LAB University of Applied Sciences

USER-ORIENTED DESIGN OF ACCESSIBLE SMART HOME SOLUTIONS

LAB UNIVERSITY OF APPLIED SCIENCES
Engineer (UAS)
Information and communications technology
Autumn 2020
Axel Tuomala

Abstract

Author(s)	Type of publication	Published
Tuomala, Axel	Bachelor's thesis	Autumn 2020
	Number of pages	
	42	

Title of publication

User-oriented design of accessible smart home solutions

Name of Degree

Engineer (UAS), information and communications technology

Abstract

Accessibility, user-oriented design, and ethics often go hand in hand, especially in the field of health care technology. This work examines the aforementioned themes through practical examples of typical user experience design practices in a service design project that was commissioned to improve a senior smart housing product. The aim was to increase the quality of life of the residents, and as such the quality of the service itself. As such, this publication is very interdisciplinary and mixes information and good working practices from the fields of technology, design and health care to enhance the quality of the end results.

This work revolves around the ethical design issues that were discovered in a smart home redesign project. The exponential growth of ICT will soon clash with the needs of the aging population and the advancements in the field of health technology. The subject of this paper is addressing many current overlapping issues at the time of the publication. It presents a critical view of accessible design and ethics in the field of information technology.

Keywords

User experience, user-oriented design, user experience design, UX design, service design, easy access, accessibility, smart homes, IoT, Internet of Things, assistive technology, ethics, health information technology

Tiivistelmä

Tekijä(t)	Julkaisun laji	Valmistumisaika
Tuomala, Axel	Opinnäytetyö	Syksy 2020
	Sivumäärä 42	

Työn nimi

Saavutettavan älykodin käyttäjälähtöinen suunnittelu

Tutkinto

Insinööri (AMK), tieto- ja viestintätekniikka

Tiivistelmä

Saavutettavuus ja käyttäjälähtöinen muotoilu ovat usein yhteydessä toisiinsa erityisesti terveydenhuoltoteknologioiden alalla. Tässä työssä tutkitaan edellämainittuja teemoja käyttämällä käytännönläheisiä esimerkkejä tyypillisestä muotoiluprojektista, jonka tehtävänä oli parantaa seniorien älytalotuotetta. Tähtäimessä oli nostaa asukkaiden elämänlaatua, ja sitä kautta myös itse palvelun laatua. Näistä syistä tämä julkaisu on hyvin poikkitieteellinen ja siinä esiintyy tietoa ja hyviä työkäytänteitä tekniikan, muotoilun ja terveysalan aihepiireistä. Näillä keinoilla voidaan saavuttaa parempi lopputulos käytännön työskentelyssä ja hyödyttää työelämää.

Projektissa tutkittiin eettistä suunnittelua tietoteknisen älytalotuotteen uudelleensuunnittelussa. ICT-alan eksponentiaalinen kasvu ja ikääntyvä väestönrakenne törmäävät vääjämättä tulevaisuudessa terveysteknologian kehitykseen, tehden tästä aihepiiristä erittäin ajankohtaisen. Työ käsittelee kriittisellä tavalla teknologiankehityksen eettisiä ongelmia.

Avainsanat

Käyttäjäkokemus, UX-muotoilu, palvelumuotoilu, käytettävyys, saavutettavuus, käyttäjälähtöinen suunnittelu, älykodit, IoT, sensorit, avustava teknologia, eettinen suunnitelu, terveysteknologia, etiikka

TABLE OF CONTENTS

1 INTRODUCTION

The drastically aging population structure of Finland is a common topic of discussion. This global megatrend is creating an increase in the demand for accessible living solutions for the disabled and the elderly. In 2011, around 15% of the population of the world was in some way disabled already (The World Bank 2011). These numbers can be expected to grow in the future and will affect the countries with similar population structure due to the aging population increasing the demand of accessibility. It should also be noted that health technology is expected to receive even more emphasis in the future (Alam 2012, 13), making it a very significant technological industry in terms of the subject of future solutions for the elderly and the disabled.

While many members of the aging population suffer from multiple common disabilities that are a natural part of aging, it should also be noted that other disabled people can benefit from similar accessible solutions as well. Equal access to services can only be achieved by focusing on increasing the accessibility of the current and future solutions that are offered to consumers. Many public sector organizations are already required to offer accessible web content by law, and private sector organizations have followed suit and even developing accessibility further.

One such technological solutions is smart home technology. Smart homes can automate certain everyday functions as well as monitor and analyse a resident's activities and condition to some extent. These functions are often used in the field of elderly care to provide a safe yet private home environment to live in for many individuals who are still able to live independent and fulfilling lives with some assistance. The individual's experiences and role in a smart home that gathers data of their everyday life is especially interesting as the issues with privacy and data gathering have been a trend in the field of ICT. Many accessibility guidelines and laws should be seen as a bare minimum for accessibility, as the practical results may not actually accommodate many typical disabled users. Involving the users in the design of the space as well as using user-oriented design tools is recommended for good-quality results.

In this document the focus will be the tools and the structure of a very typical user experience design project aiming to achieve better accessibility and living conditions in accessible smart homes. Many practical examples are based on a larger service design project that was completed for Lahden Diakonialaitos, but the actual focus will be on only the issue of smart homes and the areas of experience design concerning their development. Accessibility and user-oriented design can enhance the end results in nearly any field, as the aim is to create a technological product that promotes innovation and increases user

satisfaction at the same time. Studying the users and the inanimate objects and services in such design projects can even lead to unexpected social, technical and economical advancements.

Critical views on ethical issues hidden in technological products and services should be talked about freely during this project, as the aim is to develop better, more ethical products and services. This is useful for the development of the product or service itself, and typically aims to benefit the users, the organizations producing them, and those who are connected to the organizations. More critical views during a design or redesign process should be based on user information and experiences and be used to create better future results for all parties involved.

2 SMART HOMES

The term “smart home” refers to a branch of computing in which the domestic environment can be monitored and controlled via context-aware digital services. This enables the user to remotely control their home environment, and therefore the smart home typically uses telecommunication and web technologies to provide remote controlling functionality. Smart homes also use technologies such as sensors, multimedia devices, communication protocols and other smart home systems. (Alam 2012, 1).

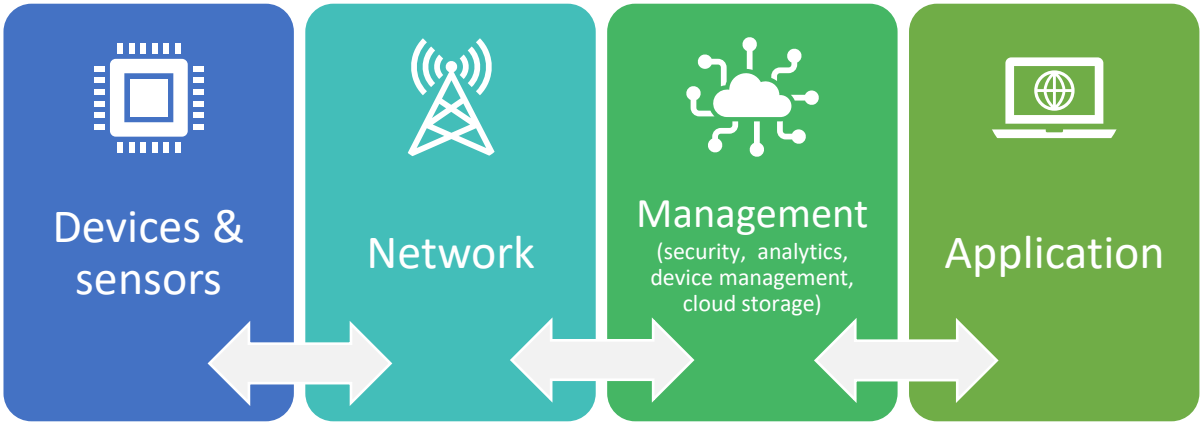


DIAGRAM 1: The relationship between smart devices and connected applications.

Smart home functions can help the user to achieve greater levels of comfort, convenience, safety, and health in the everyday applications of this functionality. These can be achieved with the many qualities that can be associated with the technologies. For example: the increase in comfort and convenience can be credited to the remote access and control of smart homes and their ability to identify activity and automate events. This describes the basic goals of the smart home technology, but it may entail a large variety of different types of sensors and data. The applications connected to the smart home may also be based on a large variety of possible technologies. (Alam, 2012, 2-4).

