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UNIVERSAL DESIGN IN DIGTAL SERVICES

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Euroopassa yli 15 prosenttia väestöstä on jonkinasteisesti toimintakyvyltään estyneitä. Hedelmällisyyden laskun ja eliniän odotuksen kasvun seurauksena maapallon väestö ikääntyy nopeasti. Vuoteen 2050 mennessä yli 60-vuotiaiden osuuden maailman väestöstä odotetaan yli tuplaantuvan ja yli 80-vuotiaiden osuuden yli triplaantuvan. Samaan aikaan digitalisaation seurauksena yhä useampi tuote ja palvelu on saatavilla digitaalisessa muodossa. Digitaalisten palveluiden kehittäjien olisi hyvä huomioida muuttuvat käyttäjäryhmät ja -tarpeet toteutuksissaan. Universal Design (UD) on keino vastata kasvavaan tarpeeseen huomioida monimuotoisia käyttäjäominaisuuksia.

Tämän tutkimuksen tarkoituksena on tarjota UD ratkaisuja ja suuntaviivoja digitaalisten palveluiden suunnittelijoille antaen samalla katsauksen UD:hen liittyviin esteisiin, ajureihin, haasteisiin ja hyötyihin. Aihe on kirjallisuudessa jokseenkin kattavasti tutkittu, mutta varsinaisiin ratkaisuihin ja suuntaviivoihin liittyvä informaatio on laajalti jakautunut lähteisiin, jotka vain sivuavat aihetta. Tämän lisäksi kirjoittajat käyttävät aiheeseen liittyvää terminologiaa usein epäjohdonmukaisesti.

Tutkimus on suoritettu kirjallisuuskatsauksena. Tutkimusmateriaali koostuu pääosin verkkopohjaisista tieteellisistä artikkeleista ja kirjoista. Joitain lähteitä muualta käytetään taustatiedon, tutkimuksen perustelun ja resurssien esittelyn mahdollistamiseksi.

Tutkimuksen tuloksena on kerätty useita ohjenuoria ja resursseja auttamaan suunnittelijoita implementoimaan UD-ratkaisuja malleihinsa. Vaikka yksittäistä oikeaa mallia ei ole olemassa, UD-käytäntöjä implementoimalla tulisi pyrkiä saavuttamaan mukautettu käyttöliittymä, joka on tarpeeksi sopeutumiskykyinen ja joustava huomioimaan käyttäjien välisiä tietokuiluja sekä erilaisia kognitiivisia, havainnollisia ja motorisia käyttäjätarpeita. Suunnitteluprosessissa käyttäjän vuorovaikutus on arvokasta käytettävyyden arvioinnissa ja tarpeiden kartoittamisessa.

Tutkimuksen tulokset ovat yleisesti päteviä suunnittelijoiden ja jatkotutkimukseen sovellettaviksi, mutta lisätutkimukselle aiheesta jää vielä huomattavasti varaa.

ABSTRACT

ILPO TOIKKANEN: Universal Design in Digital Services
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In Europe more than 15 percent of the population is disabled. Due to decline in fertility and increase in life expectancy the world's population is ageing rapidly. By the year 2050 the global population aged over 60 is projected to more than double and the number of people over the age of 80 more than triple. At the same time digitalization is resulting in an increasing amount of products and services being provided digitally. Digital service designers would be wise to address the changing user groups and their needs. Universal Design (UD) provides means to tackle the increasing need for addressing more diverse user characteristics.

This study aims to provide designers with UD solutions and guidelines for digital services while taking a look at the barriers, drivers, challenges and benefits regarding UD. The topic is relatively well researched in literature, but information regarding actual solutions and guidelines for UD in digital services is scattered within material only siding the matter. On top of this authors often use non-consistent terminology.

The study is conduced as a literature review. Research material consists mostly of web-based scientific articles and books. Some other material is used for background information, justification purposes and introducing resources.

As a result of this study, multiple guidelines and resources are gathered to aid designers in implementing UD in their designs. While no single solution will suffice, in implementing UD practices one should aim for a customized interface that is adaptable and flexible enough to address user knowledge gaps and various cognitive, perceptive and motoric user characteristics. In the design process user interaction is valuable and can be useful for mapping user needs and evaluating usability.

The results of this study are generally applicable for designers and further research. The need for more research on the topic still definitely exists.

