changes to the HTML representation of the website by modifying the rules in XSLT are also easily done without having to worry about the content.

4.2.7 Implementing the filtering functionality by manipulating the DOM using JavaScript

Most of the user interaction and accessibility on the website is handled well simply by the choice of using the proper native HTML5 elements. In order to filter the guide, JavaScript logic is needed to modify the Document Object Model which is the in-memory representation of the webpage which exists in the web browser.

- See the JavaScript code responsible for the user interaction: https://github.com/eirikhanssen/uuguiden/blob/main/js/uuguiden.js

4.2.8 The different iterations of the development of the prototype using guidelines from HCD

At the time of writing two iterations of work on the high-fidelity prototype guide has been completed with both development and getting user feedback. Work on iteration 3 is progressing and will soon be ready for user testing and feedback.

4.2.8.1 Iteration 1 work

This was the initial version of the guide, with only a couple of topics, and initial thoughts of how to filter the content being coded in html forms.

The state of iteration 1 can be viewed live at the time of writing on the url: https://iteration1.uuguiden.no/

Figure 4.1

The first version of the guide showcasing form elements for filtering the content (but with no logic behind them).

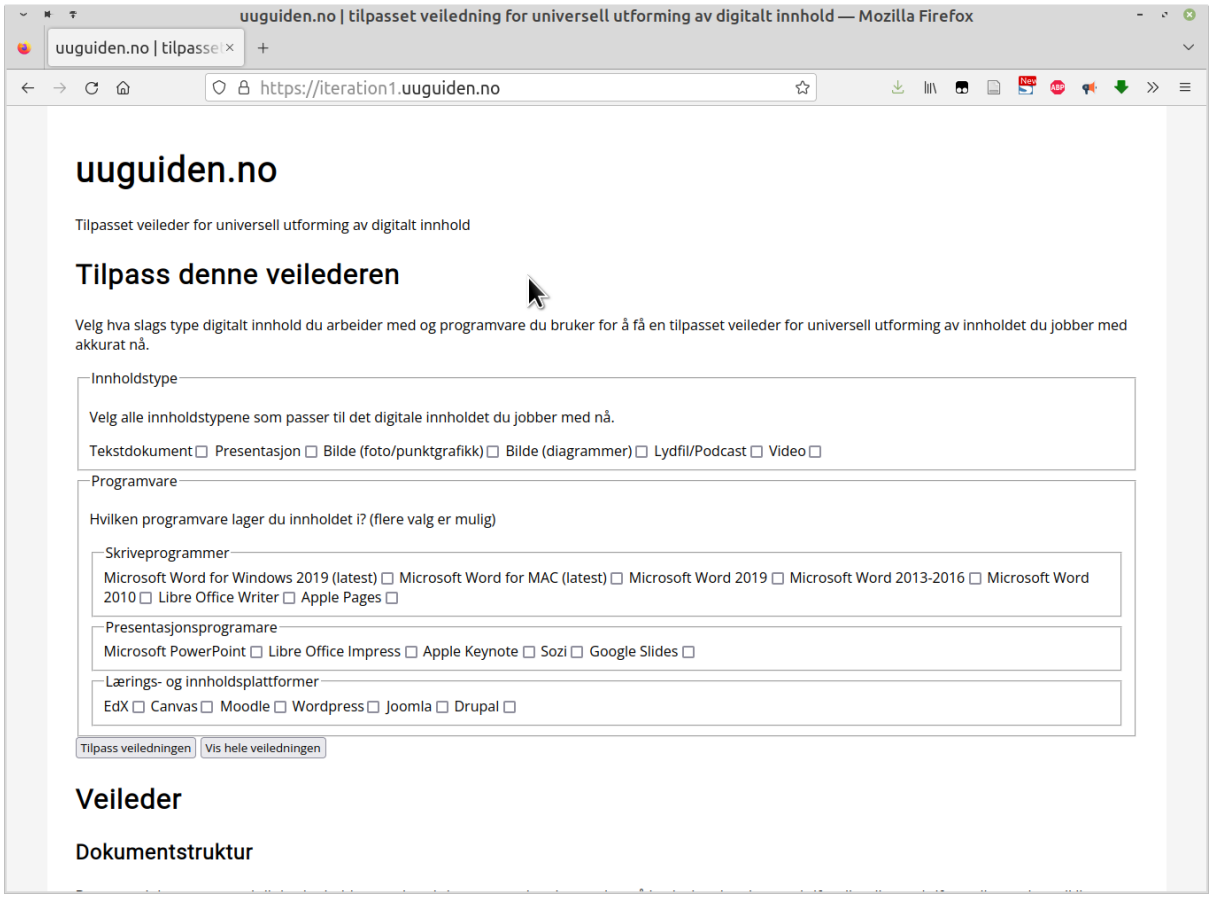
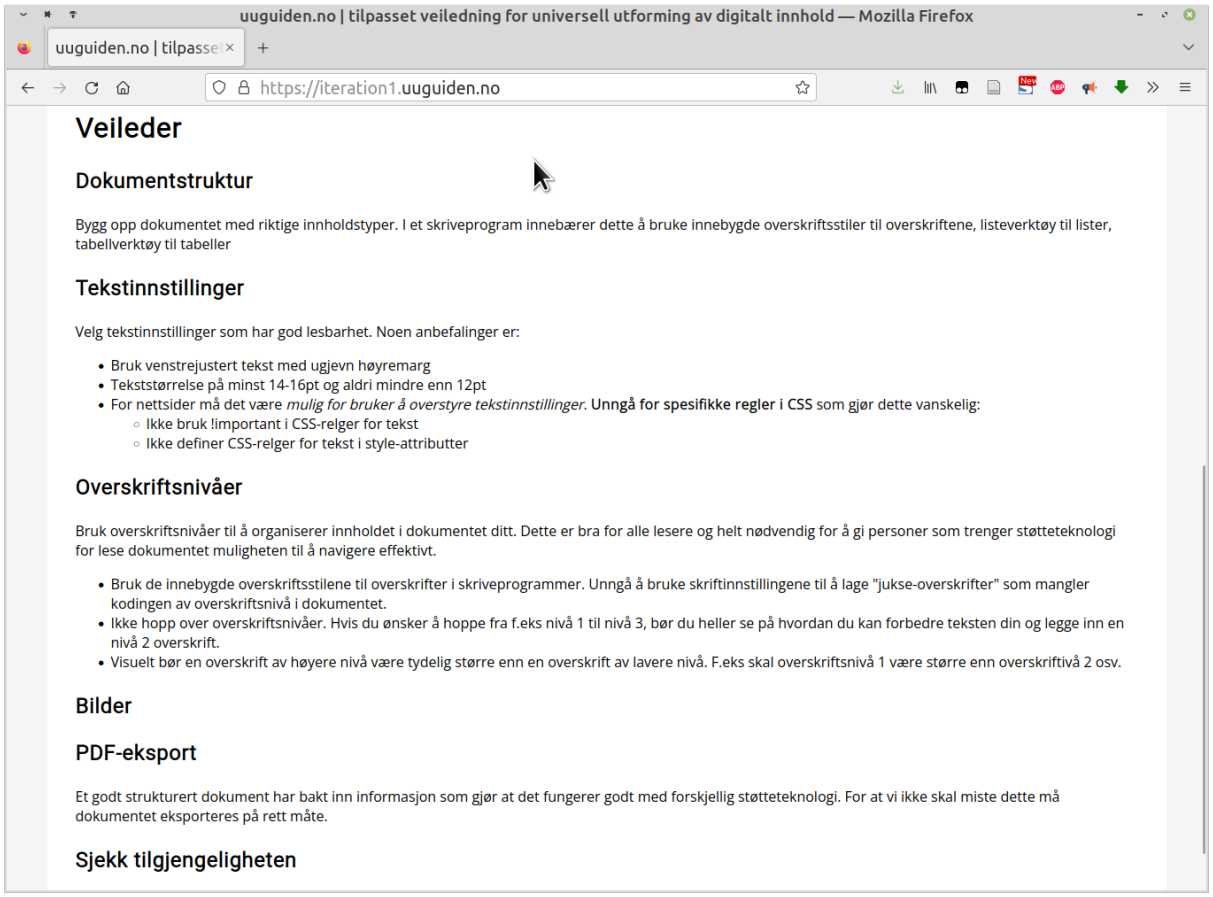


Figure 4.2

The first version of the guide showcasing the beginning of the content in the guide.



4.2.8.2 Iteration 1 feedback

Two participants evaluated the first iteration of the prototype. P1 had feedback on improving the layout of the page:

> Consider placing radio buttons or checkboxes before the label text instead of after. Try to organize input so that labels are underneath labels and checkboxes are underneath checkboxes (P1).

The first version of the prototype had two entry points, being either content type or software version. P1 suggested to begin with “innholdstype” (content type) as the entry point. Also, the form with filtering of the information should be grouped and relevant parts should be hidden or displayed depending on the choices to limit the information being presented.

P2 commented on language and spelling errors and would like words to be written out instead of using abbreviations, as well as using proper/correct language. P2 also commented

that the use of “latest version” for software was unnecessary. P2 also commented that the detailed explanations in the PDF-export section was missing. Positive feedback included: “good that it will be possible to limit the information you get depending on what you choose in the filtering section” and “good that there will be guidance on different software versions. P2 missed “webpages” as a content type.

4.2.8.3 Iteration 2 work

For this iteration I planned to improve the layout of the filtering form according to feedback from P1 to make it more readable.

The state of iteration 2 can be viewed live at the time of writing on the url: https://iteration2.uuguiden.no/

Figure 4.3

Iteration 2 showcasing the filtering options still with no logic behind.

