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Breaking barriers: Accessible self-service kiosks for everyone

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Abstract

Automation and self-service kiosks are rapidly replacing traditional interaction between customers and customer service personnel. To be able to give everyone a user experience that is equal regardless of physical or mental disabilities, it must be ascertained the kiosk products created in the industry can imitate the empathy a human being is capable of without having to segregate users.

The main objective for the thesis was to discover the design principles of an accessible interactive kiosk, and as a by-product, produce a set of guidelines that can be used by the development and design team in creating accessible kiosk products at Village Software. Producing the guidelines required exploring the limitations in design set by a varying range of disabilities.

The approach to this thesis was to review sources on user-centred design, accessibility design and inclusive design as well as draw information from existing guidelines set by governmental bodies and the disability law.

The information was gathered in a separate document that can be used as a guideline and a checklist to see whether a design is compliant. It covers three different disability groups: two physical disabilities (vision and motoric) and one mental disability (cognitive impairment).

The research findings revealed an extensive list of challenges to be taken into consideration when designing an interactive kiosk system. The findings will be used in the future developments of Village Software.

Keywords (subjects)

ticket vending machine, accessibility, usability, touch screen, user experience, self-service kiosk, inclusive design, interactive kiosk

Miscellaneous

Appendix 1 is classified confidential until 24.4.2027

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Tiivistelmä

Perinteiset asiakas-asiakaspalvelijasuhteet ovat siirtymässä pois automaation ja itsepalvelupäätteiden tieltä. Jotta jokainen saa vammasta tai taudista huolimatta samanlaisen, miellyttävän käyttäjäkokemuksen, tulee varmistaa että itsepalvelupäätteet pystyvät mukautumaan niitä käyttävän henkilön tarpeisiin saumattomasti ilman, että käyttäjä kokee itsensä syrjityksi.

Opinnäytetyön päätavoitteena oli löytää ja ymmärtää ne suunnitteluperiaatteet, joita lähtökohtaisesti vaaditaan kun valmistetaan esteetöntä itsepalvelupäätettä. Sen sivutuotteena luotiin Village Softwarelle ohje, jota kehitystiimi voi käyttää apuna luodessaan itsepalvelupäätteitä tulevaisuudessa. Ohjeen luomista varten tuli tutkia niitä rajoitteita, joita erilaiset vammat tuovat suunnittelutyöhön.

Lähestymistapa oli kerätä aineistoa käyttäjäkeskeisyyssuunnittelun, esteettömyyssuunnittelun ja "Design for All" -periaatteiden saralta ottaen myös huomioon erinäisten Iso-Britannian valtiollisten tahojen ohjesäännöt sekä Iso-Britannian vammaispalvelulain.

Tieto kerättiin erilliseen dokumenttiin josta voidaan tarkastaa, noudattaako pääte esteettömyyden periaatteita tai tarkempia ohjeistuksia. Lista käsittelee kolme eri vammaa ryhmittäin: näkövammat, liikevammat sekä erilaiset kognitiiviset vammat.

Tutkimus paljasti useita eri haasteita jotka tulee ottaa huomioon itsepalvelupäätteitä suunnitellessa. Löydöksiä tullaan hyödyntämään yrityksen tulevissa kehitysprojekteissa.

Avainsanat (asiasanat)
lipunmyyntiautomaatti, käytettävyys, saavutettavuus, kosketusnäyttö, itsepalvelupääte, käyttäjälähtöinen suunnittelu

Muut tiedot
Liite 1 on luokiteltu salaiseksi 24.4.2027 asti

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Acronyms and terminology

VSEL	Village Software Engineering Limited
UCD	User-Centred Design
UI	User Interface
UX	User Experience
HCI	Human-Computer Interaction
ATOC	Association of Train Operating Companies
TVM	A ticket vending machine
Interactive kiosk	A display device that allows the user to receive information or complete a transaction by touching the screen or through other input methods.
DDA	Disability Discrimination Act

1 Introduction

Over the last ten years the traditionally predominant ticket sale channel and station ticket offices, have experienced an absolute fall in the amount and value of ticket sales. Instead, ticket machines are now the most popular sales channel in the British railway industry, particularly for journeys of shorter distance and lower value. 21% of all tickets sold in 2014/2015 were purchased on a ticket machine (Association of Train Operating Companies 2015, 7). In spite of that, the retail market review published by ATOC (2015, 10) predicts that TVMs are likely to disappear within the next 5-10 years as a result of digital ticketing. This is believed to be the reason why train operating companies and TVM suppliers are hesitant to make big investments at this point.

