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On Assessing the Costs and Benefits of Universal Design of ICT

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Abstract. In the ICT and IT domains, Universal Design is typically viewed as a burden and an expense, and its application is often justified only by ethics and/or legislation. Advocates for Universal Design (UD) are arguing that it is cost-effective, but so far there are few studies that document this in a detailed way. In this work, we discuss related research and studies dealing with the costs and benefits of accessible and usable ICT solutions. In particular, we discuss the findings regarding what is a universally designed solution, what is needed to make such a solution, how much does it cost, what impact can be anticipated by the extra effort, and how it can be measured. Finally, we suggest an approach for carrying out cost-benefit analyses of developing universally designed solutions. There is a weak indication that the economical benefits of UD solutions are much higher than the initial and running costs.

Keywords. Universal Design, inclusive design, accessibility, bottom line, cost-benefit analysis, impact

1. Introduction

In 2009, the Council of Europe recommended to its member states that cost-benefit analyses (CBAs) of the application of Universal Design and the communication of the results be carried out to provide for greater visibility of the effects of Universal Design (UD). UD should be measured according to predefined criteria and procedures, including both social aspects and technical aspects [CM/Rec 2009]. The notion of UD here refers to the definition that is found in Article 2 of the UN Convention on the Rights of Persons with Disabilities (UNCRPD): It denotes the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design [1]. Moreover, accessibility recommendations closely related to Universal Design require not to exclude assistive devices for particular groups of persons with disabilities where this is needed [2].

However, assessing the costs and benefits of making ICT solutions universally designed is by no means a trivial task. A number of Norwegian reports have concluded that particular aspects of such analyses are, if not impossible, very difficult to conduct [3 – 5]. On the other side, it appears that indeed CBAs are necessary to make the management of companies, organizations, and the public sector aware of an anticipated positive bottom line of universally designed ICT solutions: In Norway, Universal Design of ICT is being mandated by the law [6]. However, almost one year after the

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law came into effect (in 2013), still more than 75% of the organizations the Regulation is relevant for did not know about it [7]. This demonstrates the need for increased awareness, more knowledge, and better motivation for UD.

This work extends a previously published report [8] and another work [9] investigating how CBAs of universally designed ICT solutions are related to other research fields. The main contribution of this work is to discuss the literature with regard to measurements, to set related approaches into perspective, and finally to suggest an approach with which the cost and benefits of Universal Design of ICT can be documented and assessed.

The remainder of this work is organized as follows. After a few words about the importance of the topic, we discuss how the costs and benefits of Universal Design can be quantified. After that, we consider the steps that must be taken by organizations that want to conduct a CBA in practice, before the conclusion is drawn in the end.

2. Motivation

Several numbers indicate why this is an important topic. On a national level, 19% of the Norwegian population aged 18 and older are said to have a disability [10]. This number is comparable with the 2010 estimate for the U.S., detailing that there were about 57 million people - roughly 19 percent of the population - who had a disability [11]. On an international level, 42 million European citizens (counting 27 countries in 2012) aged 15–64 are estimated to have a disability, as compared to approximately 500 million citizens in total [12], [13]. For all ages, the estimate for Europe is 80 million (or 16%), with a prognosis of 120 millions in 2020 [14]. Worldwide, the WHO have approximated that around 15% of the population have been reported as having a moderate to severe disability [15]. Moreover, with an ageing population in many parts of the world, the number of people with disabilities is expected to increase.

With these numbers, it is clear that any positive economic impact of UD will be more than considerable. This expectation is also an important reason for why e-inclusion and Universal Design (or similar approaches) has received much attention from policy makers.

If we in addition regard the hypothesis that universally designed solutions not only benefit those with disabilities, but in fact the entire population [16], any potential benefit is expected to be truly significant.

3. Quantifying costs and benefits

To be able to do a thorough CBA, there are at least three main aspects that should be clarified, measured, and documented:

1. What makes out a universally designed solution, and to what extent does a given solution fulfill this goal?
2. What additional steps are taken to arrive at a UD solution compared to a not-UD solution (NUDS), and how much did they cost?
3. What impacts are anticipated to be related to UD measures, as compared impacts of an “ordinary” solution, and how can these effects be measured?

We will take a closer look at these three aspects in the next sections.