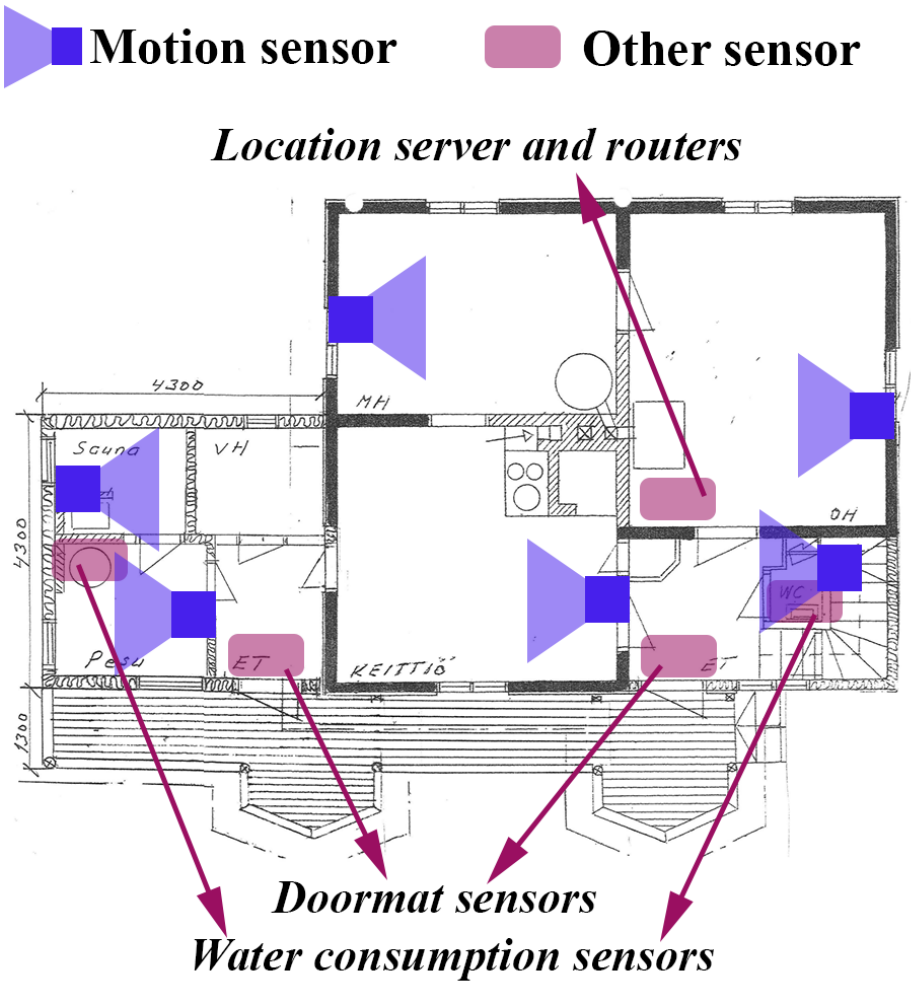


IMAGE 1: A sample plan concerning the possible locations of smart home sensors. This diagram does not include all possible types of sensors but is an example of some sensor types which are known to be in common use.

Health care support is possible via local motoring services which can be used to identify health conditions, create alarms or warnings, and most importantly to be able to contact assistive services when needed. Remote monitoring can be also used by specialized health care services to complement instant medical support in emergencies, which also relates to event automatization. These proactive responses to changes in health have been the key point of interest in the field of medical research. Similar solutions are already commonly used in elderly care, in which case sensors can detect the location and position of the habitant. If the habitant has a medical emergency, the system can alert the health care services to give immediate assistance to the habitant. (Chung, Demiris & Thompson 2016, 2-4.)

2.1 Sensors

Sensors are used in smart homes in order to gather information about the environment, for example bout the location and position of the inhabitant of the house. Sensors can be integrated to multiple settings, systems and devices, making it possible to use them as a part of a smart home. In one example, a typical movement sensor in elderly smart homes will send the signal to the local server, which in turn will send the data to a central server. In this central server it is possible to process the data in any way needed, and then present it in a desired form. This can mean the use of this data in an application or a graphical user interface, which can be monitored by a health care professional or a family member.

TABLE 1: Practical purposes of home monitoring device in smart homes. (Alam 2012, 8-10).

CATEGORY	SENSOR TYPE	INFORMATION PRODUCED
Sensors	Light	intensity of light
	PIR	user location
	Temperature	room, object or person temperature
	Pressure	user location
	Switch sensor	door opening or closing
	RFID	Identifying objects and people
	Ultrasonic	Tracking
	Current	current usage
	Power	Calculating power usage
	Water	volume of water usage
Physiological sensors	ECG	pulse rate and variability
	PPG	pulse rate and blood velocity

	Spirometer	respiration rate, penk flow, and in-hale/exhale ratio
	Galvanic skin response	sweat levels
	Colorimeter	pallor and throat inflammation
	Sphygmonanometer	oxygen saturation of blood
	Weight	body weight
	Pulse meter	heart rate
Multimedia	Camera	tracking the environment
	Microphone	voice commands
	Speaker	audio information
	Display	visual information

The choice or preference of sensors varies by the intended function of the smart home, the intended target audience, as well as the details of the user's lifestyle. Medical instruments are mainly utilized for applications in the field of health care, whereas multimedia devices will create more interactive experiences. Various nursing homes and hospitals can also benefit from such information health technologies. (Alam 2012, 8).

2.2 Ethics

Evidence of some ethical issues surfacing in the smart home industry has been shown in relevant studies in recent years. The main themes of privacy, informed consent, autonomy, obtrusiveness, equity of access, reduction in human contact, and usability have been the main categories for most academically researched ethical issues of smart home technologies. Through these categories it is possible to understand ethical issues that should be considered in the processes of designing, producing or working with smart home solutions. (Chung, Demiris & Thompson 2016, p. 7-8.)

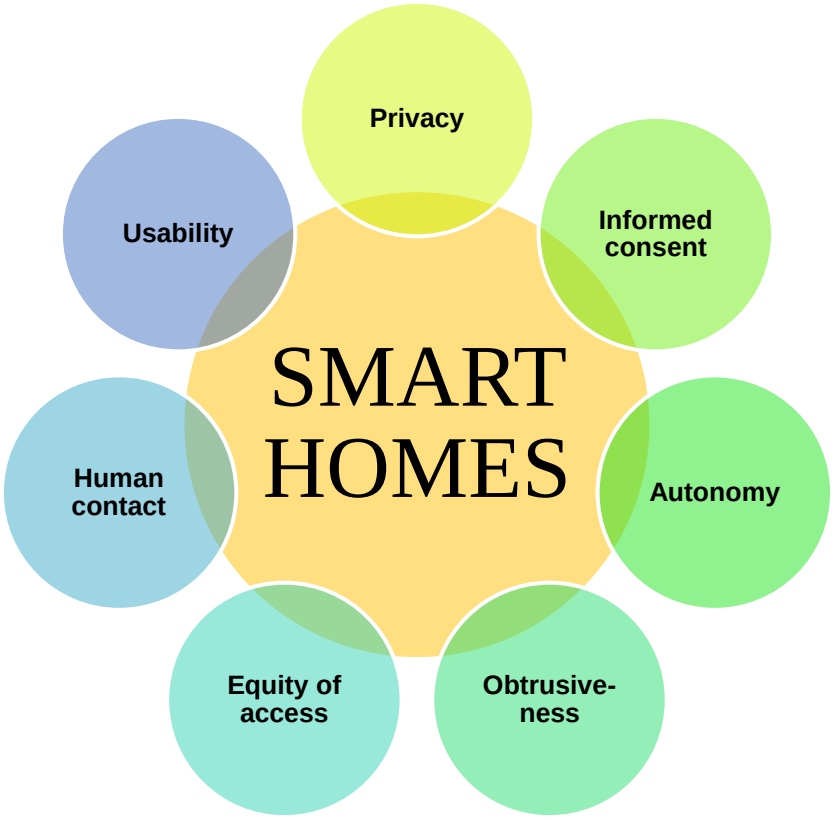


DIAGRAM 2: Main ethical issues related to smart homes.

Privacy issues have appeared in public discussions concerning smart home's technology and the closely related field of internet of things (IoT). It was considered the most significant factor in the willingness of the elderly to live in a smart home during the research project presented later in this paper. Similar opinions were expressed in other settings as well, according to Chung, Demiris and Thompson (2016). The right to privacy seems to be raised as one of the greatest concerns in the public discussion and social media as well, and two problematic scenarios are often presented in regards to this issue: either the user's personal data is shared without their consent or how to address the possibility of obtaining private information against the user's will.

All user data is collected by the sensors that allow the smart home to function. The privacy issue is connected to internet and data traffic as well as storing the information in a secure manner. Truly safe means of storing data and maintaining communications is a core issue from the engineering perspective as well. The means of encryption or security systems are typical examples of ensuring the safety of the information in these cases. These security practices are significant especially with regard to personal data which can be compiled to identify an individual user. From the perspective of the typical user the issue of privacy is often manifested as a concern about other individuals accessing information about the more sensitive details of everyday life - such as bathroom visits – or they may be worried

that other individuals might spy on them and judge their lifestyle and activity patterns in general. (Chung, Demiris & Thompson, 2016, 9-14.)

Another theme for possible issues is informed consent. This element is important when the smart home must support the well-being of the user without robbing them of their autonomy or dignity. The possible well-being gained from the usage of smart homes may be negated if the older adult is unable to make an informed decision about their participation in such living conditions. This issue is magnified in the cases of cognitive decline or any neurodegenerative conditions. Maintaining good relationships with the smart home user is vital for all interactions, and this cannot be achieved without the respect for the user's rights. It is recommended to see consent as a continuous procedure which must be maintained through discussing user's data preferences, lifestyle questions and any possible changes in their well-being or other status. This way the consent and preferences can be kept up to date. In some cases, multiple consents from both the users and their legal caretakers may be needed to achieve ethical results. (Chung, Demiris & Thompson, 2016, 14-18.)

Autonomy is a theme which arises when discussing who can access the data, as well as what sort of power these individuals hold over the user. If the datasets are used to monitor the user, the autonomy of the user should be still be maintained through these activities. Smart homes can be used as a tool to promote independence of the resident and their family, but there is also the possibility to become dependent of the technological assistance. Unless actively promoted, the passive monitoring feature may promote the user's isolation from being actively involved in all activities and management of the system surrounding them. The professionals supporting the systems should provide the end user with recommendations and plans through a continued relationship which will activate the user to be a part of their own care process planning. Many elderly may prefer to share different data with their families, health care professionals and other professionals. They also may express wanting to perform tasks and roles that they can still be a part of, instead of letting the technology take care of everything. These preferences should be acknowledged when designing the smart home service and updated during the service relationship when needed. (Chung, Demiris & Thompson, 2016, 18-19.)