Over 11 million people are affected by a limiting long term illness, an impairment or a disability in the UK according to statistics published in 2014 by the Office of Disability Issues (Disability facts and figures 2014). Retailers of all kinds obtain benefits of quicker service and lower expenses. The disabled customers want the same benefits as those without disabilities, to experience the speed and the convenience of a service. If a retailer can provide this value to its disabled customers it can translate into repeated business with them. Considering that some disabled people must seek other people for assistance every day, anything that can be done independently has enormous value. So how can accessibility be ensured in self-service devices without excluding out major groups of people?

1.1 Host company

Village Software Engineering Ltd (shortened Village Software or VSEL) is a Liverpool based software development company founded in 1986. It has been a permanent feature of the Liverpool IT industry ever since. (Village Software website, 2016.)

Village Software has several years of experience in designing ticket vending machine software, however, they have conducted very few, if any audits on the accessibility and usability of their products. The lack of systematic and unified usability testing is often the reason why the end product might have usability issues that have gone unnoticed during the development process. Village Software is now keen on designing and developing their ticket vending machine software to be more accessible for the visually impaired and those in wheelchairs or of small stature, regardless of the physical appearance of the kiosk station.

1.2 Motivation and purpose

The motivation for the study derived from the need to adapt VSEL into building more empowering self-service kiosks for all the users and from the author's long-lasting interest in user experience design. The previous experience in visual design and the knowledge of the TVM products of VSEL has given the author the confidence to choose such an extensive subject to research.

The main purpose of this thesis is to analyse and outline the design principles, patterns, and themes that are effective when designing the interface of a self-service kiosk. The main source for the guidelines came from a literature review on the subject. From the findings the author created a checklist tool of general principles that could be used during the design process and when evaluating a design made by someone else to determine whether the design can be considered accessible. The purpose of the checklist tool was to aid the designers in their work and give the developers or testers a reference for situations where an appointed designer is not available for consultation.

2 Research and implementation

2.1 Research questions

The study aims to answer the following research question:

- What are the design principles that ensure accessibility in self-service devices?

Supporting research questions are composed of as follows:

- What type of disabilities may affect an end user's ability to use a self-service device?

- What are some ways Village Software can directly benefit from when focusing more on the accessibility of their products?

2.2 Approach and methods

The primary method in this thesis is qualitative research with the support of design research methods. Qualitative research is based on the basis that there is no or very little data, theory or research on the subject. Its aim is to provide a comprehensive, holistic description of the phenomenon. To achieve this, the researcher must understand the phenomenon through the world of the research subjects (Kananen 2015, 66-67). The design research method is used to deliver tangible solutions to a problem at hand and its effectiveness can be measured when it is in practice (Kananen 2015, 37).

The material will mainly be gathered online due to a limited access to physical hardback literacy on the subject. The data needed for a comprehensive description of the problem and its solution will be sourced sourced from accessibility literacy, websites and blogs on accessibility issues, annual reports and guideline documents from governmental bodies.

An email interview will be organized with Ian Bufton, the Technical Executive of VSEL for information on what the thought process for accessibility design has been like up until now (Bufton, I. Personal Communication, 16.3.2017).

In order to follow the principles of qualitative research, Kananen’s (2015) publication Online Research for Preparing Your Thesis will be used as a guide to meet this goal.