ACKNOWLEDGEMENTS

This study is completed as a part of the bachelor's degree programme in information and knowledge management at Tampere University in the spring of 2019. The topic for me isn't very personal, but I do promote equal opportunities for everyone and feel like the subject is both relevant and timely.

I would like to thank my family, friends and fellow students for supporting me in finishing this study. A special thanks goes to the teacher responsible of the bachelor's thesis course, Pasi Hellsten, who has been very understanding regarding the schedule within which this work was completed.

Tampere, 30.03.2019

Ilpo Toikkanen

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ABBREVIATIONS

ARIA	Accessible Rich Internet Applications
HHS	Health and Human Sciences
ICT	Information and Communication Technologies
UD	Universal Design
WAI	Web Application Initiative
WCAG	Web Content Accessibility Guidelines
W3C	World Wide Web Consortium

1. INTRODUCTION

1.1 Background and justification of study

Between 1994 and 1997 the Center for Universal Design in North Carolina conducted a research and demonstration project about the development of Universal Design. Further in 1997 a group of product designers, engineers, environmental design researchers and architects were put together to gather from the existing knowledge base a set of principles of Universal Design (UD). These principles are called "The Principles of Universal Design" and there are seven of them. (Story 1998, p. 7.)

According to the group of people who compiled them, The Principles of Universal Design aim to guide the designing of environments, communications and products. They can also be used to evaluate existing designs and as an aid to both consumers and designers about the attributes of more usable products. (Connell, Jones et al. 1997).

Digitalization has been a trend for some time resulting in more and more products and services now being accessible online via digital channels (e.g. Alamäki, Dirin 2015, Hofemann, Raatikainen et al. 2014). For example in Norway the efforts towards this have led in the legislation of Universal Design of ICT (adopted in July 2013), which states that websites, mobile applications and self-service machines are to be designed in accordance with UD regulations with the purpose of promoting equality regardless of disability (Rygg, Rømen et al. 2016, pp. 471-472.). The legislation is a part of Norwegian Digital Agenda which among other goals aims to digitalize public services (Norwegian Ministry of Local Government and Modernisation 2016).

Norway is not alone with the agenda. New Zealand and Australia provide governmental services online and the shift towards an e-Governmental services is happening all around the world (Gauld, Gray et al. 2009). Finland is currently committed to a government program that aims to digitalize and make public services more user-centric by the year 2025 (Valtioneuvosto).

United Nations World Population Prospects: the 2017 revision states, that by 2050 the global population aged over 60 is projected to more than double and the number of people over the age of 80 more than triple. Decline in fertility and increase of life expectancy result in a global trend of world population ageing. Apart from Asia and Africa, birth rates globally are declining. In Europe over 25 percent of the population is already aged over 60 and the share is projected to grow to 35 percent by the year 2050. (United Nations, Department of Economic and Social Affairs, Population Division 2017)

According to Eurostat, which produces statistics for European Union under the European Commission, roughly 15 percent of the European population between 15 and 64 years old

have a disability (Eurostat 2015). The real percentage is definitely higher given unreported cases and counting people over the age of 64. Disabled people therefore account for a significant portion of the population.

Given the ageing population and amount of disabled people worldwide, in designing digital public services, the need for UD is definitely pressing. Both public and private organizations are looking for digital solutions for saving costs and increasing productivity. Digital solutions are already a part of most service processes in majority of all private and public sectors (Alamäki, Dirin 2015). Multiple studies either directly or indirectly claim that by ignoring the UD aspects in designing services, companies may be missing out on additional revenue (e.g. Björk 2009, Kurniawan 2009, Persson, Åhman et al. 2015).

1.2 Research problem and confining the scope

This thesis researches UD in digital service design with the purpose of gathering information on existing guidelines and solutions for designers to use for implementing UD. The actual process of service designing is mostly ignored in order to keep the results within reason and the emphasis is on providing tools and help to use in the process. The study explores reasons for practicing UD and takes a look into the inhibitors and drivers now and in the future.

From literature point of view the study focuses around UD without exploring too deep into inclusive design, design for all, accessible design etc., which are similar schools of design. While these schools share similarities and goals with UD, they generally highlight slightly different aspects of accessibility and usability.

The main research question is: **What guidelines exist for designing universally usable and accessible digital services?**

Sub-questions to help the main question:

- What is UD?

  In order to understand what it is the study tries to find solutions for, it is important to define UD.

- What challenges and benefits does practicing UD present?