Obtrusions on the other hand are subjective experiences and their definition can vary in each case. Typical physical issues may arise from discomfort, strain, noise, visual cues, or even pain that can be connected to the smart home technology. The technology is present in private dwellings and as such, the system should be researched and designed in a way that addresses the obtrusiveness that may be caused by the presence of the

technology. Issues may arise from the functions of the smart home, or for example a complaint might be made from the location of certain sensors. Especially audio and video gathering are seen as potentially obtrusive and may awaken feelings of privacy violations very quickly. Sensory cues of the smart home technology may also be a bother if constant lights or noises are present in places and situations where they may cause annoyance or anxiety. (Chung, Demiris & Thompson, 2016, 19-20.)

Access to health care technology is a matter of supporting the older adult population. As such, the matter of equal access arises. Digital divide is a term used to describe the gap in accessibility and usage of information or means of technological communication on the basis of the individual's age, socioeconomical status, community, disability status or other possible qualities. Many older adults are more skilled in using the digital resources than the current elderly population or those who have a low socioeconomic status. Even rural or poor urban geographical location can be a factor in the digital divide. Minorities may lack equal access to many resources as well. Accommodating all individuals in a field of high technology is an ethical issue. Access to certain functions or the ability to pay for beneficial health care services can be limited in certain groups of people. The cost of the product or service is a matter of accessibility in the smart home market as well. Limiting factors can also be present in the language or forms of information offered by the smart home product or service, which may limit the access to health care technology. (Chung, Demiris & Thompson, 2016, 20-21.)

The increase in automated solutions has brought the topic of human contact in the field of technology on the table as well. Relying purely on the services of an automated home may leave the user lacking human contact. Similar issues are found in individuals who mostly use technology to interact with their family and friends as well as all professional services they receive. While digital solutions may improve connection when used in moderation, human contact should be designed into the smart home service as well. Digital solutions are not able to replace all professional help or satisfy all need for human interaction. Most users dislike the possibility of being in such isolating conditions. Research has also shown that systems that promote human contact can lead to higher customer satisfaction due to better adoption rates in older users. (Chung, Demiris & Thompson, 2016, 21.)

Usability is a key factor in both user experience and accessibility. It will affect the processes which the potential new users will choose whether the smart home is useful or not. This subject is critical in promoting the adoption and widespread usage of smart homes.

Poor design of smart home products will ignore the needs of the users, leading to poor quality results. Human-technology interaction that is associated with cognitive functioning and heuristics is an active topic in the field of health information technology. Interestingly enough, it has not been discussed much when the spotlight is switched to the older users of such technologies. Many designs have failed to invest in age-related constraints and the low level of technological life skills in this target group. Issues may arise from simple problems such as switching the systems on or off which can be amplified further when the person has issues with vision or cognitive decline. Usability therefore still remains a blind spot in the field of health information technologies and should be tackled with more research and better design practices. Training sessions, manuals, readability and data visualization are some of the subjects identified as potential issues in contributing to usability in these target groups. Technological education and support is seen as a vital factor in older users adopting health technologies, such as smart homes. (Chung, Demiris & Thompson, 2016, 21-22.)

3 ACCESSIBILITY IN BUILT ENVIRONMENTS

An accessible smart home should be always located at an accessible building, and as such a part of the ideal process is to make sure the chosen building adheres to at least these basic modern guidelines. From the viewpoint of perfected design it is also recommended to tour the building in question with people with disabilities, as they might offer new insight beyond the technical limits set by laws. The laws governing accessible buildings can be summarized as a set of guidelines securing the person's ability to visit or live in the building and use the necessary functionality there. These laws describe the very minimum of the requirements, and as such it is recommended to get input from accessibility specialists as well as from actual disabled people during the development process. (Finlex 2017).

The entranceway should be at least 1200 mm wide and easy to spot. The surface around the entranceway area should be flat, and the materials around the entranceway should be hard and not too slippery. If there are stairs leading up to the entrance, a ramp should be placed there. The ramp should be at a maximum of 5 grade angle and at least 900 mm wide, and it should be designed so that it is safe to use with a wheelchair. There should be at least 1500 mm platform space at the top and the bottom of the ramp. If the height difference between the platforms is 1000 mm or more, the angle of the ramp can be at 8 grade angle. However, in this case the ramp should have 2 000 mm long resting platforms placed and the ramp sections can be only 500 mm in length. In outdoor spaces, the ramp can be over 5 grade angle only if it can be kept in a great condition that be compared to that of an indoor ramp. The entrance door should also have 1500 mm wide and 1500 mm long platform in front of it. The door side from which the door opens should be at least 400 mm from the corner of the wall or other such boundary. Doors inside the building should allow at least 850 mm of free space from which to enter in most rooms. In some exceptions which are not in common use of the inhabitants, 800 mm is satisfactory. Thresholds of the doorways should not be above 20 mm in height, so a wheelchair can get over it without issues. (Finlex 2017).

The corridors should be around 1500 mm wide. In some exceptions that are narrower than this, the corridor must have a 1500 mm wide space for turning every 15 m. The buildings which are meant for housing people with disabilities it is required to have a 1500 mm wide space for turning in the apartment kitchen and in front of the apartment's front door. The minimum drops to 1300 in other buildings. Elevators in accessible buildings should have a space which is at least 1100 mm wide and 1400 mm deep. In buildings that have 3 or more stories including the ground floor from which you enter, an elevator is required.

The elevator should allow movement between the entrance floor, the apartment floor(s), and the floors and spaces needed for functioning in the building. (Finlex 2017).

The bathroom should allow at least 1300 mm free space. The furniture should be placed so that a disabled person can use the space. Bathrooms for disabled people should be have at least 1500 mm of free space, but also have 800 mm of free space next to the toilet. It should also be designed in a way that it makes it possible for a disabled person to use. Exceptions to the criteria do exist in student housing, but a certain percentage of the apartments should even then accommodate disabilities. The building's shared community sauna, bathing area and the locker rooms should accommodate disabilities as well. Buildings which are not for housing should also have bathrooms available for disabled people, and they should be marked with the correct symbol. In such buildings the toilet should have 800 mm space on both sides, and a space of 200-300 mm or more behind the toilet as well. There should also be a free space of 1500 mm or more for moving. In some cases the bathrooms for disabled people should also come with a security function, if the building has a security option available. In other hygiene related spaces - such as pools, locker rooms, saunas, spas and bathrooms - the spaces for disabled people should also be marked clearly. At least one space should be available for a person with disabilities and their personal assistant to use, regardless of the gender of the person or the assistant. Pools should have special machinery to lift the person into the water safely which can be used independently. (Finlex 2017).

In spaces such as board rooms, auditoriums, classrooms, restaurants, or celebration halls with a sound system there should be an option to accommodate induction loops. Induction loops are an assistive technology for people with hearing difficulties. In hotels and other equivalent buildings should have at the very minimum 5% of the available rooms suitable for people with disabilities and their assistants. In hotels with smaller number of rooms, at least one of them should be suitable for them. Also at least half of the hygiene spaces and bathrooms in common use in the hotels should be available for them as well – at least one of the spaces must be like this, and the others should be possible to be re-equipped to accommodate them. If the building has designated parking spots, a suitable amount but at the very minimum one of them should be designated for people with disabilities. (Finlex 2017).

4 ACCESSIBILITY IN SOFTWARE

Accessibility in software has been long recommended and promoted by multiple sectors. Smart homes often are also often monitored and/or operated using a graphical user interface on a digital device, and as such the same recommendations and guidelines apply to smart home software as well. The graphic design recommendations included in these guidelines can used to some extent in the related user interface (UI) design of the smart home product. Considering the user manual as a part of the larger process for the product development is good practice, and it creates the means to ensure consistency of the product and making sure that the related reading materials are accessible to all possible clients as well.

4.1 International standards and guidelines

The most well-known international guideline is the Web Accessibility Initiative which is resented below. Finland is one of the 26 participating members of the ISO-IEC JTC 1/SC 36, which is a standardization subcommittee in charge of developing standards for the field of information technology (International Organization for Standardization 2017). In 2008 it has developed a three-part training series (24751-1, 24751-2, and 24751-3) which supports the individual adaptability and accessibility in e-learning, education and training (International Organization for Standardization 2008).

These guidelines are usually recommended especially to the public sector, as access to public service web sites is extremely vital for the entire population, including people with disabilities. For example, all American Federal agencies should make their information technology, including web content, available to people with disabilities under Section 508 Amendment to the Rehabilitation Act of 1973 of the United States (United States Access Board 2017). Ideally other organizations and web content producers would also follow the general guidelines to add access to people with disabilities.

4.1.1 The Web Accessibility Initiative

In 1997 The World Wide Web Consortium launched The Web Accessibility Initiative (WAI). The philosophy behind the initiative is to make the web more accessible to people with disabilities. The Web Accessibility Initiative is known for promoting technology development to remove barriers for people with disabilities, as well as building the infrastructure

that is the base for many education and outreach programmes on the subject. WAI is endorsed by the World Wide Web Consortium and the White House of the United States of America. (World Wide Web Consortium 1997.)

The Initiative lead to the release of Web Content Accessibility Guidelines (WCAG) in 1999, and immediately became a World Wide Web Consortium recommendation. The document describes the general principles of web accessibility, and it covers multiple general topics of the subject. In 2008 The Web Content Accessibility Guidelines 2.0 were released, and it offered some additions to the previous version. (World Wide Web Consortium 2008.)

