Noname manuscript No.
(will be inserted by the editor)

Digital assessment in higher education

Promoting universal usability through requirements specification and universal design quality (UD-Q) reviews

Miriam Eileen Nes Begnum · Rikke Julie Foss-Pedersen

the date of receipt and acceptance should be inserted later

Abstract Statistics show there is a clear relationship between higher education and employment in Norway, especially for people with disabilities. The use of digital assessment solutions is increasing in Norwegian higher education. The overall goal of this study is therefore to highlight the potential for improvement of current practices related to universal design, both for providers of digital assessment solutions and for higher education institutions. Based on a case study of practices in Norwegian higher education sector, this article reviews existing requirements for ensuring universal design in digital assessment solutions, prototypes an approach to evaluating universal design quality (UD-Q) of two major Norwegian digital assessment solutions and investigates the compliance between providers' self-assessments from interviews and UD-Q evaluation scores. The article presents two contributions; 1) an improved set of requirements for universal usability when procuring digital assessments solutions, and 2) UD-Q, a step-wise feature analysis-based expert inspection method for evaluating the universal design quality of digital assessment solutions.

Published online 05 January 2017: Begnum, M.E.N. & Foss-Pedersen, R.J. Univ Access Inf Soc (2017). doi:10.1007/s10209-016-0513-9
Download published version at: http://link.springer.com/article/10.1007%2Fs10209-016-0513-9
View free published version at: http://rdcu.be/olpu
NTNU Norwegian University of Science and Technology, Faculty of Architecture and Design, Department of Design
Teknologiveien 22, 2815 Gjøvik, Norway

NTNU Norwegian University of Science and Technology, Faculty of Electrical Engineering, Department of Computer Science
Teknologiveien 22, 2815 Gjøvik, Norway
E-mail: miriam.begnum@ntnu.no

UiO University of Oslo, USIT University Center for Information Technology
Gaustadalleen 23, 0373 Oslo, Norway
E-mail: r.j.foss-pedersen@usit.uio.no

Keywords universal design · eLearning · digital assessment · higher education · requirement specification · expert evaluation · universal usability

1 Introduction

The use of digital assessment solutions is increasing in higher education. Although eLearning systems are widely used by Norwegian universities and colleges, available research in the field is limited. However, statistics show that there is a clear relationship between higher education and employment in Norway, and disabled persons have a 4.5 times greater chance of being employed if they have higher education [1].

The purpose of universally designed solutions is to create an inclusive society [2]. The higher education sector has a responsibility to ensure that solutions procured fulfill the Norwegian law of Disability and Discrimination Act and the regulations for universally designed ICT-solutions. Preliminary findings on universal design practices in the Norwegian higher education sector indicate that the sector is aware of existing laws and regulations regarding universally designed ICT-solutions. The institutions however frequently point to the providers as responsible for ensuring adequate universal design and accessibility in digital assessment solutions.

Likewise, providers offering solutions to the public higher education sector have a responsibility to deliver universally designed digital assessment solutions according to the law, regardless of requirement specifications. The general practice appears to be that universal design requirements are not clearly defined in specifications when procuring digital assessment solutions. This seems to lead to digital assessment solutions that are delivered according to more emphasized communicated functional needs. Existing practices indicate a lack of clarity on what universal design entails for digital assessment solutions, and a lack of quality assurance and assigned responsibility for inspecting and testing solutions.

Therefore, this article proposes and prototypes a feature analysis universal design quality assessment (UD-Q) approach for assessing existing digital assessment solutions. The study conducted expert evaluations on the two major digital assessment solutions in Norway, and compared the results to quantified self-assessment of universal design quality from interviews with the providers from the two solutions. Further, the existing specification guidelines for procurement of digital assessment solutions is reviewed, and based on UD-Q results in a revised and more ambitious requirements specification for universal usability in digital assessment solutions is proposed. The study addresses four research questions:

1. Based on which criteria, and by what method could digital assessment solutions be evaluated in order to determine universal design?

2. What is the current quality of the commonly used Norwegian digital assessment solutions?
3. What is the compliance between the solution and the providers' strategies and self-assessment related to universal design and the actual quality of the solution?
4. In what ways may the Norwegian higher education requirements for ensuring universal design in digital assessment solutions be improved?

Based on these questions the study seeks to establish quality assurance practices in the development and procurement processes, as well as practices for implementation, use and maintenance.

2 The Norwegian Higher Education Sector

In 2015, there were 48 institutions in the Norwegian Higher Education (HE) sector; 1 university hospital, 8 universities, 5 state specialized universities, 3 private specialized universities, 18 university colleges and 12 other HE institutions [3]. Statistics Norway report there was 283100 HE students in Norway in the fall semester of 2015 [4] with 34.9 % of Norwegian youth within the age range 19-24 years enrolled in HE studies this semester. For the same year, The Norwegian Centre for Research Data (NSD) report the HE sector employed 42180 persons [5]. Of these, 27579 were employed at the 8 universities, with 12382 being faculty members (including all assistant, teacher and researcher positions, both part-time and full-time), 1486 at the 5 state specialized universities (830 faculty members), 1005 at the 3 private specialized universities (397 faculty members) and 10222 at the 18 university colleges (5258 faculty members). Thus, on average across all HE institutions for 2015, there are 14-15 students per faculty member (19807 faculty members and 283100 students). Looking at the number of students per full-time equivalent (FTE) for 2015, NSD reports 12.58 students per academic FTE [6].

There are few reliable statistics on the number of students with disabilities in Norwegian HE, and what is categorized as a "disability" in higher education also varies. In 2012, a survey study on educational environment was conducted across 7 Norwegian HE institutions; 4 universities, 2 university colleges and 1 other HE institution. This study also mapped aspects related to universal design. The survey had a 34 % response rate, with 8532 students responding [7]. About 1/3 of these students reported having some kind of disability, injury or chronic illness. 15 % of the respondents stated they have impairments that affect their completion of higher education. Environmental issues (such as asthma and allergies) are the most commonly reported (17 %), while 9 % report mental health issues, 5 % muscle or skeletal problems, 4 % other chronic or long-term illnesses, 3.5 % reading and writing difficulties, 1.7 % neuropsychiatric challenges (including ADHD and autism spectrum disorders), 0.7 % severe visual impairment or blindness, 0.6 % a motor disability, 0.5 % severe hearing impairment or deafness and 1 % other impairments. Based on this, 5

challenging areas are defined for Norwegian HE: 1) orientation (navigational and informational), 2) mobility, 3) focus (concentration and attention), 4) mental health and 5) healthy environment (allergy and sensory input).

A governmental initiated reorganization process was completed by January 1st 2016, merging several Norwegian HE institutions; 15 of the 48 HE institutions above are part of mergers. In 2016 there are thus 36 Norwegian HE institutions; 1 university hospital, 8 universities, 5 state specialized universities, 3 private specialized universities, 10 university colleges and 10 other HE institutions.

2.1 Universal Design Legislation

The aim of the Norwegian Discrimination and Accessibility Act [8] (DTL) is to promote equality, ensure equal opportunities and equal rights, accessibility and accommodation, and to reduce socially created barriers (as stated in §1). A Norwegian public report 2005:8 [9] distinguishes between impairment and disability, defining impairment as related to sensory, mobility, physical, psychological and cognitive abilities and disability to barriers for participation encountered in social environments. Right-based and social disability model views seem prominent in Norwegian legislations on universal design. Lid [2] argues that Norwegian legislation interprets the goal of "universal design" as ensuring inclusive societies where as many citizens as possible may participate and contribute regardless of abilities, and uses the term to prevent (dis)ability-based discrimination.

Paragraph 11 in the Norwegian Discrimination and Accessibility Act defines ICT in relation to universal design, and legislates the duty to ensure public ICT solutions are universally designed [8]. However, the act also specifies that this duty is limited by sector-related legislation. For the Norwegian HE sector this means the main legislation governing universal design regulations is the Act relating to Universities and University Colleges (UHL) [10]. In the second letter of UHL §4-3 (item i) the act states learning environments should be based on the principle of universal design, though there are no clear regulations for ICT-solutions [11]. Looking at the legislative history of UHL, we find the interpretation of universally designed is in line with DTL although mainly related to the design of physical learning environments [12]. A prerequisite for the DTL was that sector legislation would set specific requirements for universal design of ICT [11,13]. As this requirement has not been met, a proposition has been made in 2016 by the Norwegian government suggesting that DTL and corresponding regulations on universal design of ICT [14] should also govern the education sector[15].

3 Universal Design Assessment

Universal design —making courses accessible for all students regardless of disabilities —goes beyond making courses accessible. It involves creating instructional goals, methods, and assessments that work for everyone —not a single, one-size-fits-all solution but rather flexible approaches that can be customized and adjusted for individual needs. [16]

Disabled students have the same rights to higher education as non-disabled students, and should therefore also expect access to the same educational experience as their peers [17]. In order to achieve this, the recommendation is to strive for universally designed eLearning environments and digital assessment tools [18]. In contrast to individual adaptations, universally designed learning environments may be more flexible in information media, interactivity, knowledge acquisition and knowledge demonstration styles, which is likely beneficial for all students, regardless of their abilities [19].

In 2009 Buzzi, Buzzi and Leporini [20] conducted a study were they investigated the accessibility and usability for visually impaired persons in two demo courses offered by Moodle, an open source LMS tool. Based on their findings they illustrate how ARIA may facilitate interaction for the blind. Even though this study address the accessibility issues of one eLearning tool their approach is to narrow for the whole user group. They directed their study to one specific user group and one specific assistive tool without addressing general usability heuristics. Bocconi and Ott [21] have conducted a similar study in Italy where they test the accessibility of ICT-based educational products and the inclusion of students with disabilities. This study is directed against the Italian law, and is therefore not fully transferable to the Norwegian market, and the overall testing requirements seems to be a bit narrow in the context of universal design. We believe such studies indicate there is a need for universally designed educational ICT-solutions, and a need for a framework to test universal design quality in eLearning and digital assessment solutions across the EU and EEA countries.