3 Interactive kiosks

Kiosks are more than mere digital signage. What sets them apart from static signage is that they integrate many devices, include a graphical user interface application and remote monitoring, and accept user input. Although a kiosk has a screen, its purpose is different once it dispenses a ticket or guides a user through a self-checkout at a supermarket for example. (Kelsen 2010, 182-183.)

3.1 Brief History of interactive kiosks

The first self-service kiosk was developed in 1977 at the University of Illinois by Murray Lappe. Lappe's kiosk, called the Plato Hotline, gave the university students and visitors the ability to find movies, maps, directories, public transport schedules, extracurricular activities and courses, and a way to email student organizations. More than 30,000 students, teachers and visitors used the kiosk during its first six weeks of operation. For many of them it was the first time they had a chance to try out a personal computer. The first commercial kiosk connected to the internet was displayed at COMDEX computer expo in Las Vegas in 1991. It was built for the purpose of locating children gone missing. Today, almost 40 years later, kiosks have brought together the classic vending machine elements with high-tech communications with mechanic internals. Self-checkout lanes, ticket vending machines and information screens are all types of interactive kiosks that have been adapted as a part of the daily life (see Figure 1). (Kelsen 2010, 182.)

Figure 1 Two different types of interactive kiosks

3.2 Challenges of kiosk design

Like VSEL's interactive kiosks, a typical interactive kiosk is accessible in a public location and created for the use of general public. Interactive kiosks can pose a challenge to designers if effective results are desired. The first challenge is to catch the attention of a passer-by while being clear of what the kiosk's purpose is. The general public includes people of all technical literacy levels and confidence in using an interactive kiosk. Often the kiosk will be accessed by a user who has never used the system – or any similar system – before. Users may have a limited time in which to finish a task on the kiosk, which is why they should be designed to be as self-explanatory as possible. (Maguire, 1999.)

In *A Review of User-Interface Design Guidelines for Public Information Kiosk Systems* Maguire (1999) provides an effective set of recommendations for design touching several aspects of design such as graphics, the physical features and how the kiosk should be positioned:

1. **Location**
   Interactive kiosks rely on being noticed by the public passing by. The decision to use the kiosk is made on the spot. It is a good idea to set up signposting to its location within the vicinity. (Maguire, 1999.)

2. **Encouraging use**
   Running a demonstration on the screen of the use is a good way to encourage passers-by to approach the device. However, it is important to make clear how to interrupt the demonstration to start using the system. (Maguire, 1999.)

3. **Physical access**
   To give equal access to users whether they are standing or using a wheelchair, the system must be placed so it is convenient for both (Maguire, 1999).

4. **Introduction and instructions for using the system**
   A user might not have the time to read long instructions displayed on the system before using it. Instructions should be kept brief and presented at each stage of interaction. (Maguire, 1999.)

5. **Language selection**
   If the system is to be used in a place where the local community widely speaks more than one language or where it will be used by foreign tourists it might be useful to provide multiple languages to use the kiosk in. (Maguire, 1999.)

6. **Privacy**
   If the kiosk handles sensitive information, such as bank details or other personal details, the user will not want to draw attention to themselves when interacting with the system. The physical device should be designed so that user's body will block the

view to the screen from others. (Maguire, 1999.) For example ATM points are designed like this.

Whereas Maguire (1999) recognises inclusiveness, effective use, and supportiveness as the main objectives for the kiosk design, the newer generation of researchers and designers (e.g. Siebenhandl et al., 2013) seem to have switched over to a new set of objectives: user experience and emotions. The heuristics in particular and the recommendations of those like Jakob Nielsen are found to be beneficial when designing kiosks for the average user (Tala, 2016).

4 Terms and definitions related to usability

People do not often distinguish between the terms user experience and usability, the terms related to the theoretical framework of the thesis. For the purpose of the study, there is an essential need to understand what these terms mean and how to distinguish them from one another. This chapter dissects the terms and discusses factors and other concepts related to them in the context of TVMs, for example the laws surrounding accessibility.