According to the WCAG there are different levels of compliance. These levels are in increasing order as follows: A, AA, and AAA. It is possible to follow their guidelines and use online tools to analyse a website. The report will reveal the levels of compliance to different aspects of the WCAG. The WCAG is divided into main sections that have smaller subsections, which include even more specific guidelines that support and advise in the creation of these elements. According to the new guidelines, accessibility in web development should include these main elements (World Wide Web Consortium 2008):

- *Information and user interface components must be presentable to users in ways they can perceive.*
- *User interface components and navigation must be operable.*
- *Information and the operation of user interface must be understandable.*
- *Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.*

The first argument includes the support for the people with disabilities that follows from the fact that the way they perceive things vary from the general population. This can include issues with vision, hearing, or cognitive disabilities. This often leads to contents that can be presented in different media forms without much issues (e.g. text-to-speech). The content should also be able to be presentable in different forms without losing any vital information, while considering ways that promote the user's ability to separate the background elements from the content. Therefore, the subcategories of the first main argument according to the official WCAG are (World Wide Web Consortium 2008):

- *Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.*
- *Provide alternatives for time-based media.*
- *Create content that can be presented in different ways (for example in a simpler layout) without losing information or structure.*
- *Make it easier for users to see and hear content including separating foreground from background.*

The theme of the second argument is the way disabled people can operate a web page, which includes the issues around navigation and using the functions of the web page. This includes keyboard navigation, providing means of navigating, finding content and determining their location on the web page, and giving enough time for the user to read and understand what they see. The second additions are the following arguments (World Wide Web Consortium 2008):

- *Make all functionality available from a keyboard.*
- *Provide users enough time to read and use content.*
- *Do not design content in a way that is known to cause seizures.*
- *Provide ways to help users navigate, find content, and determine where they are.*

The third guideline promotes the user's capability to use their cognition to understand the content of the web page. This can include (human) language support and support for translations, mechanisms that offer explanations on abbreviations, challenging words, jargon, idioms, and the using simple content that can be easily read or understood. It also mentions using predictable web navigation, which is structured similarly as most sites, and web content that can be easily identified so that the context and relation to other elements is known. It is also recommended to install mechanisms that help the users to notice if they have made a mistake and to check information before it is sent, or to make functions reversible. The third guideline's additions are (World Wide Web Consortium 2008):

- *Make text content readable and understandable.*
- *Make web pages appear and operate in predictable ways.*

- *Help users avoid and correct mistakes.*

The last guideline handles the theme of robustness. It only offers one subtitle that revolves around the theme of “compatibility”. This line includes recommendations for the developer about the usage of complete sets of start and end tags, the usage of unique IDs, avoiding duplicate attributes, and nesting elements according to their specifications. It also offers guidelines for the developers who script their own interface elements, in which case they are urged to use only user interface elements for which the name, role and value of the element in question should be programmatically determined, and that the states, properties, and values that have been set by the user can be programmatically set. The rest of the guideline is explained the best by the line itself (World Wide Web Consortium 2008):

- *Maximize compatibility with current and future user agents, including assistive technologies.*

4.2 Relevant assistive technologies

When considering the subject of accessibility, the presence of assistive technologies is inevitable. While not all disabled people have assistive technologies in everyday use, their presence in modern society cannot be denied. Therefore, understanding the most common assistive technologies for the web is vital in the order to produce an accessible service.

TABLE 2: A list of assistive technologies for different types of disabilities

% OF POPULATION	TYPE OF DISABILITY	EXAMPLES OF RELEVANT ASSISTIVE TECHNOLOGIES
7.7% of US children (Black, Vahratian & Hoffman 2015).	Communication related	Electronic speech synthesizer, Blissymbols or equivalent (Cleveland State University 2017)
15% of US adults (Blackwell, Lucas & Clarke 2014).	Hearing related	Earphones, headphones, headsets, teletypewriters, real-time closed captioning devices (Cleveland State University 2017)

19% of the US population (Bernstein 2012).	Mobility or physical impairment related	Voice recognition software, screen readers, page-turning devices, custom keyboards, foot mouse, vertical mouse, trackballs, pedals (Cleveland State University 2017)
6.5-7.9% of US adult population (The U.S. Department of Health and Human Services, Centers for Disease Control and Prevention 2011).	Cognition related	Virtual keyboard, talking textbooks, voice recognition devices, Braille displays and devices, screen readers, optical scanners, modified monitor interfaces, screen magnifiers, reading services (Cleveland State University 2017)
2.3% of US adults (National Federation of the Blind 2017).	Visual related	Screen readers, braille devices, screen magnifiers, reading services (Cleveland State University 2017)
12% of adult population (Cortiella & Horowitz 2014).	Learning disabilities	Screen magnifiers, optical scanners, custom monitor interface, reading service, talking textbooks, screen reader, voice recognition software (Cleveland State University 2017)

In web development the most commonly used technologies are screen readers, text-to-speech assistants, modified monitor interfaces and screen magnifiers. New technologies are being developed constantly, and the list of commonly used technologies will grow within time. It is important to account for the most common assistive technologies to accommodate the most users. With the aging population of many developed countries the importance of such technologies is expected to increase.

Screen readers, custom interface settings, and keyboard controls are the major assistive technologies to consider in web development. Keyboard controls use the keyboard to explore the web pages and navigate through them. The user for example might have to use the tab button to explore the site's navigation if keyboard controls are not supported by the site in question. (World Wide Web Consortium 2008).

Screen readers will turn text into a form, typically audio, that can be processed by people who cannot read the visual input. Similarly, there are devices that translate text into braille. The reader will analyse and present the content in different ways depending on the web page's settings. For example, the screen reader will go through a table by mentioning the referring cells before each cell to make sure that the user understands the content. (World Wide Web Consortium 2008).

Custom interface settings can include colour modifications to aid people with visual impairments, but also some with cognitive disorders and learning disorders. It is also possible to modify the size of the fonts displayed to make it easier to read for the user. There is also the ability to magnify or zoom the page when needed. (World Wide Web Consortium 2008).

Many assistive technologies are not as easily available to mobile device users. Many assistive technologies have been designed to support desktop or laptop users. However, with the development of smart devices some progress has been made to add assistive functions to mobile devices.

4.3 Common methods for accessibility in web-based applications

Many methods to reassure the users of accessibility of a web application have been created. The methods consist of practices related to web and content design as well as web technologies. The web design aspect affects the way the user perceives the page and their ability to gain information from the said page. The design will also serve in making the user experience easier for users with disabilities. The web technology aspects will assist especially people who are using assistive technologies.

For web technologies the Web Accessibility Initiative has created the Accessible Rich Internet Applications, WAI-ARIA, which is a way to create accessible web content. WAI-ARIA is especially designed for using HTML, Javascript and/or Ajax to create advanced user interface controls that are suited for people who are using assistive technologies to access the web. Essentially the function of WAI-ARIA is to offer a framework for creating a site in a way that can be read by e.g. screen readers. This means adding attributes to point the assistive technologies the meaning of each element and how they relate to each other. It can be used to mark regions of pages and enable keyboard controls to move easily between these regions instead of forcing the keyboard users to press the tab button multiple times to reach the wanted results. WAI-ARIA also offers means to affect Ajax live regions, events and controls. (World Wide Web Consortium 2006.)

4.3.1 Responsive applications and device independency

Device independency is often defined as a matter of responsive design. Responsive design means making web sites that adjust to different devices and screens to offer the best

possible user experience. This often means that the site scales according to the screen size, or the site will offer a mobile device site when it detects that the screen size matches that of the wanted mobile device screens. It is recommended to make web sites responsive to make the sites more accessible to many users who might be using different devices, which also supports accessibility. However, the traditional meaning of responsive design does not always include the means to make the web site available to those who access the web via assistive technologies. Many tools, such as Bootstrap, have been made to make it easy for developers to create responsive layouts, but these layouts often do not mean that the site becomes accessible to users who are using different assistive technologies to access the web as well. Therefore, the traditional view on responsive designs in fact fails to include support for many devices.

In reality, many people use assistive technologies for a wide variety of reasons, and multiple people with different disabilities can be using the assistive technologies to explore the web. Screen readers and keyboard controls can be used by people with visual disabilities such as full blindness or partial sightedness, but also with people that have a wide variety of mobility and cognitive disabilities, as mentioned before in the section for assistive technologies.

This is why it is recommended to follow for example proper structure and labelling practices to accommodate assistive technologies. This can also often be achieved by using the WAI-ARIA, which is a development tool that has been designed to support this purpose. It allows developers to create rich web content that is translated better by assistive technologies, and thus it makes the site more accessible by the users who are using assistive technologies. It is recommended to study and follow the previously mentioned WAI-ARIA practices that have been published and recommended by the World Wide Web Consortium. (World Wide Web Consortium 2006.)

4.3.2 WCAG implementation in web applications

The Web Content Accessibility Guidelines include a long description of how to implement their recommendations. Those involved in frontend development can use it as a tool to add properties that describe the structure of the page (e.g. regions, tables/grids, and headings), roles to describe the elements (e.g. “menu”, “progressmeter”, “slider”, etc), properties to identify live regions which have the ability to update and an interruption policy for the updates in question, and lastly the means for providing keyboard navigation for the web pages in question. (World Wide Web Consortium 2017.)

The colours used on a web site need to be satisfactory to support people with visual limitations, especially those with colour vision disabilities. The Web Content Accessibility Guidelines recommend the contrast ration of at least 4.5:1 to reach the AA levels when it comes to normal sized fonts, and 3:1 when it comes to larger fonts. Large fonts are assumed to be 18 points or 24 pixels in size at minimum, but when the text is bolded the limits are decreased to 14 points or 18.7 pixels at minimum. For the contrast to reach the AAA level the aspect ratios are required to have higher contrast ratios – 7:1 for normal text and 4.5:1 for large text. It is possible to use multiple free online tools to check the contrast ratios of the fonts that have been chosen. Using high enough contrast ratios between site elements is also recommended, so the user can tell the difference between different elements easily. (World Wide Web Consortium 2008.)