  In order to find answers it is important to define the problems and challenges. Exploring the challenges and barriers, that make (or prevent) the use of UD harder, will provide the counterpart for the solutions sought. Understanding the benefits will aid in justifying practicing UD and implementing found solutions.

- What are the key elements in UD for digital services?

Understanding the key elements that make a successful design will help evaluate the usefulness of found solutions.

1.3 Structure of the study

This study consists of six chapters. The first chapter focuses on background and justification of the study. The second chapter presents the research method and acquisition of materials. The third chapter opens up the general definitions for UD and usability and further links UD with digital services.

In the fourth chapter an all-around look is taken between the barriers and challenges, and the drivers and benefits regarding UD. Looking from company, designer, social and commercial aspects this chapter aims to explain why UD is, is not or could be practiced.

From a semi-practical point of view, the fifth chapter presents guidelines, solutions and resources to help practice UD in designing and overcoming some of the challenges presented in chapter 4. The sixth chapter consists of results, assessment of results and further research possibilities.

2. RESEARCH METHODOLOGY AND MATERIALS

2.1 Research method

This study is conducted as a literature review. The research material consists mainly of books and articles found in online databases.

In order to ensure a systematic and repeatable results, the study mostly follows Fink's (2014) process model for conducting literature reviews. According to Fink, the process can be divided into seven major steps:

1. Selecting research questions
2. Selecting databases and websites
3. Choosing search terms
4. Applying practical screen (e.g. years searched, language)
5. Applying methodological screen (e.g. data analysis, conclusions)
6. Doing the review
7. Synthesizing results

Databases used for finding source material are Andor, Scopus and Web of Science. Andor searches all material acquired for Tampere University and can yield a relatively large amount of results. Scopus and Web of Science are used to narrow down the results when Andor yields a large amount of non-relevant material. Some material for justification, background of study and resources is acquired outside of these databases.

Beyond refining search words and applying said screens, a subjective assessment of relevance has been made during the gathering of materials. Table 1 presents some of the search words and screens used for filtering results.

Table 1. *Returns from some of the search terms and filters used*

Search term	**Filter/s**	**Andor**	**Web of Science**	**Scopus**
("universal usability" OR "universal design") AND digital AND "public service"		155	0	2
"universal design" AND service* AND digital	Year >= 2010	3112	24	28
"universal design" AND ("design for usability" OR "user-centered design")	Topic related fields	91	13	32
usability AND "universal design"	Topic related fields	848	72	251

Cited articles were held in higher regard even though some of them were relatively old (from the 90s). Some relevant source material was also found via the references of used sources.

3. UNIVERSAL DESIGN

3.1 Definition

UD, inclusive design, design for all, universal access, accessible design. These are all related terms with close and overlapping definitions and a relatively common goal. The terms are sometimes used in literature as synonyms (e.g. Bradley, Langdon et al. 2015, Fletcher, Bonome-Sims et al. 2015). The similarities and differences between these terms and the concepts behind them are further elaborated in a study about the concept of accessibility by Persson et al. (2015).

The definition of UD by the Center for Universal Design in 1997 is for products and environments to be usable by all people, and to the greatest extent possible, without the need to adapt or specialize (Connell, Jones et al. 1997). UD was mainly meant to guide architects, environmental engineers and product designers – there was no direct link to programming.

Since, the definition has grown to cover services and the digital aspects of designing. The Centre for Excellence in Universal Design uses the definition from the Disability Act 2005 (Ireland), which, in addition to the former, includes all electronic-based processes of creating products, services and systems, and specify that they should be usable in the most independent and natural manner without the need for assistive devices (National Disability Authority 2014).

The key word in both of these definitions is "**usable"**. Usability of a service or a product is a result of its design. Nielsen (1994, p. 26.) defines usability through five attributes: *learnability* – speed with which users can learn the system, *efficiency* – once learned, possible to reach a high level of productivity, *memorability* – having not used the system for a while, the user doesn't have to learn everything again, *errors* – low error rate and good recoverability from errors, *satisfaction* – users should be subjectively satisfied when using the system.

According to the International Organization for Standardization (ISO) **usability** is defined as the

> *"extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* (International Organization for Standardization 2010)

It is important to note that UD is a process and there are no universal designs in the sense that they would actually be usable and accessible for the whole diversity of the human race.