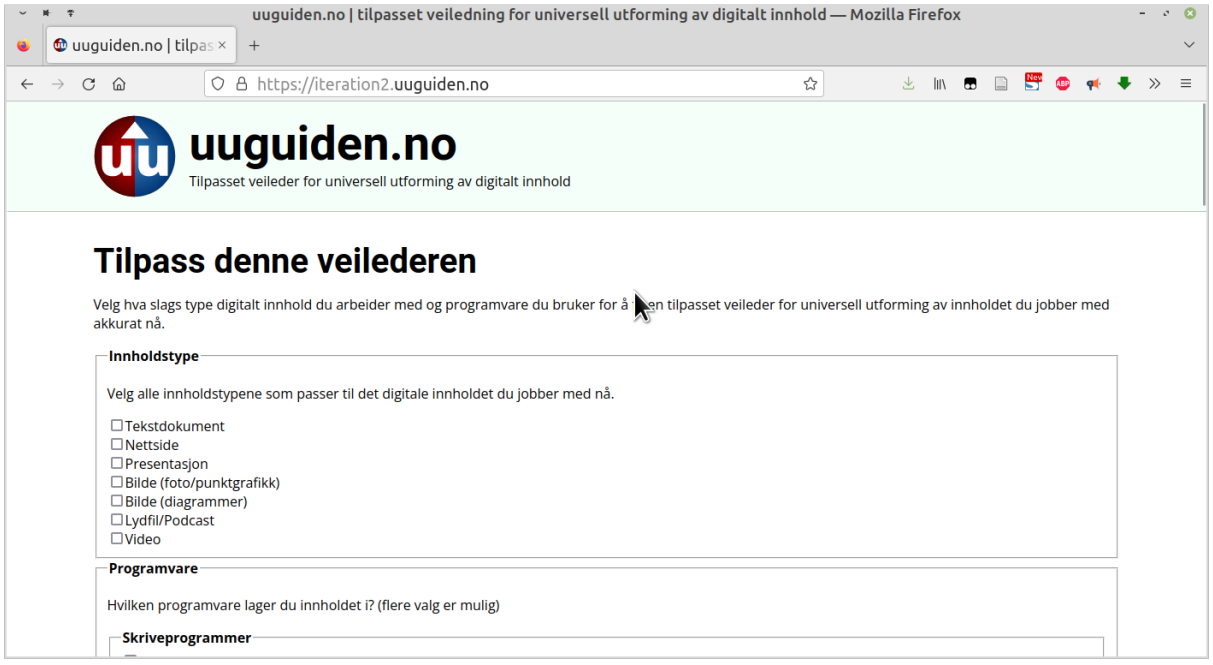


Figure 4.4

Iteration 2 showcasing more the rest of the filtering options

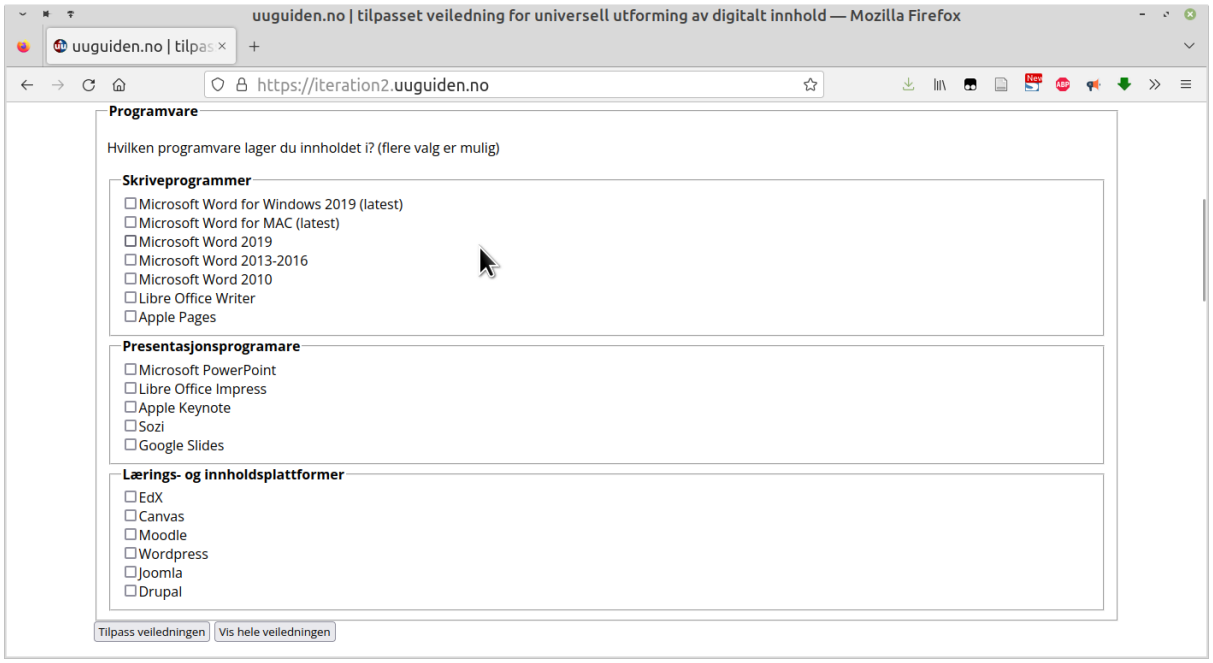


Figure 4.5

Iteration 2 showcasing more content in the guide.

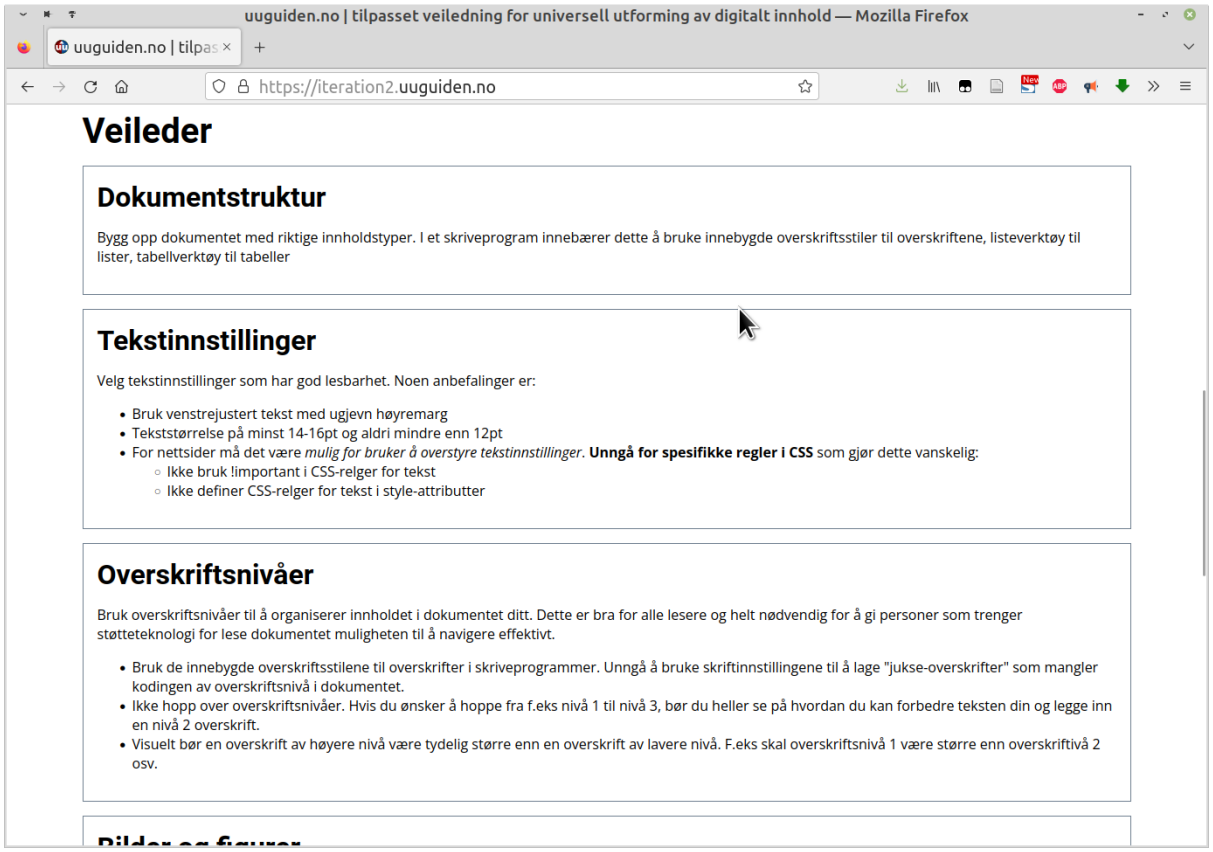
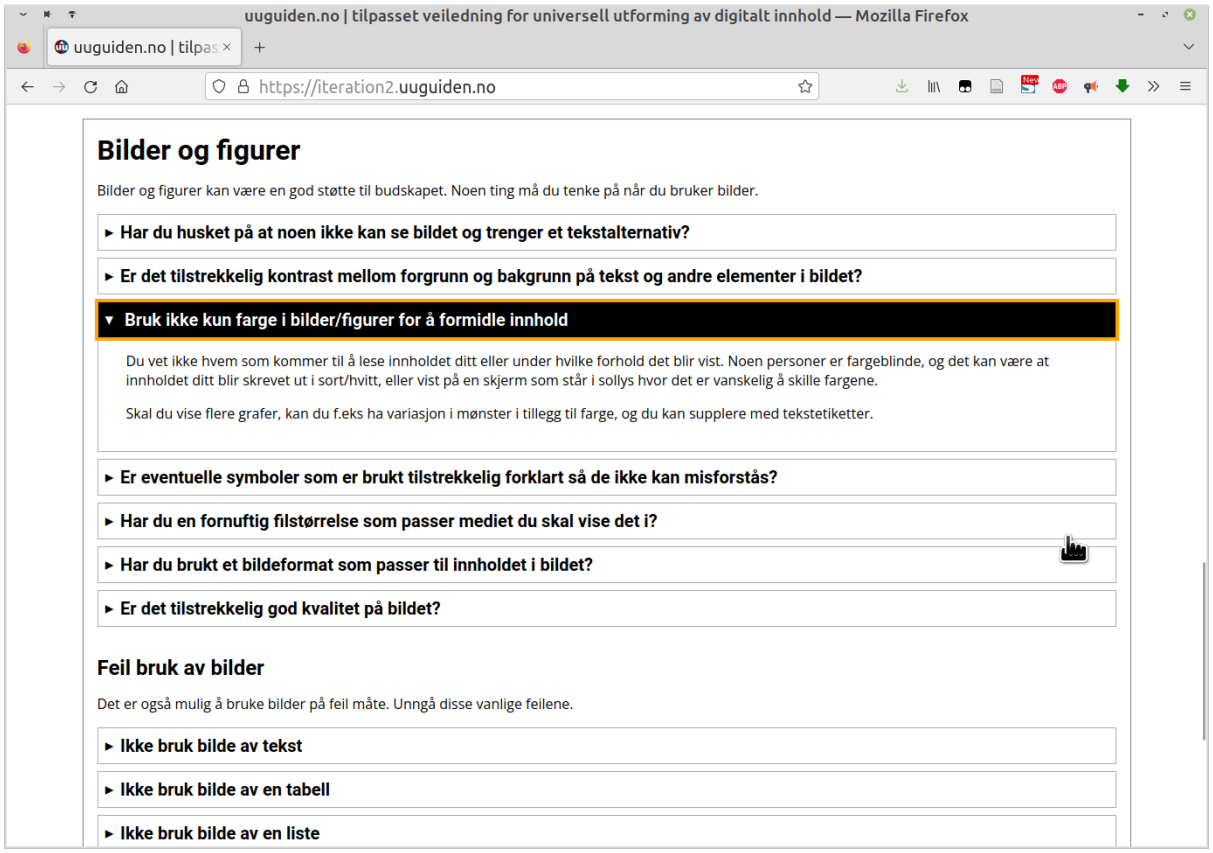


Figure 4.6

Iteration 2 experimenting with the use of details/summary to show/hide more detailed information.



4.2.8.4 Iteration 2 feedback

Three participants, P1, P2 and P3 evaluated the second iteration of the prototype.

P1 suggested to move the choice of seeing the whole guide, or to filter the guide before the filtering to allow the user to choose whether to see the whole guide or relevant parts. P1 argued that the users would probably want only the relevant information they are currently seeking. This is in line with suggestions from P3 who stated: I would go even more straight to business. After the headline “Adapt the guide” maybe just “What do you need UD-help with right now?”. P3 argued that users are always very busy and impatient. Other suggestions from P3 included that when choosing “Video” some relevant software alternatives should appear such as FinalCutX, Adobe Premiere and other relevant software. P3 also mentioned that captions are easy to add in FinalCut, but the user should be made aware that the captions should be exported to a .srt file and not be burned into the video. Unless it is a SoMe-video (social media video), where it is a common practise that text is

burned in. P3 was confused with the two buttons “tilpass” (adapt) and “tilbakestill” (reset), since the whole guide would be displayed by default. P3 suggested a reset link or button could appear next to the adapt button after adapting/filtering the guide. P3 also commented on the use of clear and understandable language and suggested some improvements to “Har du en fornuftig filstørrelse som passer mediet du skal vise det i?” (Do you have a sensible file size which suits the media you are going to display the content in?). P3 was afraid most creators of digital would not understand this language and suggested some improvements to this text:

> If you are going to publish something online, it is important to reduce the file size. This will make the files smaller, and your content will load much faster on the web page (P3).