3.1 Expert Evaluations

Common expert evaluation methods include, among others, cognitive walkthrough, heuristic evaluation and accessibility evaluations. These methods do not use end users to test solutions; rather, they are evaluated by one or more experts who assess the results in the context of a defined set of criteria and/or tasks. Guidelines are commonly used for evaluating universal design (UD), such as WAI guidelines or general design principles and heuristics [22, 23, 21]. Research indicates expert

evaluations using such guidelines are not a sufficient approach to ensuring universal design [23]. However, an expert evaluation is indicative of potential usability and accessibility issues. As it is challenging to user test for all user groups under all conditions of use, an expert evaluation is a useful method for ensuring usability [23].

In a heuristic evaluation the interface and interaction design is commonly evaluated through the lense of a specific set of design guidelines, called "heuristics". The strength of heuristic evaluations is their holistic approach, checking several aspects of a solution against a specific set of tailored criteria. The expert investigates the interface, records issues and suggests improvements [24,25]. Heuristics may be used both for evaluations, but also for guiding the design process [26]. Some evaluations utilize more checklist-based or more thorough guideline inspections, for example evaluating compliance to a larger number of guidelines (10-200) [27]. For universal design assessments, the 7 design principles for universal design are commonly utilized as heuristics. An expert evaluation specifically looking at accessibility requirements is usually called an "accessibility evaluation".

Cognitive walkthrough is based on testing a solution in a step-wise manner, simulating a user task test [24]. The approach is more systematic than the trial-and-error approach of heuristic evaluations [24], may increase user empathy and needs sensitivity as well as focus on specific tasks and functionality aspects. This approach may thus include a variety of user perspectives, taking into account the recommended in-depth understanding and quality assurance of student needs in the specific educational setting for the digital assessment solution [28–30].

A debate is ongoing related to the validity and reliability of expert inspections, and to what degree the evaluation methods are influenced by the opinions and competence of the experts [23,31,25]. In addition to expert evaluation experience, knowledge of human abilities and user needs (including the specific issues and assistive technologies of disabled users) as well as the appropriate guidelines and heuristics and how to interpret and use these [33] are needed. Automated tools exist that go through a web site or a web page, and validate the code against, for example, WCAG guidelines. The view that automated tools are unable to fully check for accessibility and guideline compliance, and that expert evaluation is necessary in order to ensure WCAG compliance [31,34] is quite common. In Norway, automated tools for accessibility checks seem to be commonly used in combination with more design and usability focused expert reviews and/or formative user testing.

3.1.1 Feature Analysis Improving Validity and Reliability

In order to overcome some of the issues related to validity, Ardito et.al. [31,32] suggest using Systematic Usability Evaluation (SUE). This approach includes evaluation templates, called Abstract Tasks (ATs). ATs provide more precise descriptions of what is to be tested and how the evaluation should be conducted. This increases objectivity, contributes to assessment consistency and may decrease the needed expert competence on accessibility issues. Kitchenham [36] approaches the SUE-methodology from a feature analysis perspective. The aim of a feature analysis is to conduct as objective and non-biased expert inspection reviews as possible, and the approach is commonly used for comparing software [36].

When conducting a feature analysis, important aspects are contributed to highlight important functions and identifying differences between solutions. In its simplest form, a feature analysis is a list of criteria, with a yes/no presence scoring [36]. All evaluated features have pre-defined assessment descriptions and acceptance threshold, which is decided on based on the relative importance for the end-user. The scoring model may describe acceptable and non-acceptable thresholds both for individual features and criteria, categories of features and criteria, and overall for the solution based on user needs. A well designed and described scoring model can be reused and improved by other researchers and/or for other solutions. As for SUE, the detailed and structured approach makes the expert evaluation repeatable. The approach ensures transparency in the evaluation criteria as well as the review process [35] and thus increases reliability [27].

3.2 Web Content Accessibility Guidelines 2.0

Web Content Accessibility Guidelines (WCAG) 2.0 is a measurable set of guidelines for achieving web accessibility. The guidelines specifically aim at ensuring technical accessibility for persons with disabilities using assistive technology. The WAI WCAG 2.0 guidelines is one of the most commonly used criteria sets in accessibility evaluations, and are frequently the starting point of universal design assessment through expert evaluation. WCAG is a technical specification written for developers and others needing measurable properties, for example for requirements specifications. The criteria are based on four main principles [37]:

- Principle 1: Perceivable - Information and user interface components must be presentable to users in ways they can perceive;
- Principle 2: Operable - User interface components and navigation must be operable;

- Principle 3: Understandable - Information and the operation of user interface must be understandable;
- Principle 4: Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

In order to meet the requirements of different disabled users, the standard prioritizes the guidelines. Level A is the most basic level, while AA and AAA level criteria further improve accessibility. For example, color contrast guidelines are found both on AA and AAA levels, where the AAA level guideline is stricter than the AA guideline [38]. Norwegian legislation requires that the core functionality of all ICT-solutions targeted towards the general public must be universally designed if possible, and all web based ICT-solutions must fulfill WCAG 2.0 A and AA level guidelines [14].

While WCAG contributes to the accessibility of web content, Accessible Rich Internet Applications (WAI-ARIA) are used to make the content more usable to disabled users [37]. Accessibility may be viewed as a pre-requisite for usage, while a usability focus increases the positive user experience of the functionality, interactions and interface design. In order to achieve higher universal design quality, one might thus move beyond accessibility and towards universal usability. Extending WCAG with ARIA is an example of this process for web content. Blind and visually impaired users may have severe difficulties using accessible content, especially with regards to getting an overview, and feeling confident in their navigation and interaction. [20] note the importance of moving from accessibility to usability for screen reader users in relation to eLearning systems.

3.3 Guidelines for Universal Design

The Center for Universal Design in NCSU has developed seven principles for universal design, aiming to guide the development and design of products and systems in order to ensure a wide range of user needs are taken into account [39]:

- 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 main focus of the design principles are ergonomic usage aspects, and may be used to evaluate ergonomic design aspects of ICT interfaces and interactions, platforms and devices.

4 Methodology

This article is a part of an exploratory case study, aiming at investigating practices regarding universal design and digital examination in the Norwegian HE sector. The goal is not first and foremost generalizable results, but rather exploring unknown conditions [40, 27]. Based on new insights, future research focuses and research designs are prompted. The study takes on a phenomenological perspective; interpreting participants' perspectives and case conditions in an iterative manner [40].

In order to increase the internal validity of the study, a triangulation of methods [42], as well as research collaboration and peer reviews of questionnaire, interview and assessment procedures [40] are used. The case study uses an initial flexible and largely qualitative approach [41], with a survey questionnaire to HE institutions and in-depth interviews among selected institutions as well as the most common Norwegian digital assessment solution providers. Based on an understanding of current practices in Norwegian HE education and potential improvements in procurement and implementation of digital assessment solutions, this article adds the methods expert evaluation and criteria assessment to the case study approach. First, the study compares interview results from the solution providers to an expert review of the two solutions. Next, the study assesses and revises current requirements for universal design related to digital assessment solutions. Figure 1 shows the overall case study approach. The study is approved by NSD (Norwegian Centre for Research Data).

4.1 Participants

The case study includes two groups of participants; 1) persons employed in Norwegian higher education institutions with positions related to procurement or implementation of digital assessment solutions, and 2) persons employed in the two largest providers for digital assessment solutions in Norway, namely Inspera assessment (Inspera) and WISEflow (Uniwise). This article focuses on selected interview data from the latter group of participants. The participants are anonymized.

4.2 Data Collection

In order to answer the first two research questions related to assessment method and current quality of digital assessment solutions, a structured expert review procedure is prototyped. Inspera and WISEflow solutions are selected for review, as these are the two most prominent digital assessment solutions in Norway at the moment. The solutions are