3.2 In context of digital services

Wheelchair ramps, elevators, disabled parking, toilets suitable for disabled, pedestrian crossings with both lights and sound. These environmental solutions and technological products such as phones, televisions and automobiles are already addressing universal usability (Meiselwitz, Wentz et al. 2010). Outside of the digital world enabling access for the disabled has become a norm and there is an increasing need for it in ICT as well (Björk 2009).

As traditional services transform and products take on digital forms, an increasing amount of services is being provided via digital channels (Alamäki, Dirin 2015, Hofemann, Raatikainen et al. 2014). In digital services it is important to understand the whole customer journey in order to design the best possible solution. Unlike in traditional services, there is no human intelligence to adapt to the various needs and behaviour of the users. (Hofemann, Raatikainen et al. 2014)

Another definition for usability by Nielsen (2012) is to see usability as a quality attribute that assesses how easy interfaces are to use. In digital services, interface is the one thing that the user directly interacts with. A big part of UD in digital service design therefore is finding and implementing solutions that improve the usability of the user interface. One aspect raised in literature is that in applying UD practices one should also account for multi-device and technological variety. (Seffah, Engelberg 2015, Fuglerud 2009)

Digitalization alone can be a step towards more universal design, but it is important to keep in mind that transforming content to be only available in a digital form can completely exclude some user groups if those groups' needs are not well considered in the design. (Ferri, Favalli 2018)

4. UNIVERSAL DESIGN IN PRACTICE

4.1 Barriers and challenges

Pressure for UD outside of the public sector doesn't really exist. Practicing UD is either not profitable or not perceived profitable (Vanderheiden 2009). Private companies are often influenced more by commercial than social concerns (Björk 2009). In other words either the successful and profitable implementations of UD aren't documented and well known enough, or the current methods aren't efficient and rewarding enough to use outside of specific areas. Meiselwitz et al. (2010) note that if UD is not included in the design process from the beginning, the costs for it can become very high.

Elderly people aren't categorized as disabled, but it's proven that ageing affects perceptual, cognitive and motoric skills. Notable changes to e.g. eyesight, hearing, memory, speed one's of cognitive processes, focus, reaction time, accuracy and even to behaviour can occur. These changes and others may also be the results of age related diseases. (Kurniawan 2009)

It can be hard recognizing the real user needs and even harder to address them in an appropriate way. Depending on the intended user groups, multiple UD related solutions might be needed for accommodating the whole variety of the user population. Righi et al. (2017) also mention that in designing for the elderly one should not only focus on compensating for the downsides, but account for other aspects of ageing such as change of habits etc. as well. The same goes for disabled people: addressing the needs of a blind person one should understand the behaviour and habits that come along with the disability.

Even though UD as a general concept is widely recognized and understood, it is not so commonly practiced by the developer community (Björk 2009). As stated in chapter 3, there are multiple terms with overlapping meaning around accessibility and usability of products, services and environments. Persson et al. (2015) point out in their study that the lack of consensus regarding the terminology used might be hindering the adaptation of UD practices on a wider scale.

As other potential barriers for UD Björk (2009) mentions technical and technological complexity, lack of interest, knowledge and techniques. Supporting her claim also Vanderheiden (2009) notes that while technological advancements produce countless opportunities, the increasing complexity of devices and interfaces produces new challenges for UD in the future.

Outside of the technological aspects, Fuglerud (2009) brings up user diversity and user knowledge gaps as some of the biggest challenges for UD. According to her, it might not be possible to design a digital service that anyone can use without prior experience of ICT. This raises the challenge of how to define the basic level of knowledge designers can expect of the users.

Measuring the usability of designs is another challenge. There are standards and models for helping assess the usability of interfaces and defining quality attributes in software metrics. Collecting, defining and interpreting the results into something accurate and useful can be hard and a need for actual models to help measure usability from a universal aspect exists. (Seffah, Engelberg 2015)

4.2 Drivers and benefits

As mentioned in Chapter 1, the world's population is ageing rapidly. Whereas this means there will be a need to address the older population's needs in designing accordingly, it also presents business opportunity – not only the numbers, but also the buying power of elderly people increases (Björk 2009, Kurniawan 2009).

A general misconception is that UD is just designing for the elderly and disabled. UD aims to design for everyone including the former. It is argued in literature (Bradley, Langdon et al. 2015, Story 1998, Persson, Åhman et al. 2015), that applying UD principles in design, even though sometimes unnoticed by the user, will often improve the overall usability and user experience even for those not impaired. Vanderheiden (2009) gives examples of how non-disabled individuals might situationally benefit from interface features designed for targeted disabilities (Figure 1).