4.1 User Experience

The international ISO standards define user experience as “a person’s perceptions and responses that result from the use or anticipated use of a product, system or service” (ISO FDIS 9241-210:2010). Every expert has their own definition of what user experience is; however most agree it involves a user, an interaction with a product, and the user’s feelings emerging from the interaction (Tullis & Albert 2013, Ch. 1).

In the context of TVMs, the surrounding conditions and social experiences seem to be important factors. Avoiding technology in this respect is caused by negative social experiences. It is not unusual that the ‘non-average’ users meet impatient reactions and even social pressure from the people waiting in line to buy a ticket from a kiosk (Siebenhandl et al., 2013).

4.2 Measuring user experience

Metrics are used to measure and evaluate phenomena or concepts such as products. Every industry and field of profession has its own set of metrics and usability is no different. Usability uses metrics such as task success, user satisfaction, and errors. Essentially all UX metrics have to be quantifiable, i.e. to be able to be counted in some way (Tullis & Albert 2013, Ch. 1). However, it is submitted that as in any other study, there is no one-size-fits-all set of metrics for UX analysis because every product is built for a different purpose and for different target groups.

Evaluation on a product's usability is conducted by inviting participants to perform tasks using the product; however, collecting UX metrics is not restricted to a certain type of evaluation method. Traditional moderated usability test utilises a relatively small group of participants. The size of this group is typically 5 to 10 people. The lab test involves a moderator and a participant in a one-on-one session. The moderator records the participant's actions and behaviour as he or she performs a set of tasks. (Tullis & Albert 2013, Ch. 3.)

Online studies are a good way to collect plenty of data in a short time from geographically scattered users. They are often set up similarly to lab tests, however, these are less ideal when a researcher wants to gain a broader insight into the user's behaviour and reactions (Tullis & Albert 2013, Ch. 3). Figure 2 exhibits how online usability test tools fit with qualitative and quantitative research methods.

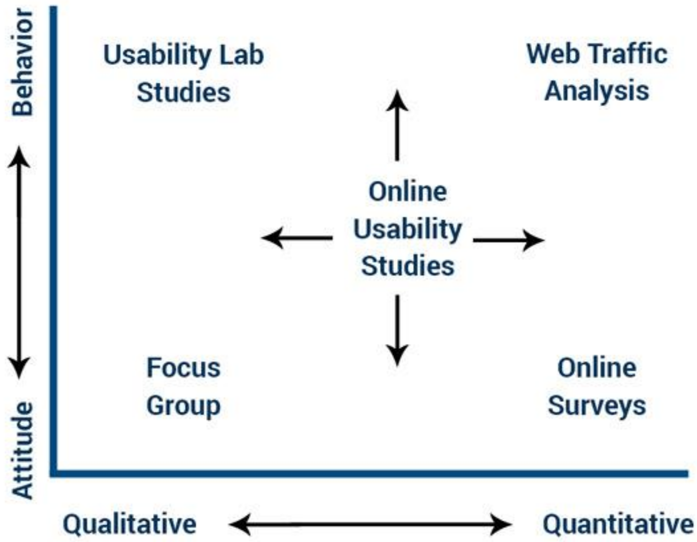

Figure 2 How usability test tools fit with user research methods (Albert & Tullis, 2013).

4.3 User-centred design

User-centred design (UCD) is a design philosophy where the end-users are greatly taken into consideration within the design process. The goal is to validate and improve the design by testing the design with real users. The emphasis is on understanding the user’s needs, wants and limitations. UCD is an iterative process, meaning it is a virtuous circle of user research to design to research and design again. This way each success in an iteration should be better than the last one. (Allen & Chudley 2012, 3-4.)