3.1. Quantifying the solution's degree of Universal Design

Researchers distinguish between technical and usable accessibility [17], also referred to as accessible design and usable design, respectively. The former is typically measured by automated tools, and the latter by involving humans. Universal design includes both approaches and stresses the requirement of a truly diverse user group, including individuals with disabilities. So what makes out a universally designed solution, and to what extent does a given solution fulfill this goal? There are multiple answers to this question on multiple abstraction levels.

On a very high level, the UN definition has already been given in the Introduction above. On a high level the Norwegian Anti-Discrimination and Accessibility Act refers to Universal Design as a strategy to avoid discrimination. In the ICT domain it requires websites and self-serve machines to be universally designed. Regarding websites, this has been operationalized to mandate WCAG 2 level AA conformance [18] with some exceptions regarding time-based media [6], leading to a conformance constraint containing 35 criteria. While these requirements are much more specific than the UN definition, the scientific community does not agree upon how to measure that WCAG is fulfilled, even though W3C claims that each of the 61 WCAG criteria is testable. As a consequence, there are many different ways to meet the WCAG guidelines in terms of testing procedures and test suites.

The standardization of the WCAG-EM guidelines is a recent W3C initiative to formalize the efforts for coping with some of the shortcomings of WCAG when it comes to the definition of testing procedures, testing formalities, and testing framework in general [19]. While this work aids measurements of a solution's degree of accessibility with regard to validity, reliability, as well as comparability with other methods, some important disadvantages with WCAG are not addressed, such as the questions of completeness and testability. WCAG-EM is nevertheless suitable also for UD assessments, and its application should be considered in any future assessment method.

Another example of uncertain assessment methods is the Universal Design of self-service machines, for which Norwegian authorities require conformance with 10 relevant international standards [20]. Here the situation is that, even though there is a limited set of standards/recommendations to fulfill, it is unclear how this can be operationalized in practice in terms of concrete testing procedures and criteria.

Related to the aforementioned is the effort in Norway to measure the quality of public websites and digital services for citizens, known as Web Quality (Kvalitet på nett, Kpn) [21]. For the 2015/2016 round, there are up to 33 criteria/indicators to be met, if applicable. Partly they cover accessibility-related topics, partly they address usability-related and technical topics. Their advantage is testability and well defined measurement criteria, tools, and testing procedures, and the use of point scores, which allows graduated testing outcomes besides a simple pass/fail. The drawback with this method is that testing is conducted by (few and subjective) experts, without involving any users with disabilities or assistive technology, and that there are relatively few tests as compared to the complete WCAG test suite. Other research has shown that experts typically cannot get to an agreement regarding what the potential barriers are [22], and that they are capable of finding less than 50% of the actual problems [23].

Also related to these efforts is the recently terminated project European Internet Inclusion Initiative (EIII), which has evaluated as many as 1065 public European websites [24]. As with WCAG and Kpn, this tool makes use of a checklist but uses

simple pass/fail decisions and bases testing solely on an automated accessibility checker, neither involving experts nor end users. This is problematic as empirical studies have found that an (automated) accessibility checker for web pages, measuring conformance with WCAG, is capable of only detecting less than 25% of the actual problems encountered by users with disabilities [25].

Considering what can be called "state of the art" in European countries, a 2015 screening found that the majority of web accessibility monitoring activities in Europe follow a combined "automated and manual expert" approach [26], and very few involve end users and manual testing. The report also found that the majority of activities apply WCAG 2, followed by national guidelines which typically deviate from WCAG in one way or other.

An entirely different approach than the aforementioned checklists is the use of an exclusion calculator to assess the degree of a solution's inclusiveness [27]. The assessor indicates what kind of capabilities a given solution requires, as well as the level of capability. A calculator then determines by means of a database with representative user samples the percentage of users which are potentially excluded by the solution. In doing that, this approach is similar to the "Can I use it?" web service frequently used by developers with its overview of support of particular technologies in popular web browsers [28]. The exclusion calculator thus estimates the true extend of a solution's universal access and could be used to minimize a service's or product's exclusion factor. In practice, however, there is a lot of uncertainty regarding the setting of the proper capabilities and levels thereof, which so far has prohibited widespread success of this approach. There is also the challenge of erecting a database with updated and representative statistics over disabilities in a country's population.