Requirement	Disability-Related Need	Situation-Related Need
Operable without vision	People who are ***blind***	People whose ***eyes are busy*** (e.g., driving a car or phone browsing) or who are ***in darkness***
Operable with low vision	People with ***visual impairment***	People using a ***small display*** or in a high-glare, ***dimly lit environment***
Operable with no hearing	People who are ***deaf***	People in ***very loud environments*** or whose ***ears are busy*** or are in ***forced silence*** (library or meeting)
Operable with limited hearing	People who are ***hard of hearing***	People in ***noisy environments***
Operable with limited manual dexterity	People with a ***physical disability***	People in a ***space suit*** or ***chemical suit*** or who are in a ***bouncing vehicle***
Operable with limited cognition	People with a ***cognitive disability***	People who are ***distracted***, ***panicked***, or under the ***influence of alcohol***
Operable without reading	People with a ***cognitive disability***	People who just ***have not learned to read a specific language***, people who are visitors, people who left reading glasses behind

Figure 1. *Overlapping interface requirements for user needs in relation to disability and situation (Vanderheiden 2009, p. 2.)*

Also Meiselwitz et al. (2010) state that strategies and technologies that integrate universal usability in interfaces have benefits beyond the intended user group. As an example a summary of these benefits is provided in Figure 2.

Solutions	Visual Imp.	Auditory Imp.	Motor Imp.	Cognitive Imp.	Learning Disab.	Age
Screen readers/voice output	x			x	x	x
Screen magnifiers	x			x		x
Captioning		x			x	x
Signing		x				
Speech recognition	x		x	x	x	x
Multi-sensory interfaces	x	x	x	x	x	x
Adaptive interfaces	x	x	x	x	x	x
On-screen keyboards			x	x	x	x
Self-paced interaction	x	x	x	x	x	x
Reduced complexity			x	x	x	x

Figure 2. *A table showing cross-benefits of integrating interface features that improve universal usability (Meiselwitz, Wentz et al. 2010, p. 258.)*

When designing for the elderly, one has to account for the age-related impairments of users. According to Kurniawan (2009), an obvious solution is to just implement UD principles to accommodate a wide variety of user characteristics.

From a business point of view both Persson et al. (2015) and Björk (2009) argue that by offering products and services that meet higher accessibility and usability companies may reach broader markets and claim otherwise lost revenue. Persson et al. (2015) further mention that companies choosing to use accessible technologies are likely to benefit their workforce. Logically in many cases it also widens the range of people the company is able to hire.

Non-discrimination and equality are important trends moulding our society. Companies investing in UD might not only benefit from the variety of customers they've given access to, but also positively affect their brands and promote themselves as a companies that care (Björk 2009). Given competition, such association can be a deciding factor among consumers.

A technological enabler now, and even more so in the future, is that people can be connected online pretty much from anywhere around the world and all the time. In practice, for disabled people, this can in some situations eliminate the need for a caretaker's presence as help can be available just by pressing a button. (Vanderheiden 2009)

Government programmes, disability acts, legislations and initiatives among with laws and regulations can also push companies towards more accessible designs (Ferri, Favalli 2018).

5. SOLUTIONS, GUIDELINES AND RESOURCES

5.1 Guidelines and directives

Regarding UD in literature, The Principles of Universal Design put together back in 1997 is one of the most frequently cited to advice for designers (Persson et al. 2015).

The seven principles are:

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

The principles are each presented with a brief description and 4 to 5 guidelines – elements that are key in the design regarding given principle (Connell, Jones et al. 1997). Even though the principles weren't originally created for designing services, they cover the aspects of UD very thoroughly and most of the guidelines are well applicable.

In her book Human-Computer Interaction Preece (1994) offers directive principles for designing an interface that is accessible and usable for everyone:

- Know the targeted user group and be sympathetic to their needs.
- Reduce cognitive load. Users should not have to remember large amounts of detail.
- Engineering for errors: provide good error messages and means to correct the error. Try to prevent error and aim for making errors to be harder (forced paths of action).
- Maintain consistency and clarity. Using appropriate metaphors to help create and maintain a mental model.

She also notes that a designer's ideas about what is clear are based on their knowledge of the users. Even though these directives are quite old, they are on a very general level and still quite applicable.