This would be easier to understand, but for those who would like to know a little more P3 suggested also adding:

> A 72 dpi/ppi resolution is often enough when publishing online. If the image is going to be printed in a book or a magazine, a resolution of 300 dpi/ppi is advised (P3).

P3 also commented that in the section “Have you used an image format which is suitable for the content of the image” would need some more examples in the text below, and to avoid to confuse the users it would be good to add that bitmap images are the most commonly found image format when using image search online, and rather explain what scalable vector graphics is especially suited for.

P2 commented that if an external web resource had incomplete information about a topic, then it would be better to create our own resources for that topic. P2 liked the drop-down construct (details/summary elements) and that they were phrased as questions, and also preferred that there is consistency within the guide.

P1 commented that if the user chooses either a text document, website or presentation, then there are certain types of content which are very likely to appear even if the user did not choose them in the filtering. This includes content such as image/photo, image/diagram, lists and tables (which by the way was missing from the content type selection). Links should be added to these content types as well.

P1 also commented to think about *document types* (word-file, ppt-file and HTML) versus *content types* (text, video, audio, image, list, table) and had a suggestion that selecting a file type such as a text document, presentation or web page should automatically select relevant content types such as image, list or table while giving the user the opportunity to deselect afterwards.

Another suggestion from P1 was to try and not overburden the users with too much information - to try and pick the most essential info while putting the rest in “read more” sections and used image as an example:

> If it is informative, people who cannot see it need meaningful alternative text so that they can understand what it is about (P1).

P1 recalled a statement once uttered by a teacher: “I don’t know how to do it, just give me a list”.

Another important comment from P1 was that low fi prototyping as known as paper prototyping is essential before coding to not be bound by the code because when doing a hifi prototype there is internal resistance to change it. P1 stated it was more difficult to give critique to a design which was already coded (a hifi prototype) rather than discussing paper prototypes which can be made with little effort in as quickly as 5 minutes and then are easily tossed away, knowing that it takes much more time and effort to create a coded hifi prototype.

4.2.8.5 Iteration 3 work

Development-wise the work for iteration 3 was the most challenging part as this is where most of the JavaScript logic which drives the interaction of adapting the guide was introduced. This includes adding functionality such as automatic table of contents generation, automatic generation of form elements for filtering the contents which are based on data-attributes present on HTML-elements in the different topics of the guide, functionality for showing and hiding parts of the document depending on the user's choices.

For the earlier iterations, there was no need in using a specific design pattern during development because of the low complexity of the HTML + CSS and JavaScript, but with the added complexity introduced in this iteration, it was difficult to move forward. For instance,

a decision to make a small change in the overall HTML structure became very hard, as was maintaining relationships between different HTML elements needed to make the logic for filtering and automatic table of contents generation. Therefore, it was decided to use the MVC pattern, where the HTML was no longer directly coded, but controlled by an XSLT transformation of XML where the content was defined.

For this iteration I decided to organize the guide filtering taking into account the suggestions of P2 and P3, where the user should be given a choice up front whether to read the whole guide or to filter the guide, as well as implementing the relationship that different topics and sections of the guide have to each other.

I needed to think about how to solve this challenge for quite a while, and the solution I came up with was was not very complicated to implement. The different topics will be marked up using section-elements with appropriate HTML markup. The HTML specification has a list of allowed attributes for each element. When developing a Rich Internet Application, which is the type of webpage the online guide will resemble the most, HTML has a standard way of defining user/developer defined attributes called data-attributes. These need to begin with "data-" in the HTML source code and can be given custom names and values. To access and manipulate these values in the DOM we rely on JavaScript and the node.dataset property. In our example we express the relationship between topics with attributes such as: data-content, data-software, data-related, data-required, data-optional.

When viewing the whole guide, these will not do anything, but when the user wants to filter down the guide to only show relevant information, the JavaScript logic will look for the contents of these attributes to decide:

For instance, when the user selects a compound content type such as "webpage", "document" or "presentation" which usually are composed of many elements of different type of content, there are certain topics that are required to be shown. Two required topics will be "outline" and "headings" which explains the heading hierarchy and the proper use of headings which is important for accessibility in any document, webpage or presentation context.

In the HTML-source, this will be expressed with a data-required="outline headings" attribute for the "webpage", "text document" and "presentation" topics. Likewise, there are

optional topics which will then be automatically selected as the user selects certain content types in the filtering, but which can be unselected before the user confirms the filtering.

Optional content types are based on experience that these content types are often found in such documents.

For "webpage", "text-document" and "presentation" such optional topics may include images, lists, tables, links, paragraphs. This can be expressed in the HTML-source as a data-optional attribute as in the example:

```
<section id="section-text-document"
    data-content="text-document"
    data-required="outline headings"
    data-optional="image list table link paragraph">
<h4 id="heading-text-document">Tekstdokument</h4>
(...)
</section>
```

Figure 4.7

A screenshot midway during the development of the third iteration of the guide. Notice that the filtering options are now hidden. When loading the page, the whole guide is shown. The user will be able to select if they would like to see the whole guide, or if they want to filter the guide based on content type they're working with or software they are using.

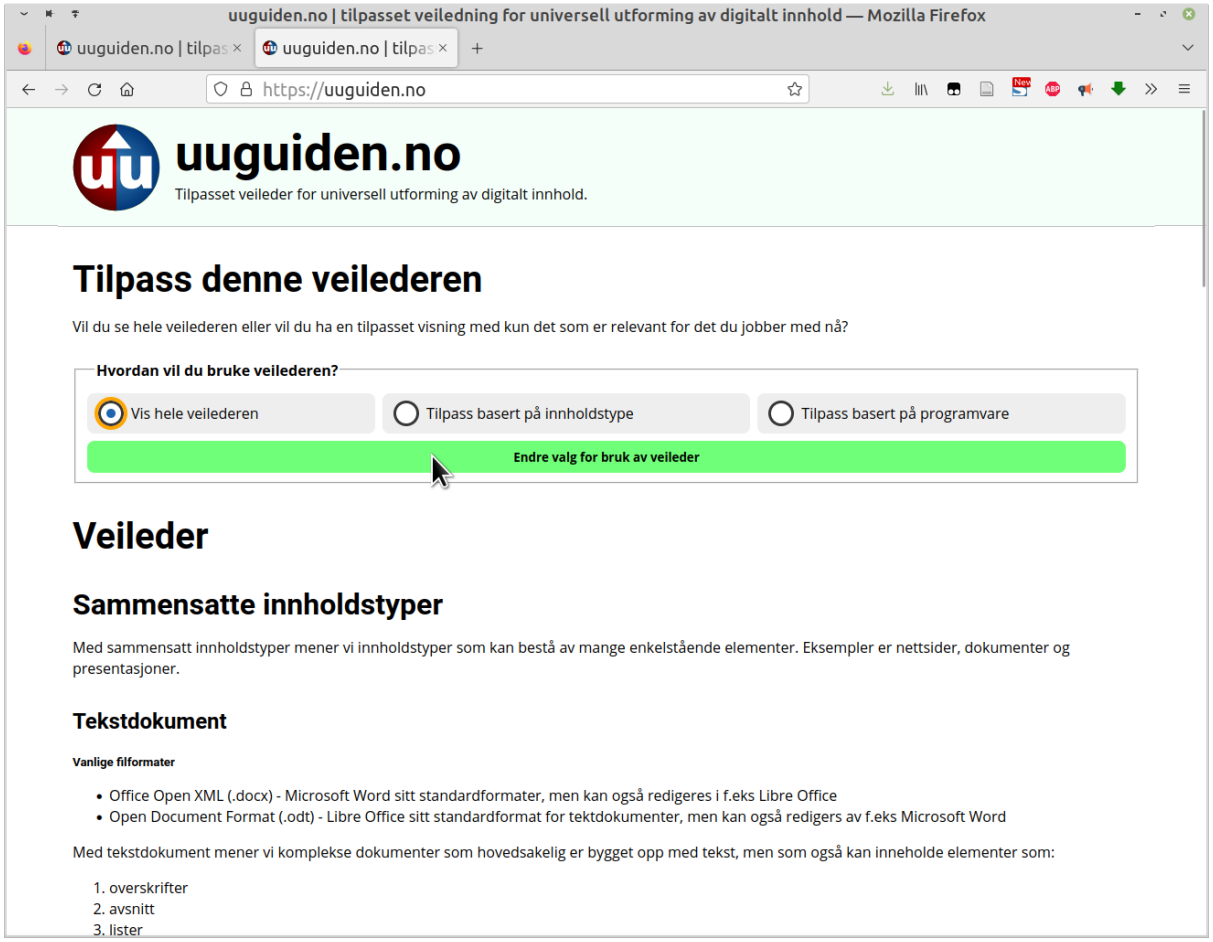
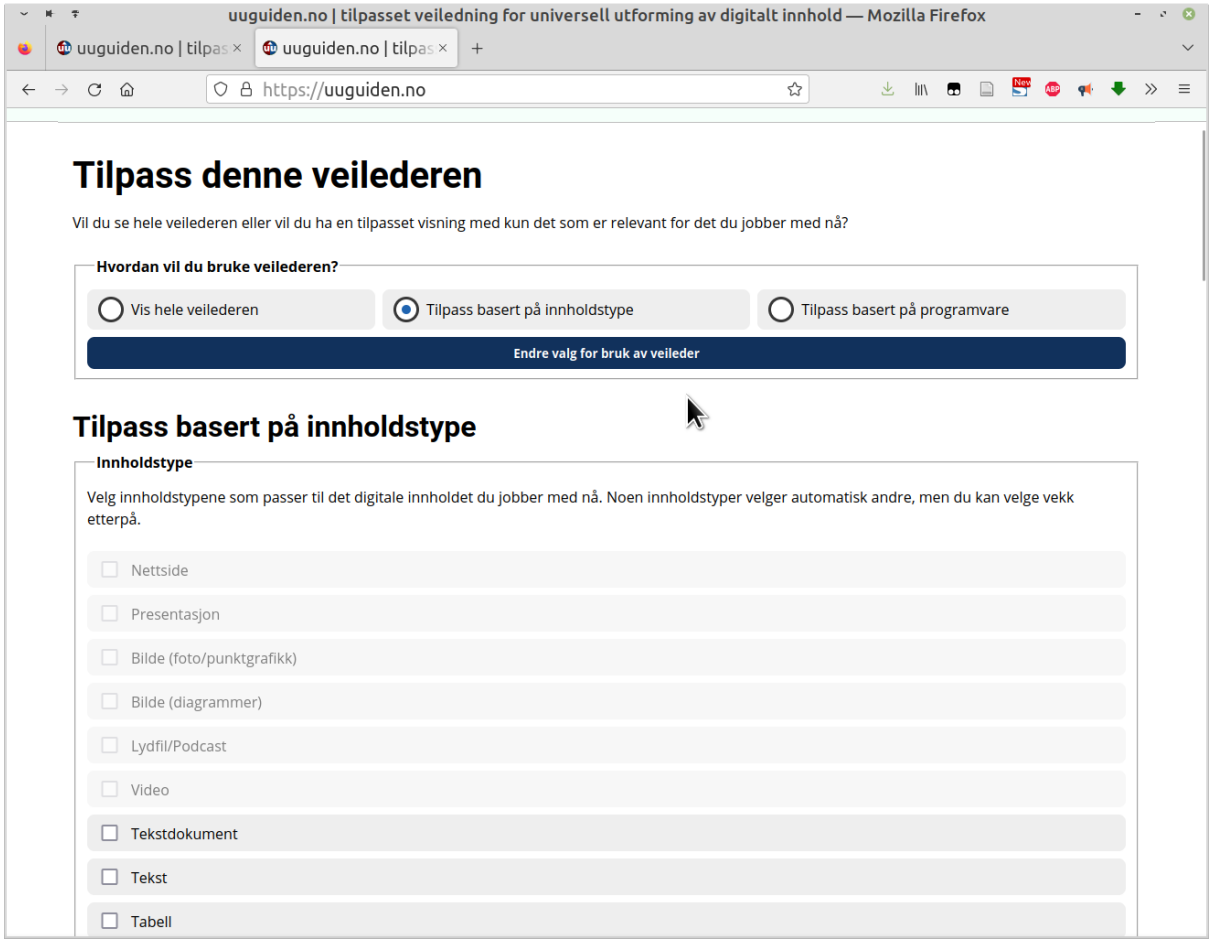


Figure 4.8

A screenshot midway during the development of the third iteration showing the filter options "adapt based on content type".