To wrap up, most current assessment initiatives for the Web either focus entirely on accessibility or use a notion of Universal Design which is not clearly distinguished from accessibility. WCAG appears to be the most popular method for measuring the degree of accessibility. Other approaches, such as the Norwegian Kpn, have broadened the range of tested topics, which makes them more suitable for measuring true Universal Design, i.e., both technical and usable accessibility. Kpn also has the advantage that its indicators are operationalized, i.e., measuring procedures and tools are properly specified, which is essential to avoid questions of how to comply with particular guidelines as this is the case with WCAG.

A final comment: There are examples of reports and studies speaking of a solution as either universally designed or not, like in a binary fashion [LDO 2011]. Any threshold regarding a number of passed tests or a minimum point score can turn the UD question into a simple yes/no outcome. This is particularly useful in order to say whether a solution fulfills a directive/regulation or not. Other than that, however, it makes more sense to refer to a point score and thereby a solution's degree or extent of Universal Design.

3.2. Quantifying costs of the Universal Design process

One challenge when trying to quantify the costs and benefits of Universal Design is that there are many opinions of what Universal Design as a process entails. What is more, the solution in question is likely to be used in a variety of contexts, and with highly heterogeneous target user groups. To make it possible to analyze and compare results from various case studies, it is important to follow a recognized process, and to document the process and the context as carefully and detailedly as possible.

It has been recommended that UD should be based on user-centered design (UCD) [29]. A general UCD process includes the following phases; a) exploration of context and user needs, b) creation of designs, and c) evaluations of designs. These activities can be carried out in one or more cycles, as part of an iterative process.

ISO 9241-210:2010 specifies a UCD process [30] and can thus be used as basis for documenting and planning the UD process. Since the ultimate goal is that the solution's design is as accessible and usable to as broad a range of users as possible, all activities within the process must be performed with this goal in mind. It is further crucial that UD activities into the general development process are integrated from the very beginning since this is far less costly and time consuming than trying to fix a solution towards the end of the development process [31], [32].

We recommend extending the design process with the following main activities:

1. Involve diverse user groups, in particular people with disabilities, throughout the process. They should be consulted during the exploration of the context and user needs, and they can be involved in design work as well as in evaluations and user testing. Detailed recommendations for involving people with impairments in the development process are laid out in the Norwegian standard NS 11040:2013 [33], which in turn is based on the UCD process described in ISO 9241-210:2010.
2. Investigate what types of assistive technologies (AT) disabled users typically have and make sure that the solution will be compatible with these technologies. This includes an investigation of cross-platform issues related to operating systems, target browsers, screen readers, magnifiers, and similar. Be aware that the types of AT that are in use can vary from country to country [34].
3. Ensure that the solution is compliant with relevant accessibility guidelines and related standards (WCAG, CSS, HTML, etc.). There are sometimes specific accessibility guidelines for particular application areas, such as for rich internet applications (WAI-ARIA) or mobile accessibility [35].

It is crucial to remove as many technical accessibility issues as possible before involving users, otherwise a user test may be ineffective and even wasted because it may be partly or totally impossible for the user to use the solution. It is hence advisable to do both automatic and manual standard compliance testing with experts before any user testing [36]. There are a number of automatic WCAG conformance testing tools that can be used for an initial accessibility compliance test. However, none of the automatic tools can do a complete conformance check, and the various tools have different strengths and weaknesses [37]. Also, some of the tools are free while others require a license. The same applies to AT with which testers and experts need to test ICT solutions. Some of this specialized equipment (such as Jaws) is very expensive.

Another standard relevant for defining UD processes and activities is BS 8878 [38]. It covers important aspects of an organization's activities related to accessibility and is based on real-world experiences with addressing accessibility in various organizations. The standard also underscores the importance of integrating accessibility activities throughout the life-cycle of the product.

All mentioned standards can be of great help when planning case studies. Following standards also makes analyses across case studies easier. However, it depends always on the particular development process, solution, and situation in question whether or not one wants to apply the steps recommended in the aforementioned standards. Documentation of what has been done and why is therefore crucial.

When the development process is sufficiently documented, costs associated with UD activities can be calculated or at least estimated. The general approach would be to document and measure costs for new or extended activities included to increase both the technical and usable accessibility level of the solution.