Including UD concepts in the design process from the very beginning instead of treating UD as a separate goal with separate costs will increase the probability of a successful design and minimize the costs of UD. Implementing UD into an already existing interface

is a lot harder than designing the interface accordingly from the beginning. (Meiselwitz, Wentz et al. 2010).

Björk (2009) along with Petrie and Bevan (2009) mention user-centered design as something that could be used with UD in order to understand the needs of the user and placing the user as a focus point around which to build the design. Persson et al. (2009) mention that having users with defined difficulties in their functioning participate in testing or designing regarding usability in that area can be very effective. They do however note that you don't want to end up choosing participants only according to their limitations as in that case you might not get a proper representation of the real users.

Understanding the user's needs is important for any design process, maybe even more so in UD. User involvement in all stages of the design process can be a big help if not imperative in order to ensure usability. Another solution for helping understand the user's needs can be creating *personas* as substitutes for real users so that the designers can better make decisions based on the "user's" point of view (Clarkson, Coleman et al. 2007). Even though personas might not always be *the* solution needed, if users are not deeply involved in the design process, designers should probably consider using *some* techniques for understanding the users' point of view.

Seffah and Engelberg (2015) suggest that universality should be defined as a quality attribute of a design. Under their working definition universality is observed and measured in three different dimensions: *User and User Experience Diversity* – the degree to which user variety is accommodated while supporting their evolving experience, *Platform and Device Variety* – capacity to deal with today's and tomorrow's changing capabilities and constraints both in software and hardware aspects, *Interactivity and User Interface Variability* – capacity to support different interaction styles including (multiple) input modalities and output media channels.

Petrie and Bevan (2009) suggest that designs should be evaluated from the aspects of accessibility, usability and user experience. They group the methods for evaluation under the following groups:

- Automated checking of conformance to guidelines and standards
- Evaluations by experts
- Evaluations using models and simulations
- Evaluations with users or potential users
- Evaluation of data collected during system usage

Suitable evaluation methods vary on the type of the design and evaluation goals.

5.2 Solutions

In designing interfaces that accommodate different levels of knowledge and experience in information and communication technologies (ICT), the goal should be to design one interface that is flexible. Features like online help, keywords searches and well-constructed error messages can reduce cognitive workload and task complexity. Frequently asked questions (FAQs) and user communities can utilize users to produce helpful information for fellow users. (Meiselwitz, Wentz et al. 2010)

Seffah and Engelberg (2015) agree that universality should not be conceived as an effort to construct a single solution for everybody, but instead, within a design, to provide customized solutions designed appropriately for alternative user characteristics. Fuglerud (2009) and Meiselwitz et al. (2010) mention interface customization as a way to tackle user diversity.

Meiselwitz et al. (2010) go a little further into detail on the different options in creating customized interfaces. They list multi-layered, multimedia, multimodal and adaptive interfaces as options that support a more diverse user population. *Multi-layered* interfaces support a variety of skill levels and can provide different levels of interaction for novice, intermediate and advanced users. *Multimedia* interfaces and *multimodal* interfaces provide users with options for interaction modalities. Given options can be, for example, such as text, images, video or audio. *Adaptive* interfaces can learn from user interaction and adjust the interface accordingly. While they can improve usability for example on small-screen devices, they have been criticized for potentially limiting effectiveness and productivity in cases where users are not fully aware of the options available. (Meiselwitz, Wentz et al. 2010)

De Castro Lozano et al. (2011) agree on using multimodal interfaces to enable different types of user-interface interaction. The methods for interacting included in the design depend on the targeted users. They further note that the technology in current multimodal interfaces is still evolving and it should eventually provide a way to remove barriers which, in situations of dependency, deny people access to certain technologies (de Castro Lozano, Salcines et al. 2011).

Google's search engine is a widely used (free) service. If we take a look at its interface view on a browser shown in Figure 3 we can recognize multiple UD viable solutions implemented in the interface.