Note. After choosing "Customize based on content-type" with the HTML radio control and confirming with the button loosely translated to "Confirm customization of the guide", the filtering options for customizing the guide based on the type of will be shown. The six topmost and greyed out form elements are placeholders which will be removed later. The bottom three are automatically generated by JavaScript based on the HTML markup in the actual guide.

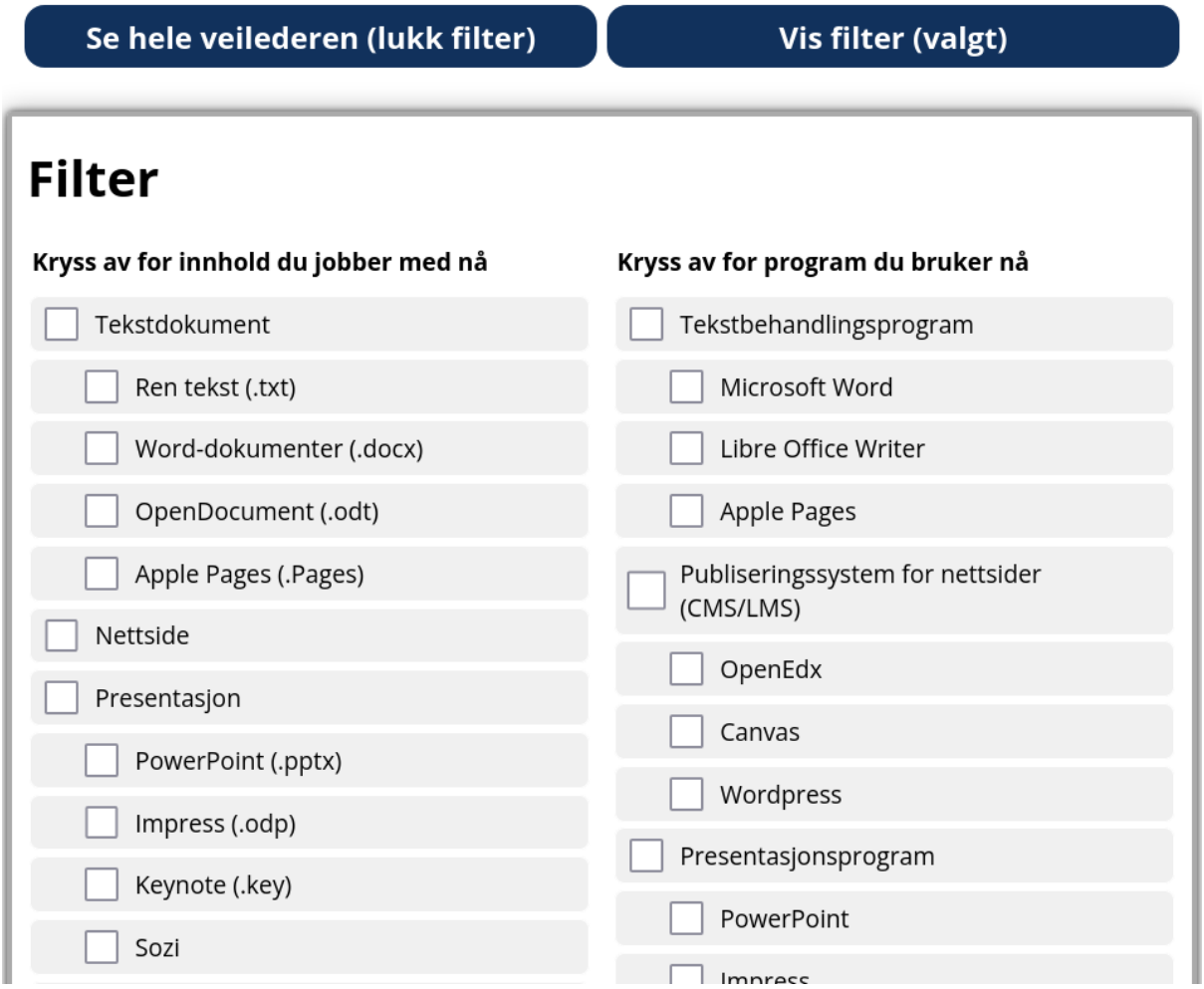
Figure 4.9

The final version of the 3rd iteration where most of the feedback from the 2nd iteration had been implemented.

Note. "How do you want to use the guide?" is followed by A yellow box with rounded corners tries to draw the user to see that there are two options: to either browse the guide for instance using the table of contents, or to get recommendations based on what the user is working on. This version implemented an automatic table of contents. To indicate that the option of browsing the whole guide was selected, the text "(selected)" was included in the button "See the whole guide (selected)".

Figure 4.10

The filter options which appear when the button "Show filter" is clicked. The text ("selected") now has moved to the button "Show filter".



Note. There are two columns in the filter options: one for content you're working on and one for applications your'e using now. For content, the main categories are text document, webpage and presentation. Text document has sub-items such as plain text, word documents, open document and apple pags document. Presentation has sub items such as powerpoint, impress, keynote and sozi. For applications you're using the main categories are text editor (word, libre office writer, apple pages), content or learning management system (OpenEdx, Canvas, Wordpress) and presenter (PowerPoint, Impress).

4.2.8.6 Iteration 3 feedback

The third iteration of the prototype was subject to more extensive evaluation than iteration 1 and 2. Here a total of 6 participants from group 2 participated in usability testing, semi-structured interviews, as well as completing a SUS survey, in addition to 4 participants in group 3 participants who were tasked with trying to use the guide to improve digital content in files.

4.2.8.7 Iteration 4 work

Work on iteration 4 is in progress, based on the findings of evaluating iteration 3.

4.3 SUS usability scores

Table 4.4

Evaluating the usability of iteration 3 of the online guide with SUS scores from the three different groups. Below the SUS scores is a parenthesis with corresponding adjective rating as described in (Bangor et al., 2009)

Group	Min	Max	Median	Mean	Standard deviation
Group 1 (N=2)	65.0 (Good)	87.5 (Excellent)	-	76.3 (Good)	16.0
Group 2 (N=6)	50 (Poor/OK)	82.5 (Excellent)	77.5 (Good)	70.0 (Good)	15.7

Group	Min	Max	Median	Mean	Standard deviation
Group 3 (N=8)	42.5 (Poor/OK)	82.5 (Good/Excellent/Best Imaginable)	61.3 (OK/Good)	63.1 (OK/Good)	15.2
Group 2 and 3 (N=14)	42.5 (Poor/OK)	87.5 (Good/Excellent/Best Imaginable)	71.3 (OK)	67.3 (OK)	15.2

Note. The interpretation of the SUS adjective rating scale used in *this* report is that if a SUS score is within one SD of the adjective word (see Table 4.5), then that adjective can be used to describe the SUS score. This means that the adjective rating scale items are interpreted not to be mutually exclusive for a given SUS score. Some values of SUS scores will fall within reach of two or even three adjective words. The SUS scores and SUS adjective rating scale should only be used as an indication of overall usability.

See 8.1 in Appendix 1 for the raw SUS scores, as it is to large and wide to include in portrait mode.

4.4 Qualitative data analysis from usability testing, interviews, and surveys

4.4.1 Background

Table 4.5

Software and tools used by participants

Software/tools used	Participants

Windows OS	P1, P4,P5,P7,P8,P9
MAC OS	P2,P3,P8,P17
Unknown OS (Didn't ask)	P6?, P10-16
Word	
PowerPoint	P13
Canvas	
Moodle	P4
Wordpress	P3, P5
OpenEdx	P3, P13
WAVE	P5
Accessibility Insights	P5
A11Y	P4
Site Improve	P5
Adobe InDesign, Illustrator, Acrobat Pro	P8
Camtasia	P5

4.4.2 Content of interest

Table 4.6

Topic/content of interest

Topic or content of interest	Participants who mentioned this
Webpage	P3, P4, P5, P13
Would like to understand more about how Assistive Technology such as a screenreader works, how and when images are read out loud and what will happen depending on an image having alternative text, being marked decorative or not.	P3, P5
Video and captions	P5
Infographics	P8
Multimodal content on the web	P3
How to write good text alternatives for images and more in depth how text alternatives works for images	P3, P5, P8
Would like to see some HTML code examples (for use in source editors in LMS)	P3, P4, P5

Several of the participants reported an interest in better understanding of Assistive Technology (AT) and how it works:

P4 noted: “Document structures for accessibility and Assistive Technology... Do you have anything more about Assistive Technology?”

P8 was interested in infographics:

> But it is a little exciting, maybe that about infographics. Maybe, because I think it is a little challenging myself. How to visualize data. Because there is a lot here and I just have to mention that one thing is the technical aspect. In my work I mostly work with the visuals, right? How to present such things (P8)

4.4.3 What worked well

In general, participants thought the online guide was clear, and simple to use. The table of contents gave an overview of the content, and the guide listed most things which is important to remember when creating accessible content. Some participants commented that the filtering functionality was welcome so that the displayed information could be minimized. Other participants felt that they didn't need the filter options because they preferred to use the table of contents instead since they felt that there was not yet so much content that they needed to filter it.

P8 found that the filtering functionality to display content based on chosen options in the filter worked as expected, expect some options that had no content yet in the guide. P8 had selected infographics, powerpoint and canvas to test how the filter worked and couldn't find any Canvas related content in the filtered guide. When informed that there wasn't any content about Canvas yet, P8 responded:

"Well, OK, then it's fine. The rest is ok. I can see that the content I was expecting to find is there."

4.4.4 Improvement potentials

4.4.4.1 User experience (UX) issues

Placement of menus and filters was discussed by several of the participants, and some would expect them to be on the left side of the webpage, always visible. That the filters should be always visible on the webpage was suggested by P8. That the menu should be visible on the left side of the webpage was suggested by P9. As P9 noted, the principle of recognition rather than recall should be considered, which is one of Jacob Nielsen's usability heuristics. This principle refers to not forcing users to remember things that are out of sight

(recall), but instead allowing users to recognize, for instance that menu items should be visible or easily retrievable when needed (Nielsen, 2020).