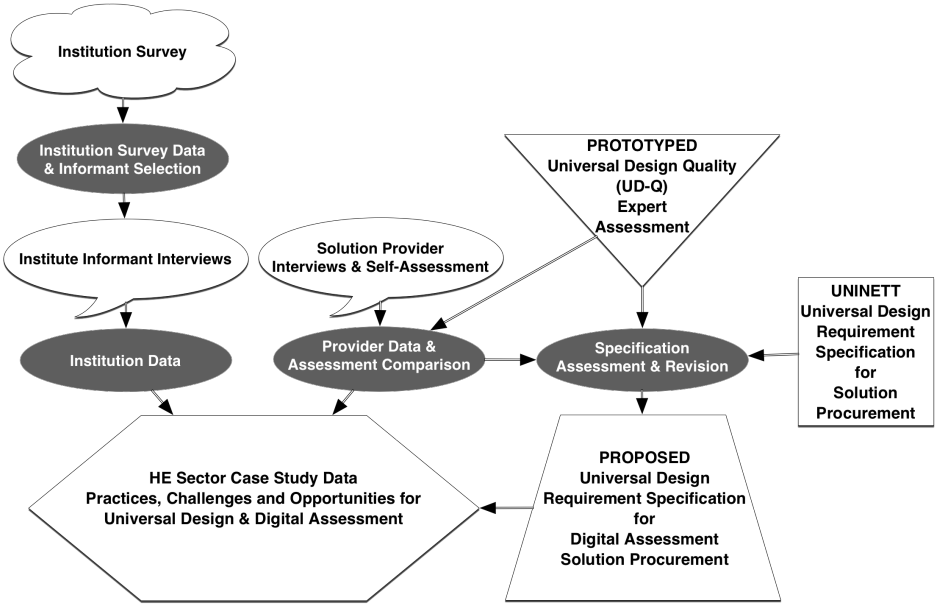

Fig. 1 HE Sector Case Study Overview

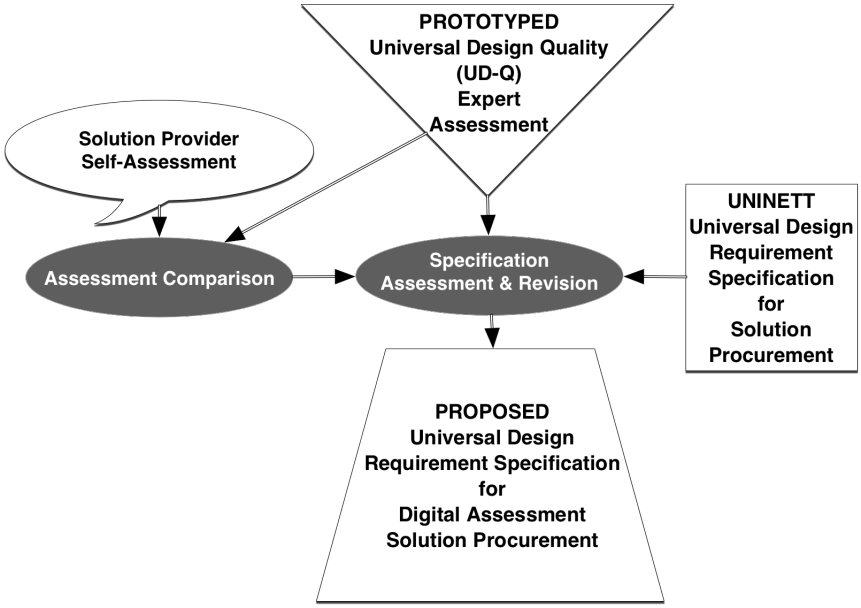

Fig. 2 Universal Design Quality and Requirement Specification Assessment Steps

anonymized. The review is based on a feature analysis approach, which increases the validity and reliability of expert evaluations by taking a transparent and structured approach [27,35]. Like other expert evaluations, a feature analysis may be viewed as a qualitative approach even if the feature assessments are quantified. This is due to the subjective aspects present in the approach, both related to determining feature assessment criteria and procedure, as well as to conducting the evaluation of feature implementation [43,44]. The feature analysis based universal design quality assessment is labeled the "UD-Q" approach.

Next, this article compares the quality assessment results from the prototyped expert review to acquired interview data from providers. The interviews are semi-structured, and the providers are asked to inform the researchers on six topics: A) personal attitudes towards universal design, B) knowledge of relevant legal regulations, C) self-assessment of the solutions quality with regards to universal design and the company's focus and competence on universal design, D) the company's processes and practices for implementing and ensuring universal design, E) universal design requirements included in existing solutions, and F) personal views on what limits or promotes universal design in the company. The compared interview data is from information given on topic C, on subjective assessments of the of the digital assessment solution's universal design quality. As such, the relationship between solution providers' self-assessment of universal design quality and the feature analysis universal design quality assessment is explored.

Finally, information given from the providers on topic D and E as well as the current set of procurement specification requirements for ensuring universal design in Norwegian digital assessment solutions are used as the basis for an improved set of requirements and process criteria. Figure 2 visualizes these steps and the process reported on in this article.

4.3 Universal Design Quality (UD-Q) Expert Assessment Analysis

In a feature analysis approach, each feature, criteria and category to be scored are pre-described in order to ensure validity, as is assessment and scoring thresholds. In order to ensure reliability, a model for assessment and scoring must also be carefully designed and described pre-evaluation. These steps provide transparency in which and how features and criteria are analyzed, minimize the degree of subjectiveness and promote more objective evaluations. The next sections present these aspects of the UD-Q expert evaluation used in this study, including criteria selection, scoring model and acceptance threshold levels.

4.3.1 Universal Design Quality (UD-Q) Expert Assessment Criteria

The features to be assessed is in this analysis are divided into four different categories:

1. The first category specifies assessment based on WCAG 2.0 requirements (level A and AA), assessed through an accessibility evaluation;
2. The second category is the 7 principles for universal design, assessed through a heuristic evaluation;
3. The third category consists of inspecting how core features function when using the screen reader JAWS, and is assessed through cognitive walkthrough;
4. The forth category entails inspecting how core features function when using 2-switch navigation, and is assessed through cognitive walkthrough.

As there are few detailed and testable requirements available for inspecting universal design, WCAG 2.0 compliance is a good starting point. However, achieving technical accessibility does not necessarily ensure universal usability for disabled users [37]. WCAG 2.0 is tailored to web accessibility, thus not a perfect fit for evaluating the accessibility in digital assessment solutions. Digital assessment solutions are homogenous solutions with specific additional requirements, for example ensuring the validity of an examination. In addition, WCAG 2.0 does not cover overall design decisions for interactive systems. Thus, achieving perfect WCAG 2.0 scores does not adequately indicate or ensure if a digital assessment solution is universally designed. In order to evaluate the overall universal usability, the accessibility evaluation is therefore extended with an overall heuristic evaluation based on design guidelines. The included guidelines are the 7 principles for universal design [26], which are treated as general design heuristics.

A solution may have high compliance with both specific accessibility guidelines and holistic design guidelines, though not work well in practice. In order to test usability in practice, a stepwise cognitive walkthrough is applied. This is an expert evaluation method that attempts to simulate user testing. The cognitive walkthrough is applied to evaluate core functionality. The core functionality selected is: 1) logging in to the solution, 2) finding and navigating to the examination assignment, 3) reading the assignment, 4) responding to the assignment, 5) delivering the examination assignment into the system and 6) receiving confirmation that the assignment is in fact delivered. The goal of the cognitive walkthrough approach within this feature analysis is to analyse if core functionality is accessible and usable for as many users as possible. Thus the cognitive walkthrough attempts to include into the

analysis edge-case user groups.

In order to evaluate the core functionality from a universal design perspective, two frequently excluded user groups are given focus: blind and low-vision screen reader users and motor impaired switch navigation users. Both user groups utilize assistive technology, and the solutions compatibility with advanced assistive technology is thus analyzed as part of the feature analysis. In this feature analysis, the choice is made to evaluate usage with the screen reader JAWS, as this is a common screen reader in Norway. A survey conducted by WebAIM in 2015 shows that JAWS is also the most popular screen reader worldwide [45]. The 2015 survey received a total of 2515 valid responses, with a clear majority of their respondents (69.4 %) from North America. Further, a 2-switch solution is selected for keyboard navigation. The cognitive walkthrough assessment of the 6 core features are repeated for these two user groups.

This feature analysis therefore contains 54 features, where Category 1 (WCAG 2.0 criteria) has 35 features, Category 2 (universal design principles) has 7 features, Category 3 (core functionality with JAWS) has 6 features and Category 4 (core functionality with 2-switch navigation) has 6 features.

4.3.2 Universal Design Quality (UD-Q) Expert Assessment Procedure

Each of the 54 features are analysed based on the following criteria:

- Is the feature implemented (yes/no)
- Is the feature correctly coded (yes/no)
- Does the feature hinder users from usage (yes/no)
- Does the feature offer high usability (yes/no)

Based on the criteria assessment, each feature is scored. Four levels are defined for the feature scoring:

- Level 0: Lacking
- Level 1: Low support
- Level 2: Good support
- Level 3: Perfected

Level 0 indicates a feature is not successfully implemented. Level 1 indicates a feature is implemented with partial success, and is having some significant shortcomings. At level 2 the feature is implemented with only minor shortcomings. The highest level, level 3, indicates the feature is very well implemented. Table 1 details assessment criteria and corresponding feature scoring. Feature scores are added up for each of the four categories in the feature analysis, resulting in category scores. Following the completion of feature analysis, all scores are added up to

Table 1 Feature Scoring

	Description	Score
Level 0: Lacking	The feature is not implemented	0
Level 1: Low support	The feature is implemented, and: may or may not be correctly coded and have high usability, but hinders users from feature or solution usage	1
Level 2: Good support	The feature is implemented, and: is either correctly coded or has high usability, and does not hinder users from feature or solution usage	2
Level 3: Perfected	The feature is implemented, and: is correctly coded, has high usability and does not hinder users from feature or solution usage	3

Table 2 Score Systems for Category and Overall UD Quality Assessment

	Maximum Score	Minimum Score
Category 1: WCAG 2.0	35 * 3 = 105	35 * 0 = 0
Category 2: UD Principles	7 * 3 = 21	7 * 0 = 0
Category 3: Core JAWS	6 * 3 = 18	6 * 0 = 0
Category 4: Core 2-Switch	6 * 3 = 18	6 * 0 = 0
Total score, unweighted	162	0
Category 1: WCAG 2.0	35 * 3 = 105	35 * 0 = 0
Category 2: UD Principles	7 * 3 * 2 = 42	7 * 0 * 2 = 0
Category 3: Core JAWS	6 * 3 * 2 = 36	6 * 0 * 2 = 0
Category 4: Core 2-Switch	6 * 3 * 2 = 36	6 * 0 * 2 = 0
Total score, weighted	219	0

a solutions total score. Thus, solutions may be assessed and compared both on category levels and overall scores.

If the four categories are not given different weights in the process of adding up the total score, each of the 54 individual features become equally important. As 35 features belong to Category 1, achieving WCAG 2.0 AA compliance will account for more than half of the overall universal design quality assessment (shortened to *UD-Q*) rating in this score system. While WCAG 2.0 may be viewed as measuring specific and theoretical accessibility, the combined 19 features of other three categories may be considered as evaluating universal design in a more holistic and practical manner. As such, it can be argued that they should have a fairly equal importance.

In order to achieve a more balanced overall universal design quality assessment (UD-Q) rating, this feature analysis proposes giving categories 2, 3 and 4 doubled weight in an alternate score system. When doubling feature scores for the three categories, this means Level 0 assessments of features still results in 0 points for the feature, while Level 1 assessment gives a feature the score 2, Level 2 assessment gives the

score 4, and Level 3 assessment gives the feature 6 points. Table 2 displays minimum and maximum scores for the two different total score systems.