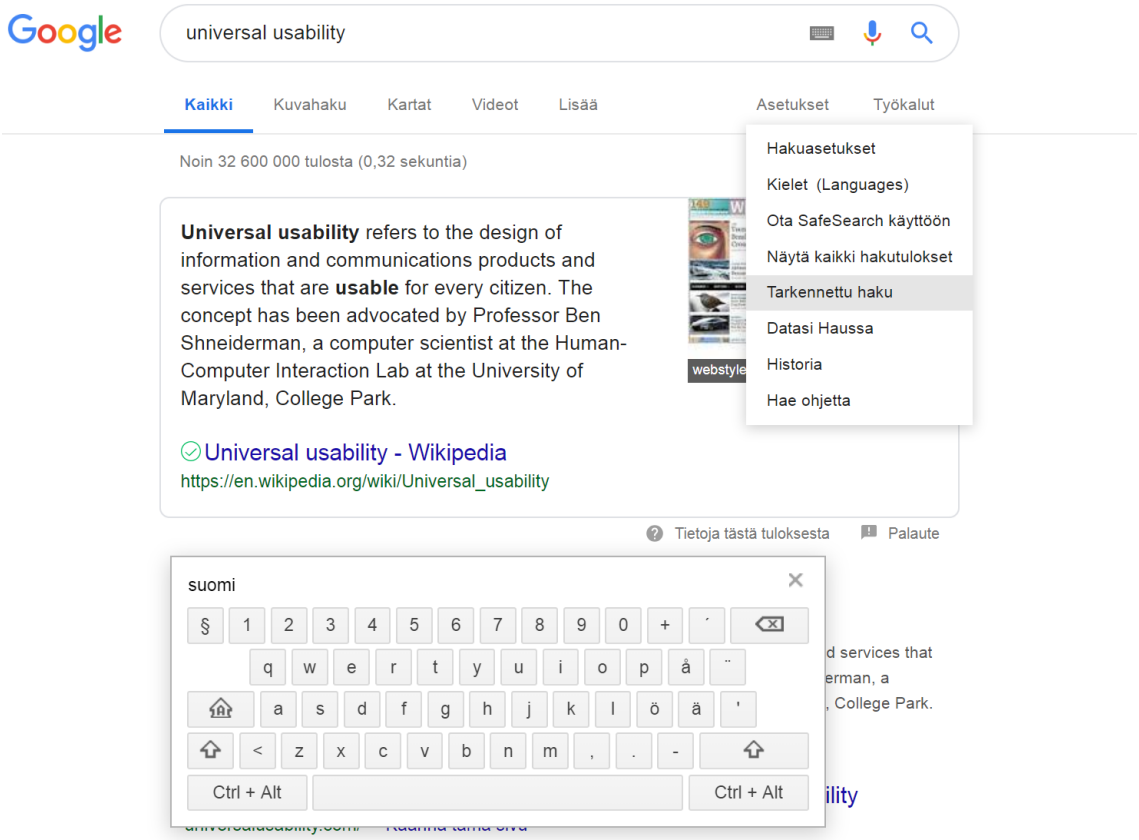

Figure 3. *Google search engine on a browser (Google)*

The interface allows to conduct searches via keyboard, mouse (virtual keyboard button on the search bar) and voice (microphone icon on search bar), enabling use for a variety of users. To address user knowledge gaps, advanced users can use the advanced search option (highlighted in darker grey) and modify search options. Apart from the normal personalization settings users have, Google also provides separate accessibility settings such as a screen reader and high contrast colours for some of its services.

5.3 Resources

Basically all the guidelines listed before in subsection 5.1 of this chapter can be considered as resources for both designing and evaluating existing designs. The following are more standardized or concrete tools and resources available.

Web Content Accessibility Guidelines (WCAG) 2.1, recommended by World Wide Web Consortium (W3C) (2018), can be used as a tool to help creating web pages, web applications and other ICT accessible and usable for all. These guidelines can also be used for assessing the usability of already existing web content. For example in the Norwegian legislation of Universal Design of ICT it is regulated that both new and existing web content are to meet 35 out of the 61 success criteria defined in WCAG 2.0 (Norwegian Ministry of Local Government and Modernisation 2016).

The Accessible Platform Architectures group working under W3C has a working draft online on Media Accessibility User Requirements, which presents accessibility requirements along with some alternative technologies as solutions to meet the needs for users with disabilities in relation to audio and video. The draft is to become an updated version of the previous publication in 2015. (W3C 2019)

Another recommendation, Accessible Rich Internet Applications (ARIA) 1.0, that defines accessible interface elements that can be used with assistive technologies in order to improve accessibility and interoperability of applications and web content was published in 2014. The recommendation was put together by the ARIA working group under W3C and it has since been updated to ARIA 1.1 in 2017. (W3C 2017)

The guidelines above are products of W3C's Web Accessibility Initiative (WAI) that aims to produce international standard level guidelines in a consensus-based process involving stakeholders in the Web accessibility such as disability organizations, industry, government and accessibility research organizations. Guidelines and evaluation tools produced by WAI offer a large bank of resources for designers. (W3C)

The Department of Health and Human Services (HHS) in the United States has put together multiple accessibility standards and usability guidelines with the intention to provide the best practices for web design and digital communication issues.