Some of the participants were confused when trying to activate the filter settings because they could see no change after clicking the “Activate Filter” button. For instance, after clicking this button once and not observing any change to the page, P4 noted: “Yes… then I’ll click one more time. Then I thought it would just disappear and that I just … Yes. I had thought that it (the filter options) should disappear, and that this (updated TOC and contents) should appear”. P5 also experienced unexpected behaviour when trying to click the “Activate Filter” button. After trying to click three times on the button P5 said “Nothing happened here!", and tried again before confirming again that nothing happened.

4.4.4.2 Organisation of the guide contents

P8 would have preferred if the different topics were organized under software/applications because that matches the way P8 works, instead of organizing different applications under topics.

> I would have organized it per application/software in some way. Now, there are different types of programs, of course, such as text editors presenters and things like that, but I think I would have liked to have it within those. For Word, for instance, what is good to know when making a word document universally designed. Maybe that would be easier to relate to (P8).
>
> I thought that if for instance the topic is table, then there can be written first something general about tables, then followed by specifics about tables in different programs or types of documents (Researcher)
>
> That’s just two ways of categorizing then. I would still expect to find it under software, I guess, because that’s how I work. It is certainly possible to think that there are other ways of doing it. Clearly. (P8)

4.4.4.3 Topics not adequately covered by the guide

Some topics that participants asked about did not yet have enough information in the guide or links to relevant information. This included topics such as more details related to image

text alternatives, working with tables in HTML source editor in an LMS, and the best way of captioning videos.

P4 asked about guidance to work with tables in a web based HTML source editor and the guide only had general information about tables and links to Microsoft 365 Customer support about creating tables in their Office suite: “Content to improve… Yes, then as I am sitting here, I was thinking a little about tools. And we were at table”.

P5 was unsure what was best of burnt in captions or closed captions:

> Yesterday we had a problem related to video and Universal Design when I made a film with Camtasia that was supposed to be on Facebook. (…) Then I was thinking. Should I have “burnt in captions” or should I create closed captions? What is best from a UD standpoint? (P5)

4.4.4.4 Content which should not be the focus of the guide

P8 noted that while it is nice to write about the fact that there are more than 2 billion people in the world who are blind or have a form of vision impairment, it might not be the appropriate place to write it (in the introduction to the section about visual impairments under “Images”, and suggest that it might be better to have background information in an ingress to the website or a separate webpage on the website, and let the guide part of the website be more like a toolbox.

> In relation to the categories, I am thinking like this. What are things supposed to be? While it is good to say that we know that 2 billion people in the world (pauses) but is it appropriate to have it there? Or should it rather be just an introduction or ingress to the whole website, and that the website is more of a toolbox, rather than an explanation to a background story. But that depends a little on what you have thought that this website should be. Of course, it’s possible to have both, but then I would prefer that one (page) is the toolbox, and the other is just an informational page (P8).

4.4.4.5 Links and instructions needed for GUI of Norwegian and English language

P8 missed this, and it was also mentioned by PX who tested the guide to attempt improving the accessibility of documents that the instructions had to be translated to find the appropriate settings in the GUI which was in a different language than the instructions from Microsoft 365 customer support.

4.4.4.6 GUI organisation of the guide

P8 was expecting the filter to appear on the side beside the contents:

“It’s supposed to be on the side, you’re thinking?”

4.4.4.7 Typography settings

P9 commented that the line spacing seemed very small and should be higher:

“I’m not sure about the line alignment. It looks very small or narrow to me.”

P9 also noted that there seemed to be too little visual distinction between the different heading levels so it made it difficult to see which headings belong to which headings.

> But then I think the heading like the headings do not seem to be very clear like which heading it belongs to because right now I think it's just slightly different between the font-size and perhaps some bold and not bold, yeah (P9).

P9 also suggested numbering headings:

“Or even use numbering to assist the users in terms of navigating”

4.4.4.8 Text alternatives for images

Several participants would like to know more about describing images well.

P3 would like to see some examples of how to describe images in practice and stated:

I can’t talk for others, but I do think that it is a difficult subject (to describe images well with text alternatives). And I know that in my workplace, there’s a lot of colleagues who come to me to discuss when they think that things are difficult (when working on accessible digital

content). So if I think it is challenging, then I am quite sure that they also think that it is challenging (P5).

P8 would like some more examples when describing images:

> Here I am afraid we haven't got it all covered. There will be a lot more to write here, because this is just a simplification. You often need to make case by case considerations. And that might not be so easy. This is a checklist, but will only give instructions up to a certain point, and then you just have to try and apply it to what you want to create (P8).

4.4.4.9 The guide should be more practically oriented Using images or pictures to illustrate how it's done

Several participants would like to see more practical examples of how to solve different accessibility tasks in practice. Suggestions included using images, or short introduction videos, and even more advanced HTML code examples to show how it's done and also why it has to be done.

P3 suggested using expandable/collapsible examples using screenshots in the guide:

"Could it be screenshots maybe? Look here's an example. Expand, and then gone."

P9 suggested to use images when showing how to do things in practice:

> One last thing, perhaps I would just comment like in very general. Is that for people that would not have the expertise. Mainly it's difficult for them to understand what it means without pictures or images that should demonstrate how things should be done. For me, if it's a user guide you have pictures to guide the users how to do things (P9).

P6 would like the option to see *short* introductiory videos for different topics, explaining why it's important and how you do it.

P12, who was assigned to the group 3 with testing the online guide and trying to improve files which were to be submitted to document inspection, complained that the guide was not practical enough.

> The guide really only appears as a simple text document with some links. Not very practical. I got a little discouraged about using this site and ended up not using it. (…) What does this guide really add, in relation to Microsoft's own guidelines and UU-tilsynet (P12).

P3, who was working with multimodal content for use in LMS missed more practical and advanced HTML code examples related to short or long descriptions of images. P3 was quite knowledgeable about UD of digital content, but thought it was a bit confusing how and when to use an image's alt-attribute or aria-describedby attributes in HTML source code.

"Yes, because that's sort of what I was missing. Like, how do you do it technically? Yes, what does an alt-tag look like, or what does aria-describedby look like"

4.4.5 Learning outcomes

In this section, topics which participants learned when testing the online guide are discussed. These topics were learned either from the online guide, from the external links found in the online guide, or from the discussion in the User Testing sessions in the case that the topic was missing from the online guide.

4.4.5.1 Creating the tables correct in Word

During the User Testing Pilot, P2 was asked to create a table and use the online guide for assistance. P2 began creating a table using old habits, which had some accessibility problems, and was then asked to see if there was more help or information offered by the online guide. After being encouraged to check out the links to Microsoft 365 customer support about creating accessible tables, P2 was able to improve the accessibility of the table, but the table was still not able to pass all the accessibility checks for tables mentioned in WCAG. After being encouraged to see if the video on the Microsoft 365 customer support page could help, P2 learned a lot if a short amount of time and was able to create a perfectly accessible table. P2 noted soon having to contribute writing a large report with many tables and was happy to have learned the techniques to create accessible tables which would be put to use very soon.

4.4.5.2 Checking and setting the language

This was not covered by iteration 3 of the online guide, but was addressed by me during a User Testing session when P4 had some unanswered questions. P4, was working on courses that were translated to several languages in a Moodle installation, which is a Learning Management System as known as a LMS. Moodle has a plugin called Multi-Language Content which is used for translating content, and content is marked up like this:

```
{mlang no,se} This sencence will only be shown if the chosen language in the GUI is either Norwegian or Swedish. {mlang}.
```

P4 was unsure how to check if the Moodle LMS correctly applied the right language so that the content would be read out loud right using a screen reader. P4 also wondered how to show text from multiple languages at the same time.

As this was not covered by iteration 3 of the online guide, P4 was shown how to check for the correct language by inspecting the HTML code in the browser to verify the lang-attribute of HTML, and also how to override the language for parts of a website by overriding the HTML lang attribute on any descendant element.

4.4.6 Thoughts about getting help when working with UD and digital content

When asked about this question in the interview, P3 commented that:

“I think that this UD guide is extremely timely now that the requirements are only being tightened, and inspections are going to increase. This online guide can’t come fast enough. So this is important work!”

4.4.7 Challenges experienced when working with UD of digital content

Some participants expressed needing someone to be able to ask when having challenges with UD of digital content, or to be able to ask or be told what tools are good to use and to get support on those tools: P5, P6,

Some participants complained that there is no central UD of ICT responsible in the IT-departement.

> In a way, there's nobody who own the responsibility at the IT-department about… in our department it is us in the department who run the website. It is OsloMet's webpages. But who is ultimately responsible? It is us in the department (P5)

4.5 Heuristic review/accessibility inspection

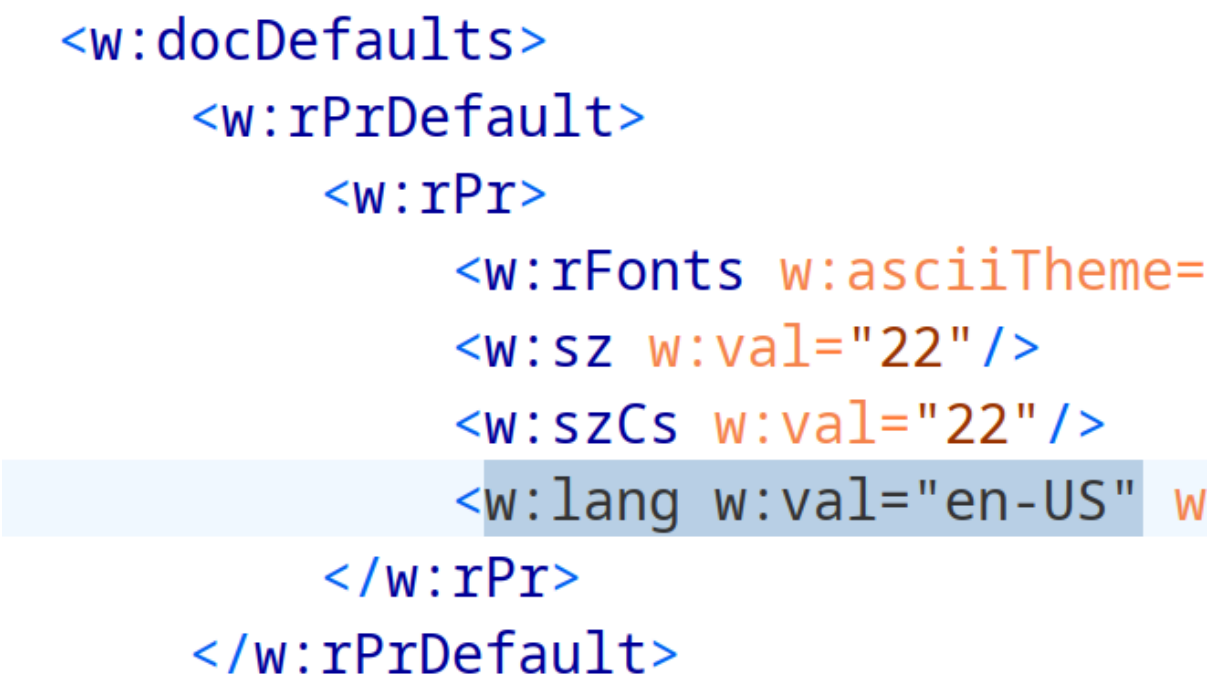
Eight participants participated in group 3, where they were asked to use the online guide to try and improve the accessibility of their files, and submit the before and after versions of these files using an online form. The before and after versions of these files were made available for document accessibility inspection. Source files and PDF-files before and after using the online guide to try and improve the files were collected in an online form. In total, 14 DOCX files, 2 PPTX files and 14 PDF files were analysed for accessibility issues. Word and PowerPoint files were analysed using the Accessibility Checker built into Microsoft 365 as well as manual checks. PDF-files were analysed using the Accessibility Checker in Adobe Acrobat Pro, as well as the command-line program exiftool.