4.3.3 Universal Design Quality (UD-Q) Acceptance Ratings

Determining reasonable score acceptance thresholds for overall universal design quality assessment (UD-Q) ratings is challenging. This study utilizes an analytical approach in order to arrive at objective and pre-evaluation acceptance ratings. This section outlines the reasoning used for the proposed thresholds.

In order to be defined as a universally designed digital assessment solution, all features in Category 1 should ideally be implemented at a minimum of Level 2 (Good support), ensuring no features hinders users from usage. WCAG 2.0 A and AA level criteria compliance may be considered soon-to-be legally required for Norwegian providers, as an added legislation specifying accessibility adherence for the HE sector is currently being considered by the Norwegian Parliament. Taking Category 1 feature compliance as a starting point, a minimum category score for an acceptable threshold may thus be considered at 70 points (35 features in Category 1 * 2 points for Level 2), which is 67 % of the possible total category score (70 points/105 maximum score $\approx$ 67 %). Based on this, the following acceptance thresholds are suggested:

- Below 25 % of possible score equals non-acceptance;
- 25-49 % of possible score equals minimum acceptance;
- 50-75 % of possible score equals satisfactory acceptance;
- Above 75 % of possible score equals excellent acceptance.

These thresholds are used both for category level UD-Q assessment, and for the overall UD-Q rating of a digital assessment solution. Table 3 details the acceptance ratings. Table 4 presents the necessary category level and overall scores corresponding to these acceptance ratings (calculated from the maximum scores for each category as outlined in Table 2).

Figures 3 and 4 illustrates the steps in the prototyped Universal Design Quality (UD-Q) expert assessment approach.

4.3.4 Interview Data and Assessment Quality Score Comparison

The study further investigates the relationship between information given by digital assessment providers in the in-depth interviews and the achieved UD-Q assessment ratings. In the interviews, the providers are asked to rate their solutions based on their subjective assessments of the solution's universal design quality on a scale from 0 to 7. If several

Table 3 Acceptance Thresholds for UD Quality Assessment

Rating	Description	Threshold
Non-acceptance	The solution lacks accessibility and/or usability, and is not filling the minimum requirements for acceptable implementation	<25 %
Minimum	The solution is filling minimum requirements for acceptable implementation, but has vital shortcomings related to accessibility and/or usability	25-49 %
Satisfactory	The solution is overall well implemented, offering satisfactory accessibility and usability ratings in most areas	50-75 %
Excellent	The solution is implemented in an excellent manner, offering high accessibility and usability ratings	>75 %

Table 4 Category and Overall Scores for Acceptance Ratings

	Non-acceptance	Minimum	Satisfactory	Excellent
Category 1: WCAG 2.0	<26 (25%=26.25)	26-52 (50%=52.5)	53-79 (75%=78.75)	>79
Category 2: UD Principles	<5 (25%=5.25)	5-10 (50%=10.5)	11-16 (75%=15.75)	>16
Category 3: Core JAWS	<5 (25%=4.5)	5-9 (50%=9)	10-13 (75%=13.5)	>13
Category 4: Core 2-Switch	<5 (25%=4.5)	5-9 (50%=9)	10-13 (75%=13.5)	>13
Total score, unweighted	<41 (Sum=40.5)	41-80 (Sum=81)	81-121 (Sum=121.5)	>121
Category 1: WCAG 2.0	<26 (25%=26.25)	26-52 (50%=52.5)	53-79 (75%=78.75)	>79
Category 2: UD Principles	<10 (25%=10.5)	10-20 (50%=21)	22-32 (75%=31.5)	>32
Category 3: Core JAWS	<10 (25%=9)	10-18 (50%=18)	20-26 (75%=27)	>26
Category 4: Core 2-Switch	<10 (25%=9)	10-18 (50%=18)	20-26 (75%=27)	>26
Total score, weighted	<55 (Sum=54.75)	55-108 (Sum=109.5)	109-164 (Sum=164,25)	>164

participants are interviewed from a provider, the arithmetic average is used for provider self-assessment.

In order to compare the self-assessment scales to the feature analysis scores, the 0-7 self-assessment scale is converted into acceptance ratings in the following manner:

- 0-1: Non-acceptance
- 2-3: Minimum acceptance
- 4-5: Satisfactory acceptance
- 6-7: Excellent acceptance.

Fig. 3 Orignial illustration: Prototyped Universal Design Quality (UD-Q) Assessment Approach

Table 5 Self-Assessment Scale and Feature Analysis Score Relationship

Scale level	Threshold	Total Score, unweighted	Total Score, weighted
0-1	Non-acceptance	<41 (<25 %)	<55 (<25 %)
2-3	Minimum	41-80 (25-49 %)	55-108 (25-49 %)
4-5	Satisfactory	81-121 (50-75 %)	109-164 (50-75 %)
6-7	Excellent	>121 (>75 %)	>164 (>75 %)

By making this conversion, the providers' self-assessment ratings can be easily compared to the feature analysis expert assessment ratings. For example, if a solution's universal design quality self-assessment is rated a 6́ón the scale from 0-7, the expected corresponding total UD-Q assessment score for the solution to achieve is above 121 points (without weighting categories 2-4, and above 164 if weighted) - i.e. in the Ëxcellentäcceptance range. Table 5 shows the relationship between total scores and each of the 7 scales, both weighted and unweighted. The gap between self-assessment and achieved feature analysis scores should not be too large if the providers' self-assessment is to be trusted as a reliable indicator of universal design quality.

Fig. 4 New Illustration: Universal Design Quality (UD-Q) Expert Evaluation Assessment

5 Results

5.1 Universal Design Quality (UD-Q) Expert Assessment

Table 6 presents the overall scores for the two digital assessment solutions, which are anonymized (Solution1 and Solution2). The solutions receive fairly similar universal design quality scores, and both achieve an assessment rating of *satisfactory*.

Both weighted and unweighted scores are calculated in order to provide the maximum comparison opportunities. The largest score difference between the two solutions is found in Category 3, where Solution1 does not allow JAWS accessibility in examination functionality using

Table 6 Feature Analysis UD Quality Assessment Scores and Ratings

	Solution1 Score	Solution2 Score
Category 1: WCAG 2.0	65	64
Category 2: UD Principles	11	11
Category 3: Core JAWS	5	9
Category 4: Core 2-Switch	10	11
Total score, unweighted:	91	95
Overall Rating:	Satisfactory	Satisfactory
Category 1: WCAG 2.0	65	64
Category 2: UD Principles	22	22
Category 3: Core JAWS	10	18
Category 4: Core 2-Switch	29	22
Total score, weighted:	117	126
Overall Rating:	Satisfactory	Satisfactory

Table 7 Technical Accessibility versus Practical Usability Assessments Scores

	Solution1 Score	Solution2 Score
Category 1: WCAG 2.0 Accessibility	65	64
Category 2-4: Practical Usability, unweighted	26	31
Category 2-4: Practical Usability, weighted	52	62

secure browser mode. The secure web browser is customised, and is blocking access to other programs running on the computer. The score for Category 3 using core functionality for Solution1 with JAWS is only 3, as the JAWS user can find and navigate to the examination assignment, though not respond to it. The weighted scores show Solution2 receives similar ratings in the Category 1 technical accessibility assessment and the more practical and holistic universal usability assessments. For Solution1 however, there is a slight difference, reflecting the issues with JAWS compatibility and thus universal usability in Solution1.

Table 7 highlights the technical accessibility assessment scores versus the universal usability assessments scores. Table 8, Table 9, Table 10 and Table 11 details the scores for each of the four feature analysis categories, with feature scores from 0 (lacking) to 3 (perfected) corresponding to the feature implementation assessment outlined in Table 1.

5.2 Self-Assessment and UD-Q Assessment Comparison

Table 12 compares the providers' self-assessments of the universal design quality of their digital assessment solution and the feature analysis UD-Q overall quality assessment, scores and corresponding ratings. The participant representing Solution1 describes the solution as (translated from Norwegian) *fulfilling many* (accessibility) *criteria, but not all. The*

Table 8 Category 1 WCAG 2.0 Technical Accessibility Assessment

Feature	Solution1 Score	Solution2 Score
1.1.1 Non-text Content (A)	1	1
1.2.1 Audio-only and Video-only, Prerecorded (A)	0	0
1.2.2 Captions, Prerecorded (A)	0	0
1.3.1 Info and Relationships (A)	2	2
1.3.2 Meaningful Sequence (A)	3	3
1.3.3 Sensory Characteristics (A)	3	3
1.4.1 Use of Color (A)	3	2
1.4.2 Audio Control (A)	3	N/A
1.4.3 Contrast, Minimum (AA)	1	1
1.4.4 Resize text (AA)	2	3
1.4.5 Images of Text (AA)	3	3
2.1.1 Keyboard (A)	1	1
2.1.2 No Keyboard Trap (A)	3	2
2.2.1 Timing Adjustable (A)	3	3
2.2.2 Pause, Stop, Hide (A)	3	3
2.3.1 Three Flashes or Below Threshold (A)	3	3
2.4.1 Bypass Blocks (A)	0	0
2.4.2 Page Titled (A)	2	1
2.4.3 Focus Order (A)	1	1
2.4.4 Link Purpose, Context (A)	2	3
2.4.5 Multiple Ways (AA)	3	3
2.4.6 Headings and Labels (AA)	1	3
2.4.7 Focus Visible (AA)	1	1
3.1.1 Language of Page (A)	0	1
3.1.2 Language of Parts (AA)	1	N/A
3.2.1 On Focus (A)	3	3
3.2.2 On Input (A)	3	3
3.2.3 Consistent Navigation (AA)	3	3
3.2.4 Consistent Identification (AA)	3	3
3.3.1 Error Identification (A)	1	1
3.3.2 Labels or Instructions (A)	2	2
3.3.3 Error Suggestion (AA)	0	1
3.3.4 Error Prevention (AA)	1	1
4.1.1 Parsing (A)	2	2
4.1.2 Name, Role, Value (A)	2	2
Total Score:	65	64