The rest of the design must include large enough elements that are located far enough from each other, as well as giving the user more power over the main elements. Intuitive design can be achieved by making the flow logical, as well as creating things that are similar to other relevant web sites which have already been ingrained into the user's memories. It is also good to remember to use clear and simple language and add instructions to steps that require it. (World Wide Web Consortium 2008.)

4.3.3 Web application navigation solutions

Navigation on web pages affects the functionality of the page dramatically, and as such developing navigation that can be used intuitively and by also people with disabilities will increase the accessibility of the web page significantly. The menu can affect the entire structure of the site itself, and therefore it is important to consider accessibility on the planning and designing stages before the start of the development project. The main challenges of the menu include the location of the menu, the sizing of the menu, the colours of the menu, the content and intuitive flow of the menu, and issues that have to be considered when coding the said menu.

The menu should be placed in a place in which it is not challenging to find, e.g. somewhere at the top part of the first view of the website. If the menu includes elements that reveal more elements, it is recommended to make this work on both keyboard and mouse controls. The revealed elements should stay visible for longer time periods to allow the users to read and understand the content, as well as give them time to navigate to the right location. This can be done by using timers or using the upper levels of navigation as toggles. (World Wide Web Consortium 2015a.)

The visual design of the menu should consider large enough size for text and the menu buttons to promote the easy access experience in those with visual limitations as well as low dexterity of the hands. For example, the minimum font size can be hard to determinate as it varies depending on the screen size and quality, window size, the colour scheme and the other elements, but many with milder visual limitations might find the font size 16 (pixels) already readable on the average laptop screen. This is also the reasoning behind the guideline that instructs that the menu should scale to varying text sizes and accommodate longer words. The buttons of the menu have to be large enough and far from other elements to be correctly reached with hands that have lowered dexterity, which is especially important on mobile applications – the proper sizing for buttons can be achieved with adding padding and including this detail in the plans on the design stage. (World Wide Web Consortium 2008.)

The menu should be designed to be shaped and coloured so that it is easily recognized as a navigation element. Visual markers for the current location in the web page navigation are recommended. Marking also the location of the mouse with different effects, e.g. the hover effect and the visited link effect, as well as an indication of active state and other states, is recommended. (World Wide Web Consortium 2015a.)

The mark-ups for the navigation code should include the start and end tags. Using the proper mark-up to point the location of the navigation menu is recommended, e.g. in HTML5 this can simply be done with the <nav> element. Labelling the menu is recommended especially when there are multiple menus to make them easier to find and use even with assistive technologies. The screen reader users will also benefit from the usage of invisible labels to determinate their location on the navigation. (World Wide Web Consortium 2017.)

Making the site navigation intuitive will not only depend on the natural underlying systems of human cognition but also the current culture, as common structures for navigation are often easier for people to use even on unfamiliar sites. The navigation content structure should follow the logic of most currently used web sites, which eliminates the need to learn a new navigation system every time the user visits a new web page. The current culture and the culture’s language provide a basis for structuring such information, and therefore time should be spent on understanding the logical flow in these areas when planning the navigation for the site. Compromises might be unavoidable when multiple cultures are involved in the intended user base. (World Wide Web Consortium 2015a.)

4.3.4 Content, media, and their alternatives in web applications

Text and other content used should be simple enough for any user to understand. Therefore, the usage of complex words is ill-advised. The text fields of the web page should be designed in a way that allows the resizing of the text fields for those who need it. Especially in mobile apps it is recommended to offer a choice for larger font sizes. The font size required by the visually impaired is often larger than that of an average user's, but setting recommendations for the font size can be challenging as the visibility of the font varies based on many variables, including differences between types of device, the screen size and quality, the environment, the colour palette of the site, and other elements of the site. Some sources state that the font size of 16 pixels or larger on an average user's laptop screen is comfortable for many experiencing mild visual impairments. However, the simple solution is to support zooming on the page and increasing the size of the font(s) that can be controlled by the user. As for the users who are using screen readers it is good to consider avoiding the usage of too many emoticons or other such supported symbols in the text, as the screen reader will read out loud the full name of the symbol in question every time it is presented on the text. If the page has social media embedded, it has to be considered that the current social media culture sometimes favours the repetition of symbols for emphasis, which will result to also repeating the symbols out loud by the screen reader repeating the same name of the icon multiple times. (World Wide Web Consortium 2008).

Following the good text practices in any form of content that includes text is recommended. In the case of other content elements there are however some additions to be mentioned. In the case of creating forms on the web site most of these complications deal with cognition and screen readers or speech input. For people with cognitive disabilities this means that the form should give sufficient feedback display clear error messages and instructions if something the user has inputted was incorrect. They also need instructions to help them to understand the contents of the form and how to complete it. The user should also be given sufficient feedback on their actions and notified by the processes such as task completion and possible errors to make it clear what has happened. Long forms should be divided into smaller parts that are easier to understand, and the structure for this should be made of logical steps that are displayed in the layout to inform the user of the progress. People who use speech input technologies, for example, also use the labels of the form to navigate and move the location to the field they are pointing to, and as such they should be clear and correctly used. Custom controls will help the use for those who have the need for it and cannot use traditional mouse controls. The elements should also be designed to be large enough and far away from each other to make it easy for people with low dexterity to click these elements. (World Wide Web Consortium 2008).

The usage of visual tables to represent content should also be developed with extremely clean and well-structured code, because certain assistive technologies often need properly structured table codes to display the data represented in the table correctly. Some alternative ways of reading the table will customize the tables, for example to make certain things more prominent. This can be done with the use of stylesheets and as such can be used to modify the visuals of the table as well as change it into a list. Screen readers will read aloud the data as it navigates the table based on the table's structure – it will read one cell at a time and reference the relevant header cells. This mechanism is designed so that the user won't lose the context for the date in tables. (World Wide Web Consortium 2014b).

TABLE 3: The usage of different types of images in easy access development (World Wide Web Consortium 2014a).

TYPE OF IMAGE	RECOMMENDED ADDITIONS
Diagram	Offer a full text equivalent of the data represented in the image is presented next to the image.
Decorative	Offer a null text alternative or visible text alternative to notify that the image is purely visually decorative.
Functional (e.g. navigation, link)	Offer a text alternative that should inform of the function of the link. Design the icons in use to be easy to recognized by almost anyone.
Graph	Offer a full text equivalent of the data represented in the image.
Group	If an image is a part of a group, offer an alternative description that should describe the content of the entire group.
Image map	If the image area contains many clickable links, offer a text alternative that should include a context for all of the links as a set. Each area that can be clicked should have their own alternative text that describes the meaning of the link.
Photo, picture, drawing, illustration	Offer a null text description or a short visible text description of the most vital information that the picture should convey. E.g. "Sir John Standing sitting."
Text as an image	Avoid the implementation of these images. If the usage of the image is not avoidable, the offered text description should include the full text that is represented in the image file.

Music and video elements also require multiple additions. Video elements should include audio descriptions that are essential especially for relevant content of the visual media that is not covered by the information given in the audio track. Audio descriptions are auditory additions that describe vital moments in the visual content for those who have visual disabilities. This is only needed for truly vital elements that are needed to understand the events of the video. Captions should be made available for videos – the captions should be properly synchronized with the video or audio media format's events. This is to assure that people with hearing disabilities can get the same information from the content in question. Sign language translations are usually not needed in most media, even though it can be added if the creators wish to do so to add support for those who use sign language as their first language. For elements that include audio, even such elements as videos, recordings, and teleconferences, the simple addition of an audio transcript is recommended. Transcriptions and captions should ideally be accessible on the moment of the publication. (World Wide Web Consortium 2016).

Carousel elements have been popular in web design, and even their usage can be made accessible. In this case the following issues must be addressed: timing, controls and keyboards, and communicating with screen reader technologies. The carousel should be possible to pause and/or hide if it becomes too distracting or fast for the user. There should be also enough time for the user to process the information properly, and the user should have their own controls over the carousel. As for people with screen readers, it should be possible that they also will have the information presented by the carousel. (World Wide Web Consortium 2015b).

5 DESIGNING AN ACCESSIBLE SMART HOME

In this section I describe typical design methods and practices that support the design process. No reference is made to real-life individuals. This description is largely based on the service design project regarding smart senior housing at Lahden Diakonialaitos during the time period of 2018-2019. In this project, Lahden Diakonialaitos requested the renewal of their senior housing services. During the project we went deeper into the practical details of smart homes, user-oriented research and designing spaces that combine physical environment and digital experiences.

The development of the living space, customer experience, the culture of the residents, and the physical smart home as well as the shared common rooms were one area of the interest of this type of project. Many other approaches were also involved in modernizing the service. Due to the scope of the paper the focus will be only on smart homes and the customer experience relating to the aspects of the smart home.

5.1 The design process structure in smart home planning

The project started with a client brief. The first half of the project will focus on investigating and understanding the task or the problem. The second half will focus on fixing the problem and generating solutions.

Our aim in the project was to improve the housing product and the client expected us to give recommendations about future improvements to the technology, physical spaces and services that the residents had in their use. The more ambitious goal that was reached by inspecting the hidden needs of the users that was to improve the client organization itself to become clearer, more dynamic and in closer relationship with the customers. The organization was not criticized for this – these goals are often typical continuous improvement efforts that almost all organizations in the current business culture have. To ensure a healthy project environment and less biased end results, it was important to maintain a culture where all facts and experiences could be brought up without fear of consequences.