To inspect the language in PDFs, it's possible to use exiftool or look at document properties in Acrobat. To inspect the language set in a .docx file or .ppt file, there is no option to view it in Microsoft Office 365 (although there is the option to set it by applying a proofing language to selected text).

DOCX files and PPTX files use the Office Open XML (OOXML) file format, which is the XML file format used for Microsoft Office documents. This is a zipped folder structure with subfolders, XML files, text files and media files such as images if those are in the document. In lack of a good tool to inspect the language of OOXML files, the contents were inspected to find the language set in the internal xml.

Figure 4.11

Locating the default language in a word file by first unzipping the word file, then inspecting the at the internal path: word/styles.xml in a XML editor at the XPath location: w:styles/w:docDefaults/w:rPr/w:lang



This default value is then overridden other places such as in word/document.xml for content with other language than the default value.

All the OOXML files (DOCX and PPTX) files inspected had defined a default language, although some of the files had wrong language defined compared to the actual text in the document.

In the case the exported PDFs where language was not reported in the metadata, it's likely due to a mistake during the PDF export. There are many ways of creating PDF files from Word or PowerPoint source files, and unfortunately several of the possible ways of performing the PDF conversion will result in data loss of important Accessibility data which is present in the source document.

Code example 4.1

Extract a docx file, which is a zip archive, on the commandline in a linux terminal and look for language attributes within the text files inside the unzipped docx file.

```
mkdir file.docx_FILES
cd file.docx_FILES
unzip ../file.docx
cd word
grep -i < styles.xml ‘lang’ # default language is found in styles.xml
grep -i < document.xml ‘lang’ # search only in the document main file
grep -inr ‘lang’ # to search in all files in the document archive
```

4.5.1 Data from document accessibility inspection

During the document accessibility inspection, all types of accessibility issues that were identified, were reported, including both the types of accessibility issues which were covered by the online guide, the built in Accessibility Checker of Microsoft 365 programs, as well as many issues which were not covered by the online guide or the built in Accessibility Checker in Microsoft 365 programs.

Accessibility improvements of the changed files were found in areas such as text properties, headings and images.

The improved text properties included correcting text alignment, choosing a sans-serif font which is more readable over a serif font, fixing text contrast issues and not using only colour to convey information.

The observed improvements in headings was one participant who learned to use a heading, when there were none before.

The largest observed improvement was seen with the accessibility of images, where 5 of 7 of the participants who had images in their documents were able to provide text alternatives to their images where there were no text alternatives before. At the same time, the document inspection revealed that getting image descriptions right is something that several of the participants struggled with. Some cases were discovered where the image should have been marked as decorative but was described with alt text instead. Also phrases such as “image-of” “logo-of” were sometimes included in the alternative text. While

this can be a little annoying and unnecessary as a screen reader would read “Graphic, image of…”, it is better than no alternative text. Some images which had got alt-text which weren’t there before had text which was not properly described. This suggests that the online guide should provide more details about how to describe different types of images.

Tables was another topic which was covered in the online guide, but for the tables that had issues, there were little improvement. Two of the participants had issues with all their tables. One participant found and corrected the contrast issues in all the tables. The problems that weren’t fixed with tables was missing heading row and split or merged cells. This was mentioned in a checklist in the online guide, as well as a video that the online guide refers to from Microsoft 365 customer support.

The built in Accessibility Checker in Microsoft 365 does report table issues such as split or merged cells, but not the issue of missing table row, and it is also worth noting that if a user defines a heading row in a Word table, and afterwards changes the Table Style, then Word will unmark the table heading row. This seems to be a bug with the Word software, so it is possible that a user has remembered to mark a row as a heading row, but that it later has been undone.

A participant who was not part of the document inspection in group 2, but took part in the data collection pilot of the user testing session was asked to create a table as an assignment. The table had issues such as no headings in the first table row, didn’t know about defining table header row, and used merged cells in the first column to create headings to describe the following columns. After being encouraged to follow the links in the guide to Microsoft 365 customer support and then again being encouraged to watch the video about creating accessible tables from Microsoft 635 customer support, the participant was able to fix all the table issues.

Details regarding document inspection raw data of accessibility issues before and after using the online guide can be viewed in Table 4.7 found in Appendix 1 due to it being a large table which doesn’t fit in portrait mode.

5. Discussion

It is argued that the Web Content Accessibility Guidelines (WCAG), while being a valuable tool for governments, is only a first step towards accessibility and that real accessibility, as opposed to only compliance with the guidelines, can only be achieved through user-centred design. (Ribera et al., 2009).

My contribution is using a Human Centred Design approach to develop and evaluate an online guide, which builds on the principles of the WCAG guidelines, but where the guide is organised around the different types of content which creators are working with as opposed to being organised around the principles of WCAG 2.0 which are perceivable, operable, understandable and robust

The goal of this study was to help content creators in higher education create accessible digital content and get a better understanding of their needs. There are mentions in the literature that content creators in higher education lack the time, knowledge and support needed to create accessible digital content (Langørgen & Magnus, 2018), and (Shinohara et al., 2018).

In this study, an attempt is made to develop an online guide that content creators can use to help themselves create accessible digital content.

The organisational approach of the guide is based on different types of content, which is a little different from WCAG which is based around the principles: perceivable, operable, understandable, robust. The approach of the online guide is to try and help the user to find relevant information about making accessible, the type of content or type of document the user is working on. The main idea is that the user is working on some type of content or document, and the guide attempts to present relevant information on how to make it accessible.

This guide is being developed both with the intention of helping content creators create accessible content and also by testing it on real users to gain greater insights into the content creators' needs and expectations.

A mixed methods approach was chosen. A Human Centred Design was chosen for the development to include real persons' perspectives in the development of a prototype online guide. Involving real users throughout the design and development of systems can ensure that the system being developed stays within users' needs and expectations. After three iterations, the prototype was tested more extensively using a combination of qualitative and quantitative data collection.

Participants evaluated the prototype in User Testing sessions while being observed, which were followed up by a SUS survey used to get a quick measure of the usability and semi-structured interview. The strength of this approach is that even if there weren't many participants in the User Testing (only 6 participants in User Testing), deep insights could be gathered due to the combined use of different qualitative data collection methods, such as observing real users and semi-structured interviews. The SUS scores can indicate how well the online guide compares to what is expected of websites. The qualitative data collected give deeper insights into important questions: What are the users' challenges when creating accessible digital content? What do content creators need from an online guide which is meant to assist them in creating accessible digital content? How should the online guide be developed further? What needs to be added to the online guide? What is problematic with the online guide the way it is right now? What works well and should be kept? Is it an appropriate approach to design an online guide to help content creators create accessible content, and if it is, then what should the online guide be?

A limitation of this study is that due to the time constraints of the project's duration, the online guide still needs to mature enough to reach its potential. However, it has enough content to have successfully been the focal point of evaluation, scrutiny and discussion, allowing a better understanding of what the guide should be in the future to meet content creators' needs when creating accessible digital content.

The goal of qualitative usability studies, which this study is an example of, is usually to find out what doesn't work with a system, then fix it and move on to a new and better version, which in turn also will be tested, improved and so forth (Budiu, 2021). The chosen approach's strength is to get insights into how the online guide should be developed further. According to Jacob Nielsen, testing with five users is enough to discover most of the issues

with a system. Nielsen argues that the best results come from testing at most five users and running as many small tests as possible. Therefore, although the number of participants is small, it is enough to identify most of the issues with the current version of the online guide (Nielsen, 2000).

In-depth data were gathered from participants in group 2, who took part in User Testing sessions while being observed, semi-structured interviews, and from participants in group 3, who, after trying to improve their files, were asked to complete an online survey which also included some open-ended questions. These survey questions were similar to the questions used in the interview guide for participants in group 2. These qualitative data have given insights into participants' needs and expectations. It was necessary to measure how effective the current version of the online guide could support content creators in creating accessible digital content, as this could validate the study.

This was done with participants in group 3, who were asked to submit files before and after using the online guide to try and improve accessibility while relying on the online guide. The files submitted were thoroughly subjected to an accessibility inspection, and all discovered accessibility issues were reported. Participants in group 3 used the same version of the online guide as the one used by participants in group 2, who participated in usability testing and semi-structured interviews and scored the online guide using the same SUS survey. A few optional questions, similar to the ones in the interview guide, were included in the survey for group 3 participants to allow them to give relevant feedback if they chose to. See Appendix 7 for more details about these questions.

As discussed earlier in the results, the accessibility improvements the participants made in their files when using the third iteration of the online guide weren't very impressive, but there were some improvements. The version tested of the online guide didn't cover all possible accessibility issues. Some of the participants had yet to improve on all of the issues covered by the guide after having used it. This could partly be explained by how motivated the participants were and how much time they were willing to spend testing the online guide and improving their files in a busy life. At the same time, these data suggest that the online guide has potential but needs further improvement. In the interviews, several participants mentioned that they liked the idea or could see the potential but would like

more practical examples with images and short videos in the online guide to make the content easier to understand.

Methodology-wise, seeing what accessibility mistakes people make in their documents and which of these they can fix after using the online guide makes sense. Of course, there are other alternatives, such as observing users while they work on their documents using the online guide as a reference, but this approach also has some drawbacks. Observing participants working on their documents is more time and resource-consuming, so this approach would have to be scaled down to how many participants it's possible to follow up given the resources available. Also, observing a participant in the same room is impossible without affecting the participant and introducing bias. Allowing the participant to work undisturbed in their work environment, at their own time and pace, mitigates the observer effect (the fact that observing a situation or phenomenon changes it). Therefore, it was decided to let the participants in group 3 work on their content without being observed. A limitation of the results from the document inspection is that there were only 8 participants and a total of 30 documents inspected, which is not enough to generalise findings.

6. Conclusion and future work

In this project, an attempt was made to design and develop an online guide with the purpose to help content creators create accessible digital content. The online guide was evaluated using a mixture of qualitative data collection (user testing, observation, semi-structured interviews and open-ended survey questions), and quantitative data collection (SUS survey and an accessibility inspection of documents before and after participants accessed the guide).

There is consistency between findings from group 2 who participated in user testing and semi-structured interviews, and group 3, who participated in testing the online guide to try and improve their documents which were analysed before and after using the guide.

Feedback from participants and data collected suggest that there is potential in an online guide such as this to help content creators in creating accessible digital content. Also, some changes and improvements need to be considered, both to the user interface, the content and the presentation of the content. Several of the participants expressed that they would like to use a website such as this, provided that it is further developed, more content added, and that content is also presented in alternative ways such as images, image carousels and short introductory videos, allowing the user to use the content according to the user's own preferences.

Needed improvements to the user interface include some improvements to the typography such as increased line spacing, better separation of sections making different levels of headings more distinct.

The organization of the content and the filter in the guide in iteration 3 does have some issues which have been pointed out by several of the participants. Going forward, I believe a good start is to look at the suggestions made by different participants and implement those. To address the organisational issues of the content of the guide, one approach could be to recruit some new participants for card sorting activities. Card sorting is a low cost and low tech UX research technique where users organise topics in groups that they think belong together. It can be used to improve the information architecture of a system (Sherwin, 2018).