Table 9 Category 2 Universal Design Principles Heuristic Evaluation

Feature	Solution1 Score	Solution2 Score
Principle 1: Equitable Use	1	1
Principle 2: Flexibility in Use	1	1
Principle 3: Simple and Intuitive Use	3	3
Principle 4: Perceptible Information	1	2
Principle 5: Tolerance for Error	1	1
Principle 6: Low Physical Effort	2	1
Principle 7: Size and Space for Approach and Use	2	2
Total Score:	11	11

Table 10 Category 3 JAWS Accessibility and Usability Cognitive Walkthrough

Feature	Solution1 Score	Solution2 Score
1. Log in	0	3
2. Find and navigate to examination assignment	3	2
3. Read examination assignment	0	1
4. Respond to examination assignment	1	2
5. Deliver examination assignment	1	0
6. Receiving delivery confirmation	0	1
Total Score:	5	9

Table 11 Category 4 2-Switch Accessibility and Usability Cognitive Walkthrough

Feature	Solution1 Score	Solution2 Score
1. Log in	0	3
2. Find and navigate to examination assignment	3	1
3. Read examination assignment	3	3
4. Respond to examination assignment	1	2
5. Deliver examination assignment	1	0
6. Receiving delivery confirmation	2	2
Total Score:	10	11

Table 12 Comparison of Self-Assessment and Feature Analysis

	Self-Score	Self-Rating	Unweighted UD-Q Score	Unweighted Rating	Weighted UD-Q Score	Weighted Rating
Solution1	3-4	Minimum-Satisfactory	91	Satisfactory	117	Satisfactory
Solution2	6	Excellent	95	Satisfactory	126	Satisfactory

technology used in our current solution is not scalable. Therefore, we are developing a new solution available for digital examination in fall 2016. This new solution is aiming at fulfilling all criteria and being universally designed. This description fits well with the feature analysis results. The overall impression from the interview is that the Solution1 participant shows high universal design awareness. The Solution1 participant is able to make a a good self-assessment of the universal quality in the solution.

The participant from Solution2 does not have the same correspondence between self-assessment and the results. The interview impression is that the level of awareness regarding universal design aspects and Solution2 is somewhat lower than for the Solution1 informants. The Solution2 participant states that the (translated from Norwegian) Solution2 *has no areas we view as lacking, we are very aware of it* (universal design). *If one uses the technology for secure web browser examination, this limits so that one cannot use different screen readers. But we continuously try to challenge ourselves, and find solutions that works for all.* This description fits well with feature analysis findings. However,

the overall self-assessment is too optimistic, even taking into account that the JAWS compatibility issues in secure browser examinations are somehow solved for JAWS using students.

5.3 Revising Universal Design Requirement Specification

The interviews indicate that digital assessment providers want to aid HE institutions in including all student groups, and that they take universal design and accessibility seriously. The providers view universal design as an overall requirement and design principle, however in their everyday work they receive few concrete demands related to securing universal design in their solutions. The HE institutions are viewed by the providers as prioritizing functionality richness. One provider says (translated from Norwegian) *there is almost not a single demand for universal design compared to functionality.* Thus, the providers state that in addition to the requirements specification they too focus on implementing functionally needs as they are being notified of these, and not on ensuring universal design. The providers are responsible for ensuring features are implemented based on the original requirements specification and added functionally needs, and tested in order to ensure user needs are met. However, the interviews reveal real-life user testing is not performed as part of the development process.

5.3.1 UNINETT Requirements for Solution Procurement

The current requirements suggested for procurement of Digital Assessment Solutions in Norwegian higher education are developed by UNINETT in collaboration with the higher education sector. UNINETT is owned by the Norwegian Ministry of Education and Research and handles national ICT tasks, including managing network and network services for universities, colleges and research institutions. UNINETT develops and operates the national research and education network, and about 200 Norwegian educational and research institutions are part of the UNINETT network. A cross-institutional UNINETT project is working towards a common national procurement of digital assessment solutions. This project is coordinated by UNINETT [46]. Of the current HE institutions (after the 2016 mergers) 20 are represented in the Norwegian procurement project, including all universities [47]. The UNINETT requirements specification for digital assessment solutions has a set of usability criteria ([48], Appendix 1: Principal requirement specification, Section 2: Usability). Here 12 universal design requirements are also included, presented in Table 13 (numbering starting at 3).

UNINETT mentions the need for awareness of the diversity of the student body, taking into account the needs of students with disabilities so that the need for special solutions is reduced as much as possible. Their goal is universally designed learning environments that include all students in the mainstream solutions. UNINETT states that in order to ensure equal opportunities and rights to social participation for students with disabilities, universal design must be supported wherever possible. In their best-practice document for Clients for Digital Assessment, they state *choice and design of clients must therefore take into account users with special equipment*, exemplified with user groups using screen readers, screen magnifiers, voice commands and speech synthesis.

However, their included universal design *requirements* only focus on language diversity; mandating that English speakers must be included, and desire New-Norwegian speakers to be included. The only requirement related to accessibility and disabled users seems to be 1-page and 2-page descriptions of the solution's *potential* for improved accessibility (Descriptions 7 and 8), as well as descriptions of how the solution's *relates* to WCAG 2.0 level AA criteria and Principles 1, 2 and 3 (Descriptions 9, 11, 12, 13). Upon review, the UNINETT Universal Design Requirements Specification is considered lacking for ensuring universal design. Table 14 thus outlines a proposed revised set of requirements.

5.3.2 Revised Requirements for Solution Procurement

The revised requirements consist of a total of 14 requirements (see Table 14), divided into *mandatory functionality* and *desired functionality* as in the UNINETT specification. UNINETT requirements 6 and 9 are moved up to desired functionality, as descriptions other than YES/NO compliance is considered unnecessary. WCAG 2.0 AA compliance is more clearly stated as an expected and desired functionality. Requirements 6 (description of the provider's strategy for ensuring universal design) and 10 (WCAG 2.0 principle 4 compliance) are added. The new specification also proposes adding requirements for *desired documentation* in addition to *mandatory documentation*. Desired descriptions are asked for, related to needs analysis and user testing processes. Two requirements from the UNINETT specification are omitted (10 and 14), as these are considered unrelated to universal design.

The revised adjustments are based on the universal design quality levels as identified through the feature analysis quality assessment, and are as such recommended as a minimum acceptability level for solutions. Since the requirements are not only focusing on disabled user groups, but also span into tradition usability requirements, the term *universal usability* is used to describe them. Usability is about applicability, efficiency and satisfaction. Universal usability is considered to

Table 13 UNINETT Universal Design Requirements Specification

	Mandatory requirements	Compliant?
3	The user interface must be available in English and Norwegian Bokmål.	YES/NO
4	User documentation must be submitted in both Norwegian and English to Principal.	YES/NO
	Desired requirements	Compliant?
5	The user interface should be available in Norwegian Nynorsk.	YES/NO
	Descriptions	Requested no. of pages
6	Describe how the solution support multi-language test assignments (e.g. Norwegian Bokmål, Norwegian Nynorsk, English) regarding spell-checker, online help, etc.	1 page
7	ICT-based products and services developed for the general market should be accessible by anyone, with minimal additional effort and expense (capability for improved accessibility). Explain how this is facilitated in the solution.	1 page
8	Describe the offered solution's capability for improved accessibility for students with disabilities including (e.g. universal design) - visual impairment, hearing impairment, physical disabilities, dyslexia.	2 pages
9	The offered solution should support setting different start and stop times for candidates taking the same test (adjusting for persons with disabilities). The offered solution should also support changing the time limit or stop time during the test (perhaps due to technical problems for one, several or all candidates during the test). Describe this functionality for the offered solution.	2 pages
10	Describe how the solution supports sending messages to examinees, and if it is possible to edit system messages sent to examinees (e.g. message before, during and after examination, about time extension, cancelled questions, final grades etc.).	1 page
11	Describe which perceivable WGAC2.0 Level AA success criteria the solutions fulfills, ref. Principle 1: Perceivable - Information and user interface components must be presentable to users in ways they can perceive.	1 page
12	Describe which operable WGAC2.0 Level AA success criteria the solutions fulfills, ref. Principle 2: Operable - User interface components and navigation must be operable.	1 page
13	Describe which understandable WGAC2.0 Level AA success criteria the solutions fulfills, ref. Principle 3: Understandable - Information and the operation of user interface must be understandable.	1 page
14	Offline functionality: Describe which parts of the offered solution that can be used offline.	1 page

be descriptive and fit for today's digital assessments solutions. The aim of the revision is to better ensure flexibility and technical accessibility both in the user interface as a whole and in all added features, thus moving towards usability for all.