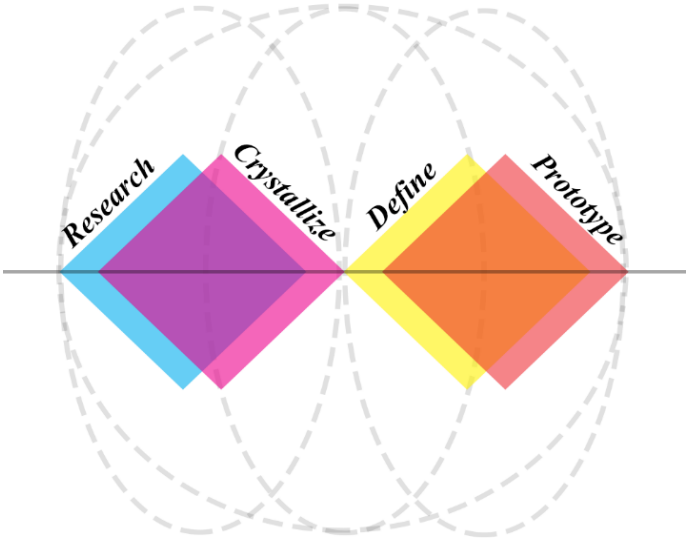


DIAGRAM 3: Iterative double diamond project structure.

The typical shape of any user experience or service design project is the “double diamond” project structure, which can be seen in diagram 3. Some variations of this exist that define more than four main phases for the project, but the most common four phases are: research, crystallization, ideation, and lastly prototyping. After the prototyping phase an additional phase for implementation and future planning are typically also a part of the design project. These phases are iterative, which describes that some loops may form between the phases – e.g. it is possible that more research may be needed before moving on to ideation, in which case the research and crystallization phases will loop again.

The research phase is dedicated to understanding your task, gathering information about the userbase and emphasizing with the users. In the crystallization phase all collected data is processed and patterns and themes are found from it, which help to form important insights and ideas about the possible problems and solutions. Ideation is typically the phase where these themes and patterns are explored to find the exact ideas and concepts that may deliver the end results. The prototyping phase was dedicated to testing these ideas and their viability, after which implementation may eventually occur if these concepts and ideas are accepted and viable for production.

5.1.1 Research

User research methods should always take into account the specific group you are researching. In this case the typical age ranges of the smart home residents were categorized as elderly. The vast majority of them are female. A large variety of disabilities and illnesses are typical in this demographic, but as this is not a medical facility but a private smart home complex with some additional services made available, the residents were still relatively independent and left a healthy impression considering their age. The typical residents did not possess well-developed technological skills to operate digital devices comfortably.

The low technological knowledge level of most residents eliminated most digital forms of communication. Extra steps to follow accessible graphical design choices were taken to make sure all residents got the information needed regarding the various activities and phases of the design project, to which they were often involved to take part in from the start. It was also carefully chosen when and where the activities would take place, as the schedule should not overlap with any other common activities that were arranged for the residents. Active participation was successfully achieved through these measures. Some examples of the design tools used in the user research phase include interviews, diaries, observation notes, journey maps, user personas, ecosystem maps and design games.

PICTURE 2: A design game for the smart home users.

Interviews were face-to face interactions with the residents, in which the aim was to understand the people who will form the demographic of our userbase. They answered rather open questions about their background and were free to describe their daily lives. Diaries were used for more in-depth notes on their daily experiences. The data from the diaries was collected and typed manually by the designers to transform it into a form that was easy to store and share during the project. The data was stored at a secure cloud service that guaranteed that no personal information was at an unsafe location. Observation notes were generated on the field when spending time with the residents and during workshops and other events.

Design games are simple tasks or games that help the smart home residents to describe their thoughts and opinions in a variety of ways. This behavioural data will compliment other data gathered from them to form cohesive patterns of experiences, views and needs. This can reveal issues not discovered in spoken language. In smart homes tasks

relating to their experiences and views of their smart home residental building were extremely useful in redesigning these spaces.

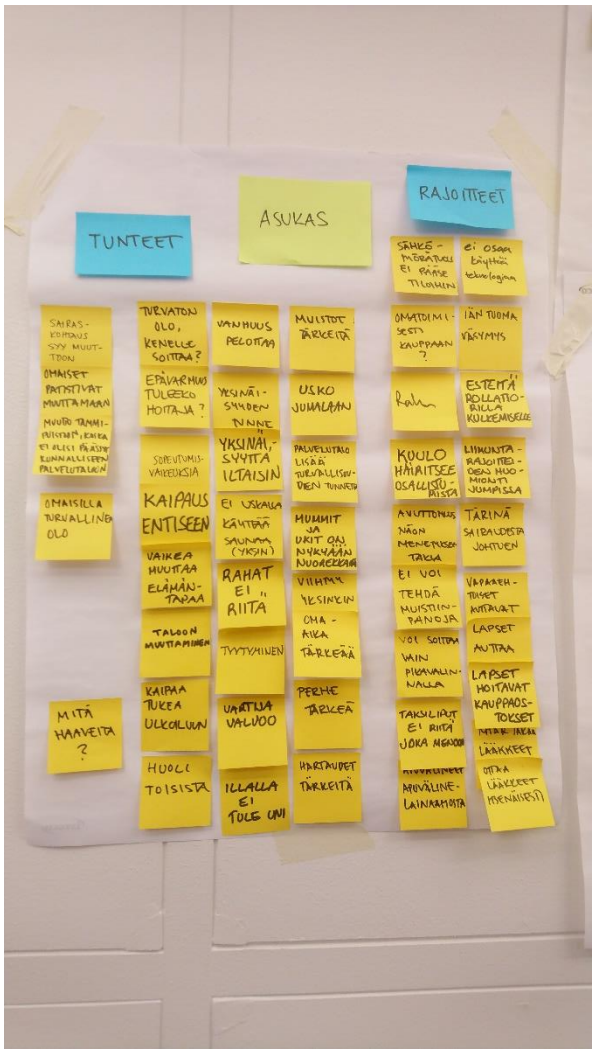
5.1.2 Crystallization

This phase is dedicated to understanding the user experience and identifying the themes, opportunities and insights of your design project. Many of the users have seemingly little to no drastic complaints and preferred to give positive or neutral answers, and they often stated that “they do not need much to survive”. However, even at the first meeting many residents had very apparent hidden needs after they had been brought up during the conversations and continued relationship. Hidden needs are typically the deeper-rooted main issue or issues that the user may not say out loud or may not even be aware of, which is relevant to the design process. The most obvious hidden needs were synthesized from the research data was identified as issues with communication between the staff and the residents. The needs of the user take the priority in user-oriented design, so identifying these hidden needs is valuable information for continuing with this project.

User profiles are a tool to simplify data and seeing typical user types in the data. In user profiles a fictional character is formed as an example of the typical user of the smart home. If multiple main groups are to be explored, each of these archetypes will lead to a new user profile persona. With the help of these user profiles a journey map was made as well.

A journey map is a description of the user’s journey through their relationship with the service or product in question, and it will help to identify the contact points that the resident has had with different sides of the client organization and other related organizations. Journey maps were used to visualize from the moment of them discovering the housing unit to them living in it or moving out, or even beyond this.

An ecosystem map will act as a visualization of all the parties involved in the service and their relationships with each other, e.g. the client organization, other organizations working in co-operation with the service, the resident, as well as the family members of the resident. These three design tools help to define and see trends in certain key points of a service by using the user data.



PICTURE 3: One part of a synthesis wall during a co-design session.

Goals for the rest of the project should be formed by crystallizing the main points of the varied data the designers have gathered during the research. For this brainstorming or some form of categorizing data can be useful. In this project a design tool called “synthesis wall” was utilized well for categorizing large amounts of data. In this method each designer writes down the most important pieces of the data they have gathered on post-it notes. All post-it notes are gathered on a wall, except for all accidental duplicates which will be eliminated entirely. One designer will act as an facilitator or an organizer as they bring each post-it note to the wall, creating rudimentary associations and groups between the contents of the notes. Soon all designers can join in and help the organizer form groups which represent common themes and ideas. These groups will be named accordingly. This will bring results and connections often missed by individual designers, and helps to crystallize all data into significant themes. The designers may interpret and use any knowledge gained from this to find the core issues that need to be solved, or unexpected themes that can help create better end solutions.

This crystallized knowledge can sometimes lead to identifying a need for more research and understanding. This is perfectly normal, and a part of the iterative design process. In this case the research phase will be done again to meet these needs. Keeping the client up to date and informing them of your progress will be a part of this phase as well.

5.1.3 Ideation

To successfully represent the user's view, every idea and concept created in the ideation phase should always be based on the research data and the needs of the users that were identified in the previous parts of the project. In smart homes the solutions target usually matters of either the physical structure, the physical setup of the technology, or the functions and design of the technology itself. It is however possible to also find solutions to most user issues outside these areas as well, as many identified problems may be rooted in larger issues with communication, perception, relationships, the client organization's systems, or a variety of other more abstract problems. In ideation phase it is important to co-operate with as many parties as possible to create solutions that are suitable for both the client and the users, as well as possibly some other relevant parties.

The ideas generated in brainstorming and co-design sessions should mature to a point in which it is possible to co-ordinate tasks that will create a prototype that can be tested or a satisfactory solution in some other form that can be displayed to the client.

Co-design is extremely vital for creating great experiences and design solutions. Co-design sessions might not only be interdisciplinary professional meetings because including the members of the user group in co-design sessions is also common, involving all parties of the project in the idea development progress. This was utilized in developing better services for the senior residents as well, as they were involved in all stages of the development. The staff of Lahden Diakonialaitos was included in development as well. It should be noted that the client organization was the one who would be in charge of the implementation of upkeep of the solutions in the future, and for that reason it is recommended to not only include them in every step of the design progress but also to create clear and easily understood documentation of all results, step by step.