Then the online guide can continue to be improved by following the iterative evaluation and development cycle based on the Human Centred Design approach while making sure to involve representative users doing representative tasks. There could also be a feature of the online guide where users could submit files for document inspection using an online form after they have tried to use the guide to improve their documents. The user can get a human expert's advice about what they need to think about when creating digital content. At the same time, these results could be used to evaluate what works well with the online guide, and to decide the next issue which needs improvement.

One interesting suggestion for future work made by several participants was the possibility of a chat box functionality, possibly driven by a context aware Artificial Intelligent system with Natural Language processing. In the chat, the user could be asked what type of content the user is working with, and then be referred to the relevant parts of the guide. Then if the user has a problem understanding some parts of the guide, the user can ask questions in the chat box again and get more detailed answers. With the latest developments in AI and Natural Language Processing, I believe this is something which is possible to implement using already existing technology, given enough time and resources.

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8. Appendices

The following appendices have been included in this report:

Appendix 1– Large result tables

Appendix 2 – Information letter

Appendix 3 – Interview guide

Appendix 4 – SUS survey

Appendix 5 – Open ended questions for document inspection group participants

Appendix 1 – Large result tables

SUS raw scores

Table 8.1

SUS raw scores for participants in group 2 and group 3 with one column added showing the Mode (M) – most often given score, for each of the questions.

Q	M	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
Q1	4	4	5	4	4	3	4	4	5	2	4	3	4	4	3
Q2	4	2	2	3	2	2	2	3	2	4	4	2	2	4	4
Q3	4	2	3	3	4	4	5	4	4	2	3	4	4	2	2
Q4	3	2	1	3	3	1	1	3	2	3	3	1	1	4	2
Q5	4	2	4	2	4	3	4	4	4	3	4	4	4	4	3
Q6	2	2	2	4	2	2	1	2	4	2	3	1	1	2	2
Q7	4	2	5	2	4	5	3	4	4	3	4	5	4	3	4

Q	M	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
Q8	4	4	2	2	1	1	2	3	1	4	2	2	1	4	4
Q9	4	3	4	3	4	4	4	4	4	4	2	3	4	4	3
Q10	2	3	1	2	2	1	1	2	1	4	3	2	2	4	1
SUS Score		50.0	82.5	50.0	75.0	80.0	82.5	67.5	77.5	42.5	55.0	77.5	82.5	47.5	55.0

Note. P4 – P9 participated in Group 2 (user testing, interviews and SUS survey). P10 – P17 participated in group 3 (document inspection of files before and after using the guide to try and improve accessibility, and an online survey). Lowest/highest scores and measures of central tendency: SUS Score (min) = 42.5, SUS Score (max) = 82.5, SUS Score (median) = 71.3, SUS Score (mean) = 66.1, SUS Score (standard deviation) = 15.2

Accessibility issues found when inspecting documents

Table 8.2

Accessibility issues found when inspecting documents. The columns P10 – P17 refer to participants in the document inspection of files before and after using the online guide to try and improve the accessibility. The column "AC covers" indicates if an automatic accessibility checker such as the built in Accessibility Checker in Microsoft 365, or in the case of PDF, Adobe Acrobat Pro's PDF Accessibility Check will catch this issue. The column "Guide covers" indicates if this issue is covered by the version of the online guide which was tested or not (iteration 3). During the accessibility check, all types of discovered issues are reported, also the types of issues that weren't addressed by the online guide. For each participant the numbers are given as before/after, so a number given as 4/3 means that the file created before using the online guide had 4 errors of this type, while the file modified after using the online guide had 3 errors of this type. "0/0" means that no errors of this type was found in the files before and after participant had access to the online guide. Sometimes values are given as percent to indicate the relative amount of the document that had this problem. Where there are changes between before and after, this has been highlighted using bold text and yellow marking. N/A, when used, means "Not Applicable".

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Source document type	-	-	docx	docx	docx	pptx	docx	docx	docx	docx
Exported document type	-	-	pdf	pdf	pdf	-	pdf	pdf	pdf	pdf
Issues with title in properties	N/Y*	N	0/0	0/0	1/1	0/0	1/1	1/1	1/1	1/1

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Title not set in document properties	N/Y*	N	0/0	0/0	1/1	0/0	0/0	1/1	1/1	1/1
Title set in document properties is wrong	N/Y*	N	0/0	0/0	0/0	0/0	1/1	0/0	0/0	0/0
Issues with document language	N/Y	N	0/0	1/1	1/1	0/0	1/1	1/1	1/1	1/1
No language specified in export (pdf)	Y	N	0/0	0/0	1/1	N/A	0/0	1/1	1/1	0/0
Wrong language in source (pptx/docx)	N	N	0/0	1/1	0/0	0/0	1/1	0/0	0/0	1/1
Wrong language in export (pdf)	N	N	0/0	1/1	0/0	0/0	1/1	0/0	0/0	1/1
Issues with use of headings	Y	Y	0/0	0/0	17/17	0/0	0/0	11/11	**1/0**	5/5
No headings in document	Y	Y	0/0	0/0	0/0	0/0	0/0	0/0	**1/0**	0/0
Headings with wrong outline level	N	Y	0/0	0/0	15/15	0/0	0/0	8/8	0/0	0/0
Number of fake headings in document	N	Y	0/0	0/0	2/2	0/0	0/0	3/3	0/0	0/0

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Content is a heading when it should not be	N	Y	0/0	0/0	0/0	0/0	0/0	0/0	0/0	5/5
Issues with text properties	N	some	some	some	some	some	some	some	some	some
Line spacing less than 150%	N	N	0/0	0/0	Y/Y (100%)	Y/Y (100%)	Y/Y (100%)	0/0	Y/Y (100%)	Y/Y (100%)
Small text used (less than 12pt)	N	Y	Y/Y (100%)	Y/Y (100%)	2/2	0/0	0/0	Y/Y (100%)	0/0	Y/Y (100%)
Hard to read font used: serif	N	Y	0/0	0/0	Y/Y (100%)	0/0	0/0	Y/Y (100%)	**Y/N (100%)**	0/0
Hard to read font used: thin variant	N	N	0/0	0/0	0/0	0/0	0/0	0/0	0/0	Y/Y (100%)
Not recommended text alignment	N	Y	0/0	0/0	Y/Y (100%)	0/0	0/0	0/0	0/0	**Y/N (100%)**
Large blocks of text in italics	N	Y	0/0	0/0	0/0	0/0	0/0	0/0	0/0	1/1

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Headings use only capital letters	N	Y	0/0	0/0	14/14	0/0	0/0	0/0	0/0	17/17
Low contrast on text	Y	Y	0/0	0/0	0/0	1/1	1/1	0/0	**50/0**	10/10
Only colour used to convey info in text	N	Y	0/0	0/0	0/0	0/0	0/0	0/0	**50/0**	0/0
Num of images/figures/charts/objects	N/A	N/A	2	7	7	**12/8**	4	3	0	10
Images/figures/charts with issues	some	some	2/2	**7/6**	7/7	**12/3**	**4/0**	**1/0**	N/A	10/10
Issues with images/figures/charts	some	some	**5/6**	**25/16**	14/14	**15/6**	**4/0**	**1/0**	N/A	32/32
Images missing alt-text	Y	Y	**2/0**	**2/0**	7/7	**5/0**	**3/0**	**1/0**	N/A	10/10
alt-text does not describe appropriately	N	Y	**0/2**	4/4	0/0	**2/0**	**1/0**	0/0	N/A	0/0
alt-text contains “image-of, logo of” etc.	N	N	**0/2**	**5/4**	0/0	**0/3**	0/0	0/0	N/A	0/0
Image contains text which is not described	N	Y	2/2	**6/4**	0/0	0/0	0/0	0/0	N/A	10/10

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Image marked decorative when it shouldn't	N	Y	0/0	**0/1**	0/0	0/0	0/0	0/0	N/A	0/0
Image not marked decorative when it should	Y	Y	0/0	0/0	0/0	**1/1**	0/0	0/0	N/A	0/0
Image should be marked decorative but has alt-text instead	N	Y	0/0	0/0	0/0	**4/0**	0/0	0/0	N/A	0/0
Only colour is used to convey information	N	Y	0/0	1/1	0/0	0/0	0/0	0/0	N/A	0/0
Images with colour contrast issues	N	N	0/0	1/1	0/0	1/1	0/0	0/0	N/A	0/0
Image with hard to read text (serifs, small, blurry, or contrast issues)	N	N	0/0	4/4	0/0	1/1	0/0	0/0	N/A	10/10
Image/graphic not inline	Y	N	**1/0**	**2/0**	7/7	0/0	0/0	0/0	N/A	2/2
Issues with lists (fake list)	N	Y	0/0	0/0	0/0	1/1	0/0	0/0	0/0	0/0
Number of tables	N/A	N/A	1	7	0	0	0	0	0	3

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Tables with issues	N/A	N/A	0/0	6/6	N/A	N/A	N/A	N/A	N/A	3/3
Issues with tables	some	some	0/0	9/9	N/A	N/A	N/A	N/A	N/A	37/37
Table missing table caption	N	N	0/0	0/0	N/A	N/A	N/A	N/A	N/A	0/0
Tables without defined header row	N	Y	0/0	2/2	N/A	N/A	N/A	N/A	N/A	3/3
Use of merged or split cells	Y	Y	0/0	4/4	N/A	N/A	N/A	N/A	N/A	31/31
Large or complex tables which should be reorganized or split up in smaller tables	N	Y	0/0	3/3	N/A	N/A	N/A	N/A	N/A	3/3
Table styles with low contrast used	N	Y	0/0	0/0	N/A	N/A	N/A	N/A	N/A	**3/0**
Links in document	N/A	N/A	37	69	9	2	9	14	1	22
Links with issues	N/A	N/A	1/1	2/2	9/9	2/2	2/2	14/14	0/0	22/22
Issues with links	N	N	7/7	9/9	26/26	2/2	2/2	4/4	0/0	44/44

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
Links with contrast issues vs background	Y	Y	0/0	0/0	0/0	0/0	1/1	0/0	0/0	0/0
Links without underline	N	N	2/2	2/2	7/7	1/1	0/0	0/0	0/0	22/22
URL which should be a link but is just plain text	N	N	0/0	2/2	0/0	1/1	0/0	0/0	0/0	22/22
Broken/non functioning links due to being split by whitespace character	N	N	0/0	0/0	6/6	0/0	0/0	0/0	0/0	0/0
Link (in body text) doesn't have meaningful text. Reference-links are not counted here.	N	N	1/1	1/1	2/2	1/1	1/1	4/4	0/0	0/0
Link spans multiple lines (becomes an issue in pdf)	N	N	2/2*	7/7*	6/6*	0/0	0/0	0/0	0/0	0/0
PowerPoint slide specific issues	Y	Y	N/A	N/A	N/A	**6/5**	N/A	N/A	N/A	N/A
Slide missing slide title	Y	Y	N/A	N/A	N/A	1/1	N/A	N/A	N/A	N/A
Slide doesn't have correct reading order	Y	Y	N/A	N/A	N/A	**5/4**	N/A	N/A	N/A	N/A

Accessibility issue	AC covers	Guide covers	P10	P11	P12	P13	P14	P15	P16	P17
PDF specific issues	some	N	1/1	2/2	**3/2**	N/A	1/1	0/0	3/3	1/1
Exported PDF is not tagged	Y	N	0/0	0/0	1/1	N/A	0/0	0/0	1/1	0/0
Exported PDF has no bookmarks	Y	N	0/0	1/1	**1/0**	N/A	1/1	0/0	1/1	0/0
Exported PDF is not PDF/A conformant	N	N	1/1	1/1	1/1	N/A	0/0	0/0	1/1	1/1

Note. Y/N in "AC covers" for title, language and appropriate nesting of headings: Microsoft 365 Automatic Accessibility checker doesn't report missing title, or missing language or problems with heading nesting for a Microsoft 365 document. Adobe Acrobat PDF Accessibility checker reports missing title, missing language or problems with nested headings in the PDF Accessibility Check.