Table 14 Revised Universal Usability Requirements Specification

	Mandatory Functionality	***Compliance***
1	The user interface must be available in Norwegian Bokmål, English and New-Norwegian.	YES/NO
2	User documentation must be available in Norwegian Bokmål, English and New-Norwegian.	YES/NO
	Desired Functionality	***Compliance***
3	The solution should meet accessibility requirements for people with disabilities. This means the solution must follow the international guidelines for WCAG 2.0 Level AA. These accessibility guidelines should guide the design and technical implementation of the solution.	YES/NO
4	The solution should support multi-language test assignments (e.g. Norwegian Bokmål, Norwegian Nynorsk, English) regarding spell-checker, online help, etc.	YES/NO
5	The solution should support setting different start and stop times for candidates taking the same test (adjusting for persons with disabilities). The offered solution should also support changing the time limit or stop time during the test (perhaps due to technical problems) for one, several or all candidates during the test.	YES/NO
	Mandatory Descriptions	***Minimum delivery***
6	Describe the provider's strategy for universal design, with a particular focus on: process methodology, user testing and assistive technology compatibility. Documentation on how universal design is ensured by the provider is welcomed.	1 page
7	Ref. Principle 1 in WCAG 2.0: Perceivable - Information and user interface components must be presentable to users in ways they can perceive. Describe which Level AA success criteria the offered solutions fulfills.	0,5 page
8	Ref. Principle 2 in ECAG 2.0: Operable - User interface components and navigation must be operable. Describe which Level AA success criteria the offered solutions fulfils.	0,5 page
9	Ref. Principle 3: Understandable - Information and the operation of user interface must be understandable. Describe which Level AA success criteria the offered solutions fulfills.	0,5 page
10	Ref. Principle 4: Robust - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies. Describe which Level AA success criteria the offered solutions fulfills.	0,5 page
11	Describe how the offered solution can be used regardless of time, location and media channel.	0,5 page
12	Describe how the offered solution facilitates the inclusion of students with disabilities, with a particular focus on: visual impairments, hearing impairments, motor impairments, reading- and writing impairments.	1 page
Total	*Documentation of Universal Usability*	*4,5 pages*
	Desired Descriptions	***Minimum delivery***
13	Document user analysis and needs analysis processes.	-
14	Document testing and user testing.	-

6 Discussion

6.1 Universal Design Quality in Digital Assessment Solutions

Both digital assessment solutions achieved an overall satisfactory UD-Q score. Looking at the overall ratings, the solutions may be described as consistently and fairly well implemented and coded, with good accessibility and usability in most areas. However, the digital assessment solutions have use cases where one or more user groups are hindered from using the solutions. Both solutions have scenarios where core functionality is not implemented for assistive technology users. Users with a need for a 2-switch navigation technology and users with a need for a screen reader are hindered from using the solutions, which is not acceptable.

These examples indicate that the UD-Q scoring model could be stricter for Categories 3 and 4, and also possibly extending the number of UD-Q cognitive walkthrough categories for other user groups. For cognitive walkthrough categories it could be added that each feature should achieve at least a feature score of Level 2 (Good support), implying a feature is implemented and does not hinder users from using the feature or in further solution usage. Following this, cognitive walkthrough categories are likely to only be acceptably implemented if they reach a category acceptance level of Satisfactory or Excellent.

Furthermore, this indicates that a technical accessibility evaluation is not adequate when conducting a universal design quality expert review of a digital assessment system. In order to ensure usability in practice, the UD-Q procedure proposes to combine accessibility features with usability evaluations of the user interface and interaction through a holistic heuristic evaluation and a stepwise cognitive walkthrough, through core features using common asssitive technologies for edge-case or marginalized users in dangers of exclusion.

The recommendation for including Category 1 WCAG 2.0 features in the proposed UD-Q procedure is based on Norwegian legislation on universal design as described in section 2.1. As the WCAG 2.0 AA criteria is a common international standard for universal access, this is arguably a good starting point for an accessibility evaluation outside of Norway as well. Different countries, including EU and EEA countries, have different accessibility laws, and some of them have no laws at all. The UD-Q framework also allows for revised feature categories, for example tailoring Category 1 to fit with Italian legislations as presented by Bocconi and Ott [21].

We chose to prototype a digital assessment heuristic evaluation using the seven principles for universal design (as outlined in section 4.3.1), however deciding which heuristics are the most appropriate to use is of course open to debate. Both Category 1 and Category 2 features could also change based on new future technologies, or depend on locally used devices and solutions. For example, app-based digital examinations may require platfrom depended accessibility features and tailored interface and interaction heuristic. The proposed UD-Q expert assessment analysis approach easily allows features to be added or removed to meet technological and specific needs.

The proposed user groups and assistive technologies for the cognitive walkthrough is based upon gathered knowledge of Norwegian user groups in danger of being excluded and their preferred assistive technologies. Of course, which students are in danger of exclusion and what assistive technologies are the most popular in the student sample may change. If so, the assistive technology used and the users in focus in cognitive walkthroughs in the UD-Q assessment approach should be revised accordingly. In this UD-Q analysis, the choice is made to evaluate usage for visually impaired students with the JAWS screen reader. Although the WebAIM 2015 screen reader survey shows a substantial decrease in JAWS usage since January 2014 when WebAIM conducted the same survey [49,45], 743 (30.2 %) of the respondents still reports that JAWS is their primary screen reader. However, from 2014-2015 the use of ZoomText and Windows-Eyes both see significant increases. In 2015, 545 respondents (22.2 %) reported ZoomText as their primary screen reader. Thus, in future studies, an updated WebAIM survey could be used as a reference point for debating the inclusion of more or different screen readers in the UD-Q evaluation framework.

In addition, the proposed core features to be tested through the cognitive walkthroughs are selected based on knowledge of key functionality needed in digital assessment solutions in the Norwegian HE sector gathered through the case study. If key functionality requirements change, or if they are different in certain contexts of use, the UD-Q criterion in Category 4 could be revised to better fit the changed, specific or local needs.

Cognitive walkthrough as used in the UD-Q approach is suggested as a fitting expert evaluation method to reveal scenarios where user groups are hindered from using a solution. The providers are also encouraged to add new interaction techniques when conducting system tests, such as a permanent task to navigate through new features only using a keyboard. A system with good support for navigation with keyboards will contribute to improved support for screen readers, as keyboards are a common navigation method for screen readers. User

stories may also be used to facilitate carrying out such test tasks, so that the task is completed within the terms of how real users use the digital assessment solution. In other words, the developers may themselves start conducting universal design assessments through cognitive walkthroughs when testing features.

Overall, the proposed UD-Q expert assessment procedure successfully indicates the universal design quality of the evaluated systems, and may be re-used as is for further analysis of digital assessment solution and for re-testing of newer versions of Inspera and WISEflow. We believe the UD-Q procedure is appropriate outside of the Norwegian HE sector, either as is or with modifications on features, criteria, score model or acceptance ratings. It can be argued that the relevance of the UD-Q procedure is not limited to Norway or Scandinavian countries, as the features may be tailored to fit new legislations, specific core features needed in a certain context of use, relevant user groups in danger of exclusion and the most commonly used assistive technologies in use.

6.1.1 WCAG 2.0 in Digital Assessment Solutions

The UD-Q expert assessment analysis and interviews reveal that the guidelines in WCAG 2.0 do not perfectly fit to the evaluation of digital assessment solutions. The WCAG guidelines are designed to check the accessibility of web sites, while digital examination solutions are relatively homogeneous, and places additional requirements on the validity of the responses. In digital assessment solutions it may be important to answer different question types, in order to assess different types of knowledge. Disabilities should not give students academic advantages. When implementing WCAG 2.0 on Level A and AA a thorough understanding of the possible implications to the success criteria is needed, ensuring the validity of the responses. For example, if an examination is to measure students' understanding of the text and historical data using a question type of fill in the blanks, the system cannot provide error messages if the student types letters instead of numbers. Such a task is designed to measure whether or not a student understands the text, and an error message based on values may guide the student to the correct answers which further leads to invalid assessments and academic advantages. It might, however, be considered as an editorial task to ensure that the use of a general text field accepts both numbers and letters in these question types and forms of examination. Such validity issues are also reported in related research [50,51]. Guenaga, Burger and Olivier suggest separating formative and summative digitals assessments, where only the latter needs careful consideration in order to ensure validity in digital assessments [50].

6.1.2 Safe Exam Browser and Assistive Technology

In addition to achieving availability for all to the exam, there is a need to secure the examination environment so that cheating is not possible. If a person is in need of a screen reader during the examination there is a possibility that the examinee may be listening to material relevant for the examination in the background. With the use of Safe Exam Browser (SEB) the examination may be executed in a secure environment [52]. The SEB blocks access to the rest of the computer until the examinee has delivered their exams. It is, however, possible to configure the SEB to allow programs such as JAWS to be used during the examination for both Windows and Mac OSX [53]. This allows the HE sector to implement secure digital assessments in the classroom without interfering with the usability or accessibility.

6.1.3 Bring your own device

The present study focuses on universal design and usability for all, with a goal of ensuring available and flexible solutions. In this respect, and related to the ergonomic usage aspects emphasized in the 7 principles for universal design, the functionality and modalities of available devices are also important. Bring Your Own Device (BYOD) is an increasing trend, where each student may bring a personal device to the classroom, and conduct the digital assessments on this device. BYOD means that the students could bring a computer, a tablet or a smartphone of choice. By offering students to use their own computer or device, institutions in the HE sector give the students an opportunity to use the devices they are familiar with, and therefore contributes to increased universal design quality for each individual.

In the study conducted two different devices have been used: Macbook Pro with an installation of OS X El Capitan, and a Windows computer with an installation of Windows 7. There was little or no difference in the user experience between the two devices. Also, the institutions conducting digital assessments with BYOD could set some limitations in the allowed devices regarding hardware and software. Older operating systems and software (mainly browsers) do set some limitations in the available technology when developing universally designed solutions. As reported by the participants, Inspera has set some limitations regarding operating systems and browser versions [54]. They have both minimum and recommended resource requirements for the Windows and Mac OS X operating systems, and they support the two most recent stable versions for a set of widely-used browsers.

As of today, the Norwegian HE sector cannot require the students to use their own devices for conducting digital assessments under the

Act relating to Universities and University Colleges (UHL) and the regulations concerning fees at universities and colleges in Norway [55]. It is also important to note that there are legal considerations to consider when implementing BYOD-assessments, e.g. related to the use of software. Furthermore, for various reasons students may not possess personal devices, or possess a supported device and software. Institutions conducting assessments with BYOD must therefore also offer machines that students can opt to use during the assessments. These considerations are not discussed further in this study.