Chen et al. (2016) note in their findings that for recruiting participants for UD testing, it is important to acquire and maintain good relationships with non-governmental organizations and disability organisations and to show the potential participants the benefits from the testing.

Even the most unique interfaces and designs share commonalities and features. A massive amount of digital services already exists online and they can and probably should be considered as a (sometimes free) resource. Nielsen (2012) mentions testing your competitor's designs as a way to collect cheap data on a variety of alternative interfaces that share similar features with your own.

6. CONCLUSIONS

6.1 Results

In the public sector a partially social pressure for equality and non-discrimination pushes governments and organizations to form laws and regulations that drive the service industry towards more universally usable and accessible solutions. Outside of the public sector the shift towards UD is much slower. Some challenges regarding UD are user diversity, user knowledge gaps, technological complexity and usability testing.

Multiple studies highlight that benefits of practicing UD aren't generally perceived to outweigh the costs of investment. Companies should not think of UD as a separate investment or goal. If UD is integrated to be a part of the whole design process from the very beginning the costs can be quite minimal. Implementing UD at a later stage of design or to an already existing design can be hard or even impossible, and most definitely more expensive.

There are benefits to practicing UD. Other studies claim that companies will possibly miss out on additional revenue if UD aspects are ignored. Elderly people are a growing consumer force and addressing a larger variety of user characteristics allows for reaching more users in general. Implementing UD solutions generally improves usability for non-disabled people as well resulting in improved user experience. Practicing UD can also improve the image of the providing company in the eyes of customers.

For usability in general, but especially in UD, it is imperative to understand the user needs. User involvement during all stages is useful for evaluating the design and user-centered design can be a useful approach in UD. Whether involving actual users or not, evaluating the design throughout the whole process is important to ensure the usability and accessibility of the end product.

Outside of user testing and input, designers should use available guidelines and standards for testing the design during the design process. The more guidelines and standards the design is tested against the better, but given the vast amount of guidelines available it would be impractical and probably even impossible to use them all. There appears to be no single set of widely recognized guidelines that has been or could be accepted as a general standard suitable for testing accessibility and usability.

The lack of such guidelines is probably at least partially due to the lack of consensus on the definitions and terminology considering UD. Different schools of design publishing books and guidelines of the same area under varying terminology makes it hard to construct something that would be adopted by all. Having the information spread out makes

it also harder for designers to gather which might be hindering the adaptation of UD in general.

Just as there are no definitive guidelines, there are no concrete universal designs. No single design is actually usable by everyone and in practice the designs are usually designed keeping specified target groups in mind. Benefits of UD solutions often extend to multiple user groups and for example in using general UD principles, the needs for elderly people are sometimes met without much specialization.

Key elements for designs are flexibility and adaptability to cover the wide variety of user characteristics and different levels of knowledge. The aim should be to make the design usable for as many as possible by including interface features that accommodate special user groups.

6.2 Assessment of results

The study answers the research questions quite well. As it turned out, the study didn't yield so many concrete *solutions* but more guidelines, directives and standards to be used to aid the designing process. Some technical and technological solutions were included as well. The more cited results were generally a bit older and concerned usability, but were still often referred to in newer research.

Research specifically about digital service design and UD linked together is rather scarce and some of the results are derived from ICT solutions regarding UD or UD guidelines in general for usability of services and products. Some of the results implied that the UD practices and solutions be applied to the interface design rather than the design as whole thereby resulting in some confusion regarding the process.

In general the results presented in this study should be applicable and of use for designers and further research.

6.3 Further research possibilities

If practicing UD is to become more common among designers, there is definitely a need for research about the concrete results of applying UD principles in digital service design from both usability and business points of view. Such research could help justify the shift towards UD in private sectors.

Collective research on UD solutions in ICT is still rather theoretical and more practical examples are lacking. Relatively new and developing technologies such as virtual reality, augmented reality, multimodal communication and others could provide ground for research in future UD applications.

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