Links spanning multiple lines are from references lists in published papers. When the document is converted to PDF and being read by a screenreader, the link will appear two times in the tab list of links.

Appendix 2 – Information letter

Are you interested in taking part in the research project "Supporting content creators in creating accessible digital content in an educational context"?

Purpose of the project

You are invited to participate in a research project where the main purpose is to investigate how to help people create universally designed and accessible digital content.

Legislation in Norway requires that digital content to be used in teaching and disseminated through websites, apps, digital learning platforms is accessible/universally designed. This means that the content must be accessible to everyone as far as is practically possible. Users shall not be excluded from the content if, for example, they have a functional impairment or are dependent on various aids when using the content. Most people who work with digital content intended for teaching are aware of this. Exactly what this entails, and how to create universally designed and accessible digital content, is something that many are unsure of how to solve in practice. Although there is a lot of information about the topic that you can read up on the Internet, it is also a challenge not knowing where to start, and also being pressed for time. In this project, we develop and test an interactive universal design guide in the form of a website, which is intended to give you exactly the necessary information you need to know when creating accessible and universally designed content that meets legal requirements according to Web Content Accessibility Guidelines (WCAG) and the implementation of the Web Accessibility Directive (WAD) that applies in Norway.

Depending on the type of content you are working with, and also the type of software you are working with, the interactive universal design guide will present you with checklists, advice and information that will help you create digital content that meets the legal requirements in Norway with regard to universal design for exactly the content that you work with.

This means that the digital content you create will be able to work for the vast majority of people, including people who have varying degrees of disability, or who depend on different aids to be able to use digital content.

We ask you to test out creating new digital content, or improving digital content you have already created, from a universal design standpoint, while being assisted by an interactive universal design guide.

Which institution is responsible for the research project?

OsloMet – Oslo Metropolitan University, Faculty of Technology, Art and Design (TKD) is responsible for the project (data controller).

Why are you being asked to participate?

You have been asked to participate because you work with digital content within higher education and research in Norway and are in the age group 18-80.

What does participation involve for you?

In this project, we collect data in several ways with observation, questionnaires, interviews and expert review of digital files that you have created. Although it is useful for the project if you participate in all the data collections, you are completely free to choose which ones you want to take part in, and you can right up until the end of the project ask for access, correction or choose to withdraw the data that has come to light with your involvement.

Testing an interactive guide (web page)

If you choose to participate in this project, it means that you will create or continue to work with digital content that you have already worked on while you get access to a website with a universal design guide. This can be, for example, a word document, website, images, figures or video material. This can take up to 30 minutes.

Observation

If you wish, and give your consent, the master's student who is responsible for carrying out the project can observe how you use the interactive universal design guide and computer program to create or work with digital content either by being in the same room, or by sharing a screen over e.g., e.g., Zoom. In that case, you can choose whether you want to work quietly, or whether you want to "think out loud". Master's student will take notes. The purpose is to assess what works well and not so well with the interactive universal design guide in relation to the task you are working on. It is not you who is assessed, but how well the interactive universal design guide works. This happens while you are working with digital content if you consent to it.

Questionnaire

If you consent to it, immediately after you have worked with the content with the help of the interactive universal design guide, you will be asked to fill in a short questionnaire digitally at nettskjema.no, or in paper form. There are 10 short questions about how easy or difficult you think the interactive universal design guide is to use. It will take you about 5 minutes to fill out.

Interview

After filling in the questionnaire, the master's student will ask you if you would like to take part in a short interview. If you agree to this, the master's student will take notes, and if you also agree to audio recording, the conversation will be recorded with a nettskjema dictaphone and stored encrypted at nettskjema.no until the audio recording is transcribed and anonymised, at which point the audio recording will be deleted. The master student will ask you about your experiences of using the interactive universal design guide to create digital content with questions such as:

- What kind of digital content did you work on today?
- Which program, operating system and, if you know, software version did you use to create digital content?
- What do you think worked well in using the interactive universal design guide to work with the digital content?
- What did you think worked less well when using the interactive universal design guide to work with digital content?

- Did you learn anything while working on the digital content, and briefly what?'
- Was there anything you missed?
- Open question: Here you can address what you think is relevant to getting help with creating universally designed digital content.

Expert review of digital content you have created

Both with, and without the assistance of an interactive universal design guide. If you agree to it, you can give the master's student access to one or a few files with digital content that you have created previously, without access to the interactive universal design guide, and in addition files that you have created or worked on when you had access to the universal design guide. The purpose of this is to be able to identify which and how many accessibility problems exist in the digital content created without or with access to the interactive universal design guide. This is to be able to highlight how effective the interactive guide is as an aid in creating universally designed and accessible content. In addition, if you wish, you will receive an expert review of digital content you have created with a summary of what should possibly be improved in the digital content from a universal design standpoint. The files that you share will not be published anywhere and will be deleted after the expert review. Only the number and type of accessibility problems without and with the use of the interactive universal design guide will be reported in the project.

Your contribution is important and can lead to the improvement of an interactive guide that you and others can use in work with universal design of digital content.

You will probably learn more about universal design of digital content.

Participation is voluntary

Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a 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

We will only use your personal data for the purpose(s) specified here and we will process your personal data in accordance with data protection legislation (the GDPR).

- Student and supervisor at the institution responsible for processing (OsloMet) will have access to raw data such as questionnaires and audio recordings from interviews.
- Data stored in nettskjema.no is anonymized, and name/e-mail is replaced with a code which is stored on a separate name list separated from other data. Data is stored encrypted in nettskjema.no. Only students and supervisors have access to audio recordings and questionnaires that are stored in nettskjema.no and only with authenticated and encrypted login.
- After an audio recording in an interview, the recording will be transcribed and anonymized, and the audio file saved with the online form Dictaphone will then be immediately deleted.
- As a project participant, you will be able to request access to which data is registered about you as long as we process personal data about you (until the end of the project before the link between the link key and your name is deleted). Until then, you can also have information corrected or ask to have information that you have contributed to deleted.

Data processor is nettskjema.no.

It will be very difficult to recognize the participants in the publication. Only type of position and faculty will be stated about respondents in the publication. Age, gender and place of work/institution are deliberately left out and are not asked about to avoid project participants being indirectly recognizable in the research.

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

The planned end date of the project is June 30, 2023. At this point, the data is already anonymised. Audio recordings of interviews are deleted earlier, immediately after being transcribed with anonymisation. After the end of the project, links between name and code will also be deleted.

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with OsloMet – Oslo Metropolitan University, Data Protection Services has assessed that the processing of personal data in this project meets requirements in data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- OsloMet – Oslo Metropolitan University via:
  - Eirik Hanssen, eirikh@oslomet.no, tel: 41 93 00 79 (student)
- Weiqin Chen, weiche@oslomet.no, tel: 67 23 86 71 (supervisor)

- Our Data Protection Officer: Ingrid Jacobsen, ingrid.jacobsen@oslomet.no, tel: 67 23 55 34
- If you have questions about how data protection has been assessed in this project, contact: Data Protection Services, by email: (personverntjenester@sikt.no) or by telephone: +47 53 21 15 00.

Yours sincerely,

Weiqin Chen (project leader, supervisor) Eirik Hanssen (Student)

Consent form

I have received and understood information about the project Supporting content creators in creating accessible digital content in an educational context and have been given the opportunity to ask questions.

I have received information that I only need to tick the points that I agree to, and that I can participate in the project with the options I consent to even if I do not consent to all the options.

I give consent:

- ☐ to participate in the testing of an interactive guide (website) to work with universally designed digital content
- ☐ to participate in observation of how I work with the interactive universal design guide where the student sits in the same room making notes while I work with digital content with the assistance of the interactive universal design guide.
- ☐ to participate in observation with screen sharing over e.g., Zoom or MS Teams, where the student observes how I work with digital content while being assisted by the interactive universal design guide. The screen sharing will not be recorded.
- ☐ to fill in a short questionnaire about my experience of how easy the interactive universal design guide is to use

- ☐ to participate in an interview with the student about my experiences and thoughts about using the interactive universal design guide
- ☐ that the interview is recorded with a nettskjema dictaphone app and stored securely on nettskjema.no for later review until the audio recording has been transcribed and anonymized.
- ☐ that the student can get access to some data files with digital content I have worked on which I can send to the student where the purpose is to find accessibility problems in the digital content before and after I have had access to the interactive guide (these files will not be published, and will be deleted after they have been examined).
- ☐ that anonymised information which has emerged with my participation can be published

I give consent for my personal data to be processed until the end of the project.

(Signed by participant, date)

Appendix 3 – interview guide

Interview guide for «Supporting content creators in creating accessible digital content in an educational context»

Hi!

Thank you for stopping by and taking the time to test the interactive tutorial. I thought we would now talk about your experiences and thoughts about using it to work with universal design of digital content and the interactive guide.

Is it okay for me to make audio recordings of the interview that are securely stored until they have been transcribed and anonymized?

Date and time:

Code:

- What kind of digital content did you work on today?
- Which program, operating system and, if you know, software version did you use to create digital content?
- What do you think worked well in using the interactive universal design guide to work with the digital content?
- What did you think worked less well when using the interactive universal design guide to work with digital content?
- Did you learn anything while working on the digital content, and briefly what?'
- Was there anything you missed?
- Open question: Here you can address what you think is relevant for getting help with creating universally designed digital content.

Appendix 4 – SUS survey

SUS survey for evaluating the guide

Key: ____

Explanation of the scale

1 = Strongly disagree

2 = Disagree

3 = Unsure/don't know

4 = Agree

5 = Strongly agree

Rate the following statements from 1 (strongly disagree) to 5 (strongly agree)

1. I think that I would like to use this interactive guide frequently

2. I found the interactive guide unneccesarily complex

3. I thought the interactive guide was easy to use

4. I think that I would need the support of a technical person to be able to use this interactive guide

5. I found the various functions in this interactive guide were well integrated

6. I thought there was too much inconsistency in this interactive guide

7. I would imagine that most people would learn to use this interactive guide very quickly

8. I found the interactive guide very cumbersome to use

9. I felt very confident using the interactive guide

10. I needed to learn a lot of things before I could get going with this interactive guide

Appendix 5 – Optional questions for group3

Open ended questions which group 3 participants (from the document inspection group) had the option of answering while submitting files in an online form for document inspection, if they wished to leave feedback (translated from Norwegian).

Feedback (optional)

If you wish to give more feedback about the website you have tested, you can do so here, or you can contact the person responsible for this form and give oral feedback if you prefer that instead.

Did you find anything in your document which you could improve the accessibility of? (optional)

Please give a short list of what (if any) you worked on improving in the document.

What worked well? (optional)

Please give short list of what you thought worked well.

Was there anything you thought didn’t work well with the online guide, or was there anything you missed? (optional)

Here you can give feedback on what worked less well or if there were something you missed from the guide.

Open question (optional)

Is there anything else you would like to bring up that might be of interest?