One must bear in mind, though, that several of the activities that are recommended to achieve Universal Design, such as involving diverse user groups and conformance with accessibility guidelines, can be part of a general strategy for improved an ICT solution's quality. In a study concerning the motivation for implementing accessibility standards in websites, it was found that IT experts believe that improving accessibility also can contribute to an increased quality of the website in general, such as increased simplicity, clarity, usability, code quality, and download speed [39]. This illustrates the difficulty of separating Universal Design measures from general quality improvement measures. When studying the effects of UD, it is therefore important to monitor general quality-related parameters as well as accessibility-related parameters. Another aspect that should be mentioned is the fact that some of the activities and costs may only occur the first time an organization implements UD (e.g., acquiring certain accessibility testing tools), while other costs might decrease for each process (e.g., staff education). Yet other costs will occur each time (e.g., producing content such as providing alternative texts for new pictures or captions for new audio material). For a thorough CBA analysis, one should hence always document to what extent costs are a one-time investment or whether they are likely to occur in subsequent processes/projects.

With the example of requiring WCAG for achieving UD, previous studies and attempts of cost-benefit estimations list the following typical expenses posts [5], [40]: Staff training and education and/or buying of external expertise, modification of internal routines and quality assurance, system improvements (either as new systems or own development, or both) and/or acquiring necessary tools and equipment, content conversion and enhancements, and improved continuous content production. It is further advisable not only to calculate costs for particular areas, such as work, education, and transport as done in [40], but also to do uncertainty calculations for the estimated values by means of Monte Carlo simulations as done in [4].

To give more concrete examples, [40] estimates one-time expenses of 741 million NOK for the enrollment of WCAG 2 AA in Norway, while [4] estimates the costs for deploying WCAG 2 AA and ATAG 1 on websites of the public sector in Norway to be within 164 and 225 million NOK with a 90% probability, and with an average of 173 million NOK. A calculation for European countries (EU27) is given in [41], estimating 2.4 billion EUR for implementing web accessibility in the initial and first year.

3.3. Quantifying the benefits of the universally designed solution

So what positive impact and UD measures can be anticipated as compared with an ordinary solution, and how can these effects be measured?

Benefits come in different domains. On an individual level, it should be possible to use a barrier-free and usable solution effectively, efficiently, and with satisfaction, according to ISO 9241. While "effectively" means empowering, that is, giving all people the same rights and opportunities, "efficiently" refers to low costs, and low energy and time consumption.

Empowering applies to all aspects of life: To participation in work life, also at higher ages, the possibility for education, participation in democratic processes, including the ability to vote, utilization of public transport, participation in

organizations, associations, clubs, and many other aspects. There are multiple secondary effects too, such as better personal economy, more and better human relations and social networks, less human isolation, increased feeling of usefulness, integrity, dignity, mobility, and autonomy, as well as health/wellbeing (e.g. [42 – 44]), happiness, freedom, and a higher satisfaction with life in general.

Also increased efficiency applies to virtually all aspects of life: Faster task/problem solving, less time spent on decision making, higher personal productivity, as well as better communication and less expenses for assistive technology and human assistance are some of the more important aspects.

The organizational domain of the impact is applicable for companies, public entities and authorities, and member organizations alike. Here, UD solutions are anticipated to result in improved products and services, a greater target group (more customers/members), more satisfied customers, citizens, and employees, more sales (with the appropriate legislation and requirements), less expenses for user and member support, less expenses for legal cases concerning the lack of UD, and better public relations and reputation among customers and citizens, to name the most important.

On a societal level, barrier-free and user friendly solutions anticipate that citizens live longer independently, that there are more tax payers, less expenses related to social insurance and healthcare, increased possibilities for all to participate in public debate and political activities as well as various societal arenas, and therefore strengthened democratic principles, to name a few.