5.1.4 Prototyping and future implementation

Prototyping can be done with many different methods with varying levels of real-life engagement and input. The most used method was the mock-up, in which the designers constructed a quick low-cost version of the service in question and test it for a limited time, gathering some data about the concept's viability. An example of small-scale mock-ups was the Face Wall, in which all the members of the staff were photographed in their working attire. These photographs would be attached to the first name and the occupation of the professional in question to the residents, making it easier to connect the person to the face, and to contact them or talk to them when needed. The professionals were also given larger name tags, which were clear and easy to read. Previously most residents did not know or remember of the professionals who they met every day, and they reported very positive results after the mock-up run. Such small and easy improvements were also made to inspire change in the organization itself, as they saw that they could finally start taking baby steps in the direction of clear and open communication with the residents.

Mock-ups relating to the smart homes included new layout designs for the physical common rooms and suggestions for the improvement of the physical environment, and creating more feedback and regular monitoring of customer satisfaction about the technological issues, which would eventually aim to opening up feedback channels with the smart home provider for the development ideas for the smart homes and wearable technology. Improvements of the common areas outside the apartments were not prototyped but rather tested by implementing new layouts and functional additions to spaces based on the renewed methods of communication and feedback. This helped to add all needed functionality needed to these spaces in co-ordination with the building's limitations and requirements. An accessibility check of the building was also scheduled before suggesting these fixes. An accessibility check will check the measurements stated in the accessibility laws, but more throughout testing should be performed with the help of the actual disabled people who use these spaces to make sure all issues are heard and can be taken into account. A test should be performed after the fixes as well, to make sure that the new solutions work as intended when the users can finally naturally test their effectiveness.

And experience prototype was also planned as a prototyping session for the newly envisioned version of the smart home monitor, which could involve tablets optimized for the elderly and the disabled where they could see and inspect all data that was gathered of them, as well as update their privacy settings at will. If possible, the application could also display the daily schedule for the dinners and available activities that the house offers and even act as a communication device between residents and even their friends and family.

Their family and the nurses may have the access to the same smart home sensor data, but would not be able to see the communications log or change any settings that belong to the resident. In an experience prototype the key touchpoints that are linked to form the intended experience with less resources, so the user is able to test new possibilities faster. The tablet solution could give the residents more understanding and access to information that was now only posted as weekly schedules on the info wall of the common area. This concept idea was favoured by many, but the timing for it was too early in the development process and was put on hold until possible later projects. Working within the limited resources defined by the client and making plans for future development directions should play role in every design project as well, and these changes would be presented later when the co-operation with the technology provider would strengthen. A new co-operation project focused on the UI and UX of the application should be arranged to prototype and develop this user experience path further.

A virtual simulation was arranged for the nursing professionals to improve their customer introduction period communication and methods. They defined their new process and trained how to meet new customers, and how to explain the aspects of their new housing situation and the services they get, and how to start a new mutual relationship based on communication and learning. The entire process of becoming a customer was redone in a manner that encouraged learning and sharing information in various ways, so it could be revised and revisited more frequently until it was absorbed truly. This will also help with the issues of consenting to data gathering and storing and understanding the usage and function of the smart homes that the user lives in, as the resident will be more connected to the process as a whole. The resident will also own a binder full of clear and simplified information on the services and functions surrounding them, making the entire user manual of the house available to the seniors themselves in a clear form.

Most prototypes and ideas were seen as positive changes according to the feedback from both residents and professionals, but they were further tuned and improved as well. The idea was to create more dialogue and taking bigger and bigger steps to positive changes that show how dynamic changes that respond to their current and even future needs will be beneficial to the organization. The prototyping and testing should be done at a calm pace if members of the client organization so wish, as they are a part of the design process as well. Iterative nature of the design process enables designers to later revisit ideas that were not possible before, or to start over with some issues completely based on the feedback. As such, future re-evaluation and development for that idea should be planned if the concept is approved by all parties and will be produced and launched in the future.

5.1.5 Ethical questions of smart homes

When working with people - and especially when the people in questions are in more vulnerable situations or positions – the ethics of the research must be paid careful attention to. The consent for data gathering and the safekeeping of private information is not only mentioned here in the academic or legal sense, but it should be adapted to the behaviour of those involved or working in the design and development of services. Especially when working in a housing unit that is someone's home, a careful amount of time should be given to communication and building of mutual trust. The aim of the design project was to create ways to increase the life quality of the residents of the smart homes – and as such the quality of the service itself – but also the effects should manifest as long-term benefits. As such, a relationship between the residents and the service providers and professionals should be enhanced by giving new ways for communication, mutual feedback, and building trust.

A common ethical issue of smart homes especially is the ethical question of data and privacy. Many of the residents let it be known that they are not perfectly satisfied or aware of the functions or the data the devices gather of them and/or the functions of the devices. In elderly care it is common to use smart home technology to survey the inhabitants. However, the inhabitants themselves might not have well-developed technological skills and as such they might not always understand that their personal information about their everyday life is being stored and presented to others, even if they have technically given their consent. On one occasion during the project the habitant even thought that someone is surveying every habitant from the windows, as she could not have thought of any other way for them to know if she is awake at night or not. A person (or if the person is unable to make such decisions, their legal custodian) should ideally be able to give their consent only after they clearly understand who capable of seeing the information, how the information is handled, and what sort of information does the smart home gather about them. Handling this information might be slow learning progress in individuals with low technological knowledge, but it should be seen as a process that is facilitated by the service provider when helping the new habitant to settle in. This was the case in our project, but the people involved in different projects may present different ethical dilemmas for the designers as well.

Such ethical questions should be brought up during the design process and worked together with both groups: the users and the professionals working with them. In the case of the project, the professionals that were interviewed were aware of this issue as well, and

wanted to try out finding better possible solutions. This dialogue, too, is a way of co-designing many of the vital contact spots and systems seen in the user journey method for the designers. Being aware of ethical issues and behaving accordingly is a vital skill when working in user-oriented design, user experience design or service design. Finding solutions to these problems is a key feature in creating user friendly products and services.

5.2 Choosing new smart home technologies

Taking part in some of the project's decision making to bring out the aspect of good design practices can help to ensure higher quality end results in the smart home project. The sensors in accessible homes in the field of health care are typically installed as a permanent or semi-permanent part of the home or the building, which often can only be removed by renovating the space entirely due to the sensors located in the walls and in the flooring of the living space. These technologies are typically sold by health technology companies. The housing location for the installation is typically build or renovated to be legally accessible and suitable for inhabitants with special needs. After the implementation of the smart home, the floors and walls hold a lot of the sensors mentioned above and can be sensitive in future renovations. The sensors typically send data to an application that can be used by the habitant, relatives or nurses to monitor the activity and well-being of the habitant. The habitant often also wears a wrist band or some other wearable technology which might monitor and/or be used to call for help. A communication hub is also usually installed at the home for the purpose of contacting the habitant in the cases of an emergency. Installation of such smart homes are usually performed by professionals as a part of a renovation or a building project. These are often found in elderly care or in other health care-centric housing locations.

During the senior housing projects in such smart home buildings the inhabitants often described a series of typical issues, which should be considered in future planning. A habitant's everyday life must not be too often disturbed by the sensors making false alarms, but the sensors should be still sensitive enough to remain functional when they are needed. Even a gentle breeze of wind or air-conditioning moving curtains near the sensors might trigger false alarms, which can lead to disturbances in the habitant's domestic life even in the middle of the night. These events create an air of confusion or even mistrust in their living space for the resident. It is also important to consider the presence of all living things in the house – including children and pets – and how their presence might alter the functionality of the sensors and smart home functions. As such, it is important to

provide information for the customers about such recommendations and reasons behind certain recommendations, but also to consider their needs and lifestyles in planning.

Other solutions are also available for all consumers to be chosen from for lighter forms of smart home creation. They are often seen as luxury items, but many people with disabilities can also use the technology to ease their everyday tasks without the need to move into a house marketed as a smart home. This technology is already widely available in the market. Examples of these products include Alexa from Apple, Google Assistant from Google, or Echo from Amazon. The products typically are personal AI assistants which use natural language processing to communicate with the user. Installation guides for these smart homes are available for the consumer and the smart home in its entirety can often be installed by the consumer or their family. The user can also hire a professional to help with the installation if they so wish, but it does not require more technological knowledge than being able to set up and use most other smart devices that are widely in everyday use already. This technology can be used to customize commands and chain events to suit the user's unique wants and needs. (Charara. 2018).

By using voice commands and connected applications the user can control other smart devices connected to the application, or the assistant can be used to run certain programs or perform tasks online – good examples of this are online shopping, playing media for entertainment or even playing games. The AI assistant typically uses language processing to browse answers from the web. "I need a taxi" and "call me a cab" are both interpreted to mean the same thing in modern language processing and will produce a similar web search and a similar response from the AI assistant. The AI can also run other applications or actions which are referred to as "skills" in Cortana and Alexa – e.g. Spotify can be used to play music, the Domino's application can order a pizza for lunch, Fitbit can check your step count or maybe Dark Sky gets the weather forecast. Unique combinations for chosen commands can typically be saved for the assistant to use in the future. (Charara. 2018).

The smart device market is also full of different technological devices that can be added to your smart home to bring more functionality. Microsoft's Cortana as an example is typically connected to a smart speaker – a cylindrical speaker called Harman Kardon Invoke was launched in 2017 for this very purpose. Other typical example is the smart thermostat (e.g. Johnson Controls' Glas). It is also usual to combine lighting, media devices, or even smart locks and smart home appliances as a part of the smart home. It is possible to purchase and use smart devices from many sources that can be controlled from the same

smart home assistant, and each smart home developer company often releases their own devices for these purposes as well. (Charara. 2018).