6.1.4 Relationship between UD-Q and Interview data

While interviews with the providers reveal solid knowledge of universal design and awareness of universal design and accessibility issues in the solutions, the results indicate that provider self-assessment of overall universal design quality is not necessarily indicative of true universal design quality. Even though the UD-Q scores for the two solutions are fairly similar, the self-assessment given by the two solution participants clearly differ (see Table 12). The Solution1 provider is the most pessimistic with regards to the universal design quality, and the self-assessment rating (minimum-satisfactory) correspond quite well to the UD-Q rating (satisfactory). The Solution2 participant on the other hand is much more confident and optimistic in his self-rating (excellent) though with slightly higher scores for Solution2, and the same overall rating (satisfactory). A possible explanation for this may be that the providers had very limited basis for comparison when taking into account the very limited UNINETT universal design requirements. If the expected universal design quality is made clearer to the providers, for example through more detailed requirements specification or a specified quality assessment approach, the self-assessment scores may be improved.

6.2 Requirements for Digital Assessment Solutions

A possible reason for the UNINETT specification only asking the providers to describe accessibility potentials, instead of making universal design requirements, is the expectation that it would be unreasonable to expect compliance at this point in time. If so, these views should now be revised. A reasonable level of universal design quality to be expected in digital assessment solutions has been benchmarked through the UD-Q assessment. The providers are motivated to ensure more inclusive, usable and universally designed solutions. They also wish to adhere to the communicated functionality needs form the higher education sector.

By making WCAG 2.0 compliance an explicit requirement in the revised specification, with a possibility for the provider to describe strategies and planned processes for universal usability and user centered work, the proposed set of requirements seeks to contribute to boosting the universal design focus. Our opinion is that the proposed and revised requirements should be required of any new digital assessment solution procurement. As the revised requirements are tailored to the current level of universal quality in digital assessment solutions, the requirements could be expanded upon in the future.

We also hope the revised requirements specification will provide a clearer division of responsibilities between providers and institutions with regards to universal design. The providers are responsible for ensuring features are implemented based on the requirements specification and added functionally needs, and tested in order to ensure user needs are met. However, the interviews reveal real-life user testing is not performed as part of the development process. A clearer set of requirements and a strategic plan may boost both enthusiasm and available resources for doing universal usability work.

UNINETT's interpretation of universal design is designing, or accommodating, the main solution with regards to physical conditions, so that the solution may be used by as many people as possible regardless of disability. Further, they view universal design as a dynamic concept that is becoming increasingly widespread and is applicable in many different fields. They state one of these areas are in the planning of information and communication technologies so that the tools can benefit all students. We agree with this notion. Our proposed requirements aim to ensure universal design through adequate levels of availability, flexibility and usability in the digital assessment solutions' content, user interface, user interaction and technical accessibility.

The requirements of the Norwegian HE sector for digital assessment solutions may differ from other educational systems due to different functional needs affecting the requirements. However, we believe that basic usability and universal design needs are fairly general across countries, regions and education systems that are aiming at universally designed digital assessment solutions. The proposed requirement specifications for universal usability should therefore be both relevant and valuable internationally, as a contribution to the iterative development and refinement of what aiming at universal design in digital assessment solutions should entail.

7 Conclusion

This study presents and prototypes the UD-Q universal design quality expert evaluation approach for digital assessment solutions, which is a feature analysis based, transparent, structured and step-wise approach aimed at preserving validity, objectivity, reliability, repeatability and comparability. The UD-Q evaluation of two major Norwegian solutions show the solutions receive acceptable ratings. However, the results also show that in both solutions vulnerable user groups such as 2-switch navigation users and screen reader users are excluded from core functionalities. As the correlation between higher education and employment for disabled persons persists, and the use of digital tools in higher education increases, these results are not encouraging.

The overall focus in digital assessment solution procurement and development seems to be functionality oriented, focused on feature density over core feature accessibility and universal usability aspects. Digital assessment providers demonstrate both universal design competence and a willingness to contribute to improve higher education for all. The study concludes current universal design requirements for digital assessment solutions are lacking in specificity and do not challenge the providers of digital assessment solutions to strive for universal usability. The key to increasing universal design quality assurance seems to be related to strengthening universal design and accessibility aspects in the requirement specifications, as well as aspects related to validity.

Accordingly, this study proposes a revised set of requirements specification guidelines for ensuring universal usability in procurement of digital assessment solutions. The set of requirements is based on the level inherent in the current digital assessment solutions. The proposed requirements are recommended as a minimum expectancy from the higher education sector, based on the UD-Q ratings in major available solutions. Providers of eLearning solutions in general and digital assessment solutions are encouraged to be aware of their strategies for universal design.

Regardless of current national educational legislations, the use of eLearning and digital assessment tools is increasing. There is a need to ensure usability and accessibility for all in several countries and educational systems. Our hope is that both the proposed requirement specification for digital assessment solutions and the prototyped UD-Q expert assessment approach presented in this paper will be transferable and valuable beyond Norwegian boarders to support this work internationally.

7.1 Future Research

Providers and higher education institutions are encouraged to utilize the UD-Q results as benchmarks for a) iterative improvement of, and b) expected accessibility levels in, existing and future solutions. The results from the feature analysis are communicated in detail to the providers of both digital assessment solutions, along with suggested improvements. The Solution1 provider have invited us to a meeting and a conference where they would like us to present the used methods, results and suggest improvements for their solution. They have also invited us to be a part of their expertise network and contribute to evaluate future solutions and elements. We welcome this collaboration.

Providers of Solution1 are already developing a new solution that will be available for use shortly, which according to plan will meet WCAG 2.0 requirements and is to be universally designed. On the basis of these plans it would be appropriate to conduct a feature analysis of the new solution. If the expert reviews are carried out in accordance with the analysis in this study, both the institutions in the higher education sector and the providers will have comparable results.

The providers of the digital assessment solutions and the higher education sector also need to address the issues regarding security when the examinee has a need to for third party applications. It would be interesting to conduct a new feature analysis with and without the Safe Exam Browser activated to allow the use of e.g. JAWS. This will address both the accessibility of the solutions, as well as the aspects regarding security to see whether or not it is feasible to allow third party applicaions without compromising the validity during the digital assessments.

Furthermore, it could be interesting to compare our feature analysis universal design quality assessment (UD-Q) approach to, for example, the Systematic Usability Evaluation (SUE) approach suggested by Ardito et al. [32]. Finally, the criteria and scoring model may be adjusted and improved following the evaluation, based on new insights or altered specifications.

The prototyped UD-Q evaluation may be adjusted to better fit other countries' laws and regulations, core features and necessary specific functionality, user groups in danger of exclusion and popular assistive technology. The belief is that overall digital assessment solutions needs should be fairly similar across countries and contexts. In order to test assumptions of similarity it would be interesting to conduct similar studies, including outside of the Scandinavian countries - especially since Inspera have been adopted in countries such as Poland and Great

Britain.

The proposed requirements for universal usability are based on the level universal design quality identified in reviewed digital assessment solutions. Future revision is suggested in order to consider extending the requirements for universal design and usability, for example by the end of 2018. Potential new legislation for the Norwegian higher education sector should also be taken into consideration. The improved set of requirements are currently being reviewed by the UNINETT project.

Acknowledgments.

A warm thank you to UNINETT, Inspera, WISEflow (Uniwise) and all our HE institution participants.

References

1. The Norwegian Directorate for Children, Youth and Family Affairs, Utdanning. [online] URL: http://www.bufdir.no/Statistikk_og_analyse/Nedsatt_funksjonsevne/Oppvekst_og_utdanning/ (16.09.2015)
2. Lid, I. M., Universell utforming - Verdigrunnlag, kunnskap og praksis. Cappelen Damm Akademisk, Oslo (2013)
3. The Nordic Institute for Studies in Innovation, Research and Education (NIFU), Institusjoner i universitets- og høgskolesektoren. [online] URL: http://www.nifu.no/statistikk/om-fou/hvem-utforer-fou/institusjoner-i-uoh-sektoren/ (27.10.2016)
4. Statistics Norway (SSB), Studenter ved universiteter og høgskoler, 1. oktober 2015. [online] URL: https://www.ssb.no/utdanning/statistikker/utuvh/aar/2016-04-14?fane=tabell&sort=nummer&tabell=260693 (27.10.2016)
5. Norwegian Centre for Research Data (NSD), Database for Statistikk om Høgre Utdanning, Gjennomsnittsalder tilsatte. [online] URL: http://dbh.nsd.uib.no/statistikk/rapport.action?visningId=150 (27.10.2016)
6. Norwegian Centre for Research Data (NSD), Database for Statistikk om Høgre Utdanning, Studenter per faglige årsverk. [online] URL: http://dbh.nsd.uib.no/statistikk/rapport.action?visningId=159&visKode=false&columns=arstall&index=1&formel=801!8!802!8!803&hier=insttype!9!instkode!9!fakkode!9!ufakkode&sti=&param=arstall%3D2015!9!dep_id%3D1 (27.10.2016)
7. TNS Gallup, Universell, Prosjektrapport, Felles norsk lœringsmiljøundersøkelse (LMU) 2012. [online] URL: http://www.universell.no/lmu/laeringsmiljoeundersoekelser/ (27.10.2016)
8. Ministry of Children and Equality (BLD), Lov om forbud mot diskriminering på grunn av nedsatt funksjonsevne (diskriminerings- og tilgjengelighetsloven), LOV-2013-06-21-61, Lovdata (2013) [online] URL: https://lovdata.no/dokument/NL/lov/2013-06-21-61 (28.10.2016)
9. Syse, A. et.al., NOU 2005:8, Likeverd og tilgjengelighetâĂŤ Rettslig vern mot diskriminering på grunnlag av nedsatt funksjonsevne. Bedret tilgjengelighet for alle. Ministry of Justice and Public Security [online] URL: https://www.regjeringen.no/no/dokumenter/nou-2005-8/id390520/sec1 (28.10.2016)
10. Ministry of Education and Research, Lov om universiteter og høyskoler (universitets- og høyskoleloven), LOV-2005-04-01-15. [online] URL: https://lovdata.no/dokument/NL/lov/2005-04-01-15 (28.10.2016)