The general view in previous studies and reports is that it is impossible to quantify most of the aforementioned benefits [3 – 5, 40]. Indeed, measuring for instance an individual's perceived autonomy or feeling of dignity as the direct or indirect effect of Universal Design appears to be a venture of impossibility, not only due to the difficulty of quantifying feelings and subjective views, but also because there is an enormous number of other factors which may influence the outcome. In particular secondary effects and effects for society fall into this category. Only in a very few, rarest situations, a single universally designed solution would have a considerable impact on society. Other parameters, however, are perfectly measurable, many of which are related to general usability. We mention number of sales, time to target, number of clicks/taps, number of inquiries to customer support, customer satisfaction, and many more. A reference work here is [45]. Only measurable effects should be taken into account in CBAs. It is further advisable to weigh the impact of a particular measure with the anticipated outreach as done in [4]. Assume for instance that website A serves X people and another site dubbed B provides a service for Y people with $Y > X$. Then the outreach of the same measure on both sites differs, and thus the benefit of UD efforts on B is larger than the benefit of efforts on A. All assumptions, maximum and minimum values, confidence intervals, impact factors, and other techniques should be properly documented.

Despite the fact that only few systematic attempts have been made to quantify the benefits of UD, there is a number of indicators that the positive impact is likely to be immense. If only 5% of today's group of unemployed people with disabilities became and stayed employed over a 10-year period, an estimated NOK 13 billion (NOK 900 000 per individual) could be saved in Norway [46]. Another study from Canada estimates the production loss to be around 7% of the GDP if persons with disabilities are kept outside the workforce [47]. A U.S. report found that 57% of computer users of working age were likely or very likely to benefit from accessible technology due to mild or severe difficulties or impairments [48]. To get work experience in early years

has a positive effect for people with disability, and it increases the probability of being part of the workforce and contributing to society in later years [49], and to actually be employed or in education is an important welfare factor of a young adult [50]. The purely social gain for users of implementing web accessibility in European countries (EU27) is calculated to be an estimated 412 billion EUR [41].

4. Suggested approach for CBAs

To summarize the above discussion, we suggest the following first sketch of a procedure for a cost-benefit analysis as adapted from [51]:

1. Start with planning the UD process. We recommend to base the UD process on recognized standards and to carefully document the extra steps that are taken towards achieving UD.
2. Estimate the costs of implementing the UD plan. Once the plan is made, the extra costs connected accessibility can be calculated. It should be noted whether the costs are a one-time investment or whether they are likely to occur in every project. One should also ensure to record the actual costs so that they can be compared to the estimates later on.
3. Select relevant benefit categories. There are a number of potential benefits of UD, including various types of quality improvements. The benefit categories will depend on the type of ICT solution in question.
4. Estimate the benefits. This involves finding appropriate measurements units, tools, and techniques that can be used to measure the potential outcomes. Because most of the costs and benefits will be specific for the particular case in question, it is necessary to measure both before and after the UD process has been implemented.
5. Compare costs to benefits.

5. Conclusion

We have reviewed related literature and case studies and discussed how the costs and benefits of Universal Design (UD) of ICT solutions can be measured effectively and reliably. The discussion focuses on three main aspects: quantifying the solution's degree of UD, quantifying the costs of the UD process, and assessing the solution's benefits. We have discussed related research and case studies, and, based on this, proposed an approach to properly conduct and document cost-benefit analyses of UD projects in the future.

The discussion demonstrates that this is a complex area. The notion of Universal Design is still tightly linked to accessibility and is not clearly defined in terms of testability and operationalization. It is thus not clear what the eventual low-level goals are, and how these goals can be reached. We suggest that any relevant national and international legislation is unbound from their focus on accessibility and gives more attention to the involvement of users with disabilities during the development process. Regarding the costs of UD measures, we argue that any UD process should be based on user-centered design principles and related standards and thoroughly documented as to what parts of what standards have been adopted in the process. There are few case studies and estimates in this field, and comparability is doubtful due to insufficient

documentation of acknowledged factors, employed methods, and involved measurements. Further, we recommend to measure and estimate only primary and well specified benefits, in particular those related to usability, as such methods are well proven. Any estimations should be accompanied by uncertainty calculations to indicate the reliability of the given results. This applies to both costs and benefits and hence the overall bottom line.

Some of the previous studies have come up with estimates of both costs and benefits for the case of universally designed webpages and conclude with a positive bottom line, however without accurately specifying the benefits [3], [40]. A third report claims a negative bottom line on an organizational level, though [41].

To look ahead, well documented case studies are necessary to contribute to knowledge about the cost-effectiveness of UD. It is further mandatory with details about the organization and products/services in question, organizational characteristics, markets and customers, the specific UD process and techniques that are applied, as well as surrounding and contextual factors that might influence the outcomes.

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