Most connected applications for smart homes require a web connection. Choosing between web-based application and native application when planning the project should still be viewed on a case-by-case basis. Web applications have an existing standard for accessible applications, but the same guidelines can be followed in native applications as well even though other technologies might be in use. Certain smart platforms only accept certain types of applications of a satisfactory quality. However, studying the Web Content Accessibility Guidelines can be recommended when designing the user interface and the user experience of native applications as well. Developing a new application for a smart home is also an ambitious project due to the high security concerns of the field due to their presence in private domestic environments and the highly personal data it gathers. (Charara. 2018).

The platforms on which the application is run should also be optimized for the target audience. Certain assistive technologies can be only used on certain devices, while people with some limitations in their body coordination and vision might find it easier to use mobile devices with large screens. As such, the common recommendations for this issue often include the most common technologies used which can be accommodated in many web applications.

SUMMARY AND AFTERWORD

Smart home technology offers many possibilities to better the lives of people with disabilities – including the older adults and the elderly. Smart devices, sensor technology and any means of communicating this information to relevant individuals can be used to increase the safety and convenience of living, increasing the possibility of leading an autonomous lifestyle. The ethics of smart homes are relevant to all users, but the ethics and the loss of general autonomy is especially an issue that is often faced as a part of the aging process itself. The issues discussed in the chapters concerning ethics will become more and more apparent in these types of projects.

Many residents of the senior housing location stated that the main reason for them choosing this housing service was their physical condition reaching a point where they were unable to live safely at their own home even when they had some professional nurse's assistance available. As such, they stated that the public health care services were not able to help them yet, and as such had to go to the private sector to seek a compromise. The economic situation is not always ideal when they have to make such decisions. However, at the same time many were facing anxiety due to this increased incapability to be in charge of their own lives and the knowledge of the loss of autonomy being a near future possibility was a concern many spoke openly about. Hospitalization was seen as a negative issue, and the community separated themselves from nearby elderly customers who were in more hospitalized housing form and had nurses attending to their needs around the clock. The userbase's physical state and their common shared anxiety was a challenge to the project, leading the way to improving usability and accessibility beyond the minimum guidelines. The second challenge was to improve the client organization's culture for both the clients and the other professionals working for them in a way that supports good design practices and the ethical development of the smart home service. These goals were tackled with user research, multiple design tools, and ethical practices.

Each project will form unique and specialized solutions that will answer to the issues faced in that specific design case. As such, the examples given in this project are just one way of solving user-friendly product design challenges. Promoting ethical approach and improving the client organization from the inside tackled the main needs of the userbase in this specific case. The theory behind the project's results and project structure are, however, somewhat universal in modern design processes and practices. Ethical issues should be discussed and addressed in the co-design projects of the future, and more research is needed still in many issues concerning smart home development. Each project that promotes better ethics and more user-friendly design are a step in the right direction.

It may lead to practical solutions and new tools that can be used to combat these issues more efficiently, but at the very least the aim is to increase the well-being and the standard of living of all individuals and parties related to the case despite their possible differences. Developing ethical solutions in the ever-growing field of technology would benefit the clients, the organizations producing the products and services, as well as those connected to or working in these organizations.

The project was very educational in working with different customer groups, as well as in modern issues concerning information technology and design. Interprofessional differences in project work, even within creative fields, was also extremely useful to experience at this point of my career. Multiple problems were tackled during the project and the experience from working on such a large-scale project was a good introduction into the world of ethical design. Working with the field of social and health care services has also brought insight in the specifics of that field. Familiarizing yourself with this field can be an invaluable skill professionally, as the issues in social and health care services are expected to be even more relevant in the future in Finland. Creative professionals also seemed to often have greatly varied preferences in working culture and creative work, and for example solutions that were familiar to who were coming from UI/UX design background caused more stress and problems to some interior design professionals, and vice versa. Not only was the project quite ambitious from the start, but the interprofessional project management proved to be quite challenging as well.

The project introduced many interesting topics that need future work and investigation. It helped me to investigate my own personal strengths and weaknesses, and to develop the weaker skills to be able to work in an unfamiliar field with different working culture and systems. In comparison to my previous work in the field of software development, the expectations and practices were dramatically different in the field of social and health care services. My growth as a professional was clear during the 1-2 years while investigating these issues in this project, as it was a quite challenging project for those involved who were only starting their careers. The project was in the end still successful in renewing and revitalizing the organization’s smart home product and general practices.

SOURCES

Aira Tech Corp. 2017. Aira product page [referenced 8.3.2018]. Available: https://aira.io/.

Alam M. 2012. A Review of Smart Homes – Past, Present, and Future [referenced 1.3.2019]. Available: https://www.researchgate.net/profile/Muhammad_Raisul_Alam/publication/262687986_A_Review_of_Smart_Homes_-_Past_Present_and_Future/links/5593001d08aed7453d464fba/A-Review-of-Smart-Homes-Past-Present-and-Future.pdf

Black L.I., Vahratian A., Hoffman H.J. 2015. Communication disorders and use of intervention services among children aged 3–17 years. The United States of America: National Center for Health Statistics.

Blackwell D.L., Lucas J.W, Clarke T.C. 2014. Summary health statistics for U.S. adults: National Health Interview Survey. The United States of America: National Center for Health Statistics.

Bernstein, R. 2012. Nearly 1 in 5 People Have a Disability in the U.S., Census Bureau Reports [referenced 4.3.2018]. Available: https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html

Charara S. 2018. The Cortana smart home: Your need-to-know on Microsoft's voice assistant [referenced 12.3.2020]. Available: https://www.the-ambient.com/guides/cortana-smart-home-guide-250

Chung J., Demiris G., Thompson H.J. 2016. Ethical Considerations Regarding the Use of Smart Home Technologoies for Older Adults: An Intergrative Review [referenced 6.6.2020]. Available: https://pubmed.ncbi.nlm.nih.gov/26673381/#:~:text=Ethical%20Considerations%20Regarding%20the%20Use%20of%20Smart%20Home,Older%20Adults%3A%20An%20Integrative%20Review.&text=Key%20ethical%20issues%20of%20the,in%20human%20touch%2C%20and%20usability.

Cleveland State University. 2017. Assistive Technology Equipment List [referenced 4.5.2018]. Available: http://www.csuohio.edu/disability/assistive-technology-equipment-list

Cortiella C. & Horowitz S. 2014. The State of Learning Disabilities: Facts, Trends and Emerging Issues [referenced 5.3.2018]. Available: https://www.ncld.org/wp-content/uploads/2014/11/2014-State-of-LD.pdf

Elliot A. 2015. Color and psychological functioning: a review of theoretical and empirical work [referenced 6.3.2018]. Available: https://www.frontiersin.org/articles/10.3389/fpsyg.2015.00368/full

Elliot A. & Maier M. 2014. Color psychology: Effects of perceiving color on psychological functioning in humans [referenced 6.3.2018]. Available: http://www.annualreviews.org/doi/abs/10.1146/annurev-psych-010213-115035

Finlex. 2017. Valtioneuvoston asetus rakennuksen esteettömyydestä [referenced 15.3.2018]. Available: https://www.finlex.fi/fi/laki/alkup/2017/20170241

International Organization for Standardization. 2017. ISO/IEC JTC 1/SC 36 - Information technology for learning, education and training [referenced 4.3.2018]. Available: https://www.iso.org/committee/45392.html

International Organization for Standardization. 2008. Standards catalogue [referenced 4.3.2018]. Available: https://www.iso.org/committee/45392/x/catalogue/

Microsoft. 2018. Microsoft Garage: Hearing Ai [referenced 8.3.2018]. Available: https://www.microsoft.com/en-us/garage/profiles/hearing-ai/

National Federation of the Blind. 2017. Blindness Statistics [referenced 5.3.2018]. Available: https://nfb.org/blindness-statistics

The U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. 2011. Cognitive Impairment: A Call for Action, Now! [referenced 5.3.2018]. Available: https://www.cdc.gov/aging/pdf/cognitive_impairment/cogimp_poilicy_final.pdf

The World Bank. 2011. World Report on Disability [referenced 6.3.2018]. Available: https://datacatalog.worldbank.org/dataset/world-report-disability

United States Access Board. 2017. About the Section 508 Standards [referenced 4.3.2018]. Available: https://www.access-board.gov/guidelines-and-standards/communications-and-it/about-the-section-508-standards

World Wide Web Consortium. 1997. World Wide Web Consortium (W3C) Launches International Web Accessibility Initiative [referenced 4.3.2018]. Available: https://www.w3.org/Press/WAI-Launch.html

World Wide Web Consortium. 2006. WAI-ARIA Overview [referenced 6.3.2018]. Available: https://www.w3.org/WAI/intro/aria

World Wide Web Consortium. 2008. Web Content Accessibility Guidelines (WCAG) 2.0 [referenced 4.3.2018]. Available: https://www.w3.org/TR/2008/REC-WCAG20-20081211/

World Wide Web Consortium. 2014a. Images Concepts [referenced 6.3.2018]. Available: https://www.w3.org/WAI/tutorials/images/

World Wide Web Consortium. 2014b. Forms Concepts [referenced 6.3.2018]. Available: https://www.w3.org/WAI/tutorials/forms/

World Wide Web Consortium. 2015a. Menu Concepts [referenced 6.3.2018]. Available: https://www.w3.org/WAI/tutorials/menus/

World Wide Web Consortium. 2015b. Carousel Concepts [referenced 6.3.2018]. Available: https://www.w3.org/WAI/tutorials/carousels/

World Wide Web Consortium. 2016. Multimedia Accessibility [referenced 4.3.2018]. Available: https://www.w3.org/2008/06/video-notes#q1

World Wide Web Consortium. 2017. WAI-ARIA Authoring Practices 1.1 [referenced 6.3.2018]. Available: https://www.w3.org/TR/wai-aria-practices/