11. Agency for Public Management and eGovernment (Difi), Utdanningssektorens plikt til universell utforming av IKT, report 2015:20. ISSN 1890-6583 [online] URL: https://www.difi.no/rapport/2016/01/utdanningssektorens-plikt-til-universell-utforming-av-ikt-losninger (28.10.2016)
12. Ministry of Education and Research, Proposisjoner til Stortinget. Ot.prp. nr. 40 (2001-2002), Om lov om endringer i lov 12. mai 1995 nr. 22 om universiteter og høgskoler og lov 2. juli 1999 nr. 64 om helsepersonell. [online] URL: https://www.regjeringen.no/no/dokumenter/otprp-nr-40-2001-2002-/id167065/ (28.10.2016)
13. Regjeringen.no, Høringsnotat om felles likestillings- og diskrimineringslov. [online] URL: https://www.regjeringen.no/contentassets/5342e1dd1467426a98d4b02b7a4a79ca/horingsnotat.pdf (13.11.2015).
14. Ministry of Local Government and Modernisation (KMD), Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger, FOR-2013-06-21-732, Lovdata (2013) [online] URL: https://lovdata.no/dokument/SF/forskrift/2013-06-21-732?q=Forskrift%20om%20universell%20utforming%20av
15. Regjeringen.no, Høring - forslag til felles likestillings- og diskriminerslov. [online] URL: https://www.regjeringen.no/no/dokumenter/horing—forslag-til-felles-likestillings–og-diskrimineringslov/id2458435/ (19.11.2015).
16. Zhuhadar, L., Carson, B., Daday, J., Nasraoui, O., A Universal Design Infrastructure for Multimodal Presentation of Materials in STEM Programs: Universal Design. Proceedings of the 24th International Conference on World Wide Web, Florence, Italy, 569-574 (2015)
17. Klironomos, I., Antona, M., Basdekis, I., Stephanidis, C., White Paper: promoting Design for All and e-Accessibility in Europe, Universal Access in the Information Society, 5(1), 105-119 (2006)
18. Bocconi, S., Dini, S., Ferlino, L., Martinoli, C., Ott, M., ICT Educational Tools and Visually Impaired Students: Different Answers to Different Accessibility Needs. Universal Access in Human-Computer Interaction, Applications and Services, Lecture Notes in Computer Science, 4556, 491-500 (2007)
19. Rose, D. H., Strangman N., Universal Design for Learning: meeting the challenge of individual learning differences through a neurocognitive perspective, Universal Access in the Information Society, 5(4), 381-391 (2007)
20. Buzzi, M., Buzzi, M., Leporini, B., Accessing e-Learning Systems via Screen Reader: An Example, Lecture Notes in Computer Science, 5613 Human-Computer Interaction. Interacting in Various Application Domains, 21-30 (2009)
21. Bocconi, S., Ott, M., ICT and Universal Access to Education: Towards a Culture of Accessibility. Information Systems, E-learning, and Knowledge Management Research, Communications in Computer and Information Science, 278, 330-337 (2013)
22. Squires, D., Preece, J., Predicting quality in educational software:: Evaluating for learning, usability and the synergy between them, Interacting with Computers, 11(5), 467-483 (1999)
23. Petrie, H., Bevan, N., The evaluation of accessibility, usability and user experience, The Universal Access Handbook, CRC Press (2009)
24. Benyon, D., Designing Interactive Systems - A comprehensive guide to HCI, UX and interction design, 3rd ed, 219. Pearson, London (2014)
25. Nielsen, J., Usability Engineering, 155-156. Academic Press, London (1993)
26. The Norwegian Directorate for Children, Youth and Family Affairs, Universell utforming A-B-C. [online] URL: http://www.bufdir.no/uu/Universell_utforming_A_B_C/ (14.09.2015)
27. Lazar, J., Feng, J. H., Hochheiser, H., Research Methods in Human-Computer Interaction, 150. John Wiley & Sons Ltd., Chichester (2010)
28. Granić, A., Ćukušić, M., Universal Design Within the Context of e-Learning, Universal Access in Human-Computer Interaction. Applications and Services, Lecture Notes in Computer Science, 4556, 617-626 (2007)

29. Granić, A., Adams, R., User sensitive research in e-learning: exploring the role of individual user characteristics. Universal Access in the Information Society, 10(3), 307-318 (2010)
30. Pullin, G., Newell A., Focussing on Extra-Ordinary Users, Universal Access in Human Computer Interaction, Coping with Diversity , Lecture Notes in Computer Science, 4554, 253-262 (2007)
31. Ardito, C., Costabile, M. F., De Marsico, M., Lanzilotti, R., Levialdi, S., Plantamura, P., Roselli, T., Rossano, V., Tersigni, M., Towards Guidelines for Usability of e-Learning Applications, Lecture Notes in Computer Science, 3196 User-Centered Interaction Paradigms for Universal Access in the Information Society, 185-202 (2004)
32. Ardito, C., Costabile M. F., De Marsico, M., Lanzilotti, R., Levialdi, S., Roselli, T., Rossano, V., An approach to usability evaluation of e-learning applications, Universal Access in the Information Society, 4(3), 270-283 (2006)
33. Yesilada, Y., Brajnik, G., Harper, S., How much does expertise matter?: a barrier walkthrough study with experts and non-experts, Proceedings of the 11th international ACM SIGACCESS conference on Computers and accessibility, Pittsburgh, Pennsylvania, USA (2009)
34. Tanaka, E. H., Da Rocha, H. V., Evaluation of web accessibility tools, Proceedings of the 10th Brazilian Symposium on Human Factors in Computing Systems and the 5th Latin American Conference on Human-Computer Interaction, Porto de Galinhas, Pernambuco, Brazil, 272-279 (2011)
35. Kitchenham, B. A., DESMET: A method for evaluating Software Engineering methods and tools, Technical Report, University of Keele (1996)
36. Kitchenham, B. A., Evaluating software engineering methods and tool part 1: The evaluation context and evaluation methods, SIGSOFT Softw. Eng. Notes, 21(1), 11-14 (1996)
37. Tollefsen, M., Web og Universell Utforming, 63. Universitetsforlaget, Oslo (2013)
38. Agency for Public Management and eGovernment (Difi), WCAG 2.0 standarden. [online] URL: https://uu.difi.no/krav-og-regelverk/wcag-20-standarden (29.09.2015)
39. Universell, Sju prinsipper for universell utforming. [online] URL: http://uukurs.universell.no/gammelt-innhold/universell-utforming/prinsipper-for-universell-utforming/ (05.11.2015).
40. Leedy, P. D., Ormrod J. E., Practical Research Planning and Design, 10th ed. Pearson Education Limited, Essex (2014)
41. Thagaard, T., Systematikk og innlevelse: en innføring i kvalitativ metode, 4th ed. Fagbokforlaget, Bergen (2013)
42. Creswell, J. W., Miller, D. L., Determining validity in qualitative inquiry, Theory into practice, 39(3), 124-130 (2000)
43. Nes, M. E. S., Appraising and Evaluating the Use of DAISY: For print Disabled Students in Norwegian Primary- and Secondary Education, University of Oslo (2007)
44. Nes, M. E. S., Ribu, K., Tollefsen, M., DAISY - Universally Designed? Prototyping an Approach to Measuring Universal Design, Proceedings ICCHP, Linz, Austria, Lecture Notes in Computer Science, Computers Helping People with Special Needs, 5105, 268-275 (2008)
45. WebAIM web accessibility in mind, Screen Reader User Survey #6 Results. [online] URL: http://webaim.org/projects/screenreadersurvey6/ (1.11.2016)
46. UNINETT, Breakthrough in Norway: paperless exams. [online] URL: https://www.uninett.no/en/content/breakthrough-norway-paperless-exams (27.10.2016)
47. UNINETT, Digital assessment leap: Norwegian research and higher education sector concludes on three ICT systems. [online] URL: https://www.uninett.no/en/digtal-assessment-three-vendors-chosen (27.10.2016)
48. UNINETT, Kravspesifikasjon for digital eksamen. [online] URL: https://www.uninett.no/sites/default/files/portal_docs/3_ssad_digital_assessment_v2.docx (10.11.2016)

49. WebAIM web accessibility in mind, Screen Reader User Survey #5 Results. [online] URL: http://webaim.org/projects/screenreadersurvey5/ (1.11.2016)
50. Guenaga, M. L., Burger, D., Olivier, J., Accessibility for e-Learning Environments, Proceedings ICCHP, Paris, Lecture Notes in Computer Science, Computers Helping People with Special Needs, 3118, 157-163 (2004)
51. Hansen, E. G., Mislevyb, R. J., Steinbergc, L. S., Leed, M. J., Forere, D. C., Accessibility of tests for individuals with disabilities within a validity framework, System, 33(1), 107-133 (2005)
52. Eidgenössische Technische Hochschule (ETH) Zurich, Educational Development and Technology (LET), Safe Exam Browser, About - Overview, Concept. [online] URL: http://safeexambrowser.org/about_overview_en.html (1.11.2016)
53. Eidgenössische Technische Hochschule (ETH) Zurich, Educational Development and Technology (LET), Safe Exam Browser, Windows - User Manual, Safe Exam Browser 2.1.3 for Windows. [online] URL: http://safeexambrowser.org/windows/win_usermanual_en.html (1.11.2016)
54. Inspera, 1: Støttes nettleseren og operativsystemet ditt? [online] URL: https://inspera.atlassian.net/wiki/pages/viewpage.action?pageId=73465971 (1.11.2016)
55. Ministry of Education and Research, Forskrift om egenbetaling ved universiteter og høyskoler, FOR-2005-12-15-1506. [online] URL: https://lovdata.no/dokument/SF/forskrift/2005-12-15-1506 (1.11.2016)