Newell (2008) summarises some factors to consider when talking about UCD for older people or people with disabilities. These include but are not limited to:

- Challenges in considering of the great variety of user characteristics and functionality
- The challenge to find suitable “representative users”
- Clashes of interest between accessibility for the people with varying disabilities
- Conflicts between accessibility and ease of use between people with different disabilities (e.g. greater contrast helps those with visual impairment but may cause problems for the dyslexic)
- Situations where “design for all” is not applicable (e.g. legally blind drivers of motor vehicles)

4.4 UCD in an Agile environment

Because VSEL is mainly an Agile environment and follows the Scrum principles it is useful to find out how implementing UCD in an Agile development works. Traditional UCD and Agile certainly have a potential to conflict, as Agile favours sacrificing initial design time in the interests of delivering code quickly instead of performing analysis and design. However, UX tasks typically begin long before the development sprints take place. (Allen & Chudley 2012, 6). Table 1 illustrates an example of a Scrum development cycle where UX related tasks are defined.

Table 1 UCD activities within Agile Scrum development (Allen & Chudley 2012, 7)

<table>
<tr><th>Phase</th><th>UX/UCD tasks</th></tr>
<tr><td>Pre-development</td><td>• Business requirements
• Competitor analysis
• Contextual analysis
• Task models
• Personas
• High level wireframes</td></tr>
<tr><td>Sprint 0</td><td>• Detailed wireframes for sprint 1</td></tr>
<tr><td>Sprint 1</td><td>• UX support for current sprint
• Detailed wireframes for next Sprint
• Preparation for user testing</td></tr>
<tr><td>Sprint 2</td><td>• UX support for current Sprint
• Detailed wireframes for next Sprint
• User test work to date and latest wireframes</td></tr>
<tr><td>Sprint 3</td><td>• UX support for current sprint
• Detailed wireframes for next Sprint
• Preparation for user testing</td></tr>
<tr><td rowspan="2">Repeat until development complete</td><td>• UX support for current Sprint
• Detailed wireframes for next Sprint
• User test work to date and latest wireframes</td></tr>
<tr><td>• UX support for current sprint
• Detailed wireframes for next Sprint
• Preparation for user testing</td></tr>
<tr><td>Final Sprint</td><td>• UX Support for current sprint
• User test work to date</td></tr>
</table>

4.5 Usability

Usability is usually considered the capability of the individual to execute a task successfully. (Tullis & Albert 2013, Ch. 1) The international standard ISO 9241-11 (1997) defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” It is debated when computer usability was born. It followed usability work for non-computer machines in other industries and human factors. Usability for computer machines became a topic of interest to some professionals by the late 1970s when the first conferences about the topic were established. (Hartson & Pyla 2012, Ch. 1.)

Some misconceptions and mischaracterizations still exist even though usability is already an established part of the technology world. Words like “dummy proofing” and “user friendliness” are considered demeaning and misdirected by some users and designers alike. It is argued that to say usability is about friendliness downplays the design process and ignores the importance of other aspects such as user performance and productivity (Hartson & Pyla 2012, Ch. 1.).

4.6 Accessibility

Accessibility is a major part of usability. Accessibility is a measure of an individual’s capability to interact with the subject, in this case a self-service application. Once the individual can perform a given task with little or no external human help the application can then be considered as both accessible and usable (Mueller 2003, Ch. 2). Accessibility is also a concept that can be applied to a physical, mental or a cognitive condition that prevents equivalent use of a product or a service. To design for users who are unlike us one must temporarily disconnect from his or her own preconceptions to have a better grasp of the world they live in. (Smith 2013, Ch. 1.)

There are many reasons as to why developers and designers should build the products accessible: it makes good business sense, everyone should have the same opportunities and equal access; it is a huge potential market and it is not just a good idea but it is the law. However, many of those designing products seem sceptical about the idea that building accessible products would not affect everyone else’s experience negatively. This scepticism overshadows the fact that accessibility is simply the right thing to do. By investing in their work slightly more as developers and designers, they can create equality and improve the daily lives of people who have disabilities or those who live with certain limitations. (Krug 2006, 170-171.)

4.7 Metrics for (web) accessibility

The problem surrounding accessibility metrics are the inevitable biases humans have. Usability metrics (see chapter 4.1.1) are used as a core approach, however, they are all subject to bias. Depending on which task was attempted by which user, with which disabilities, the results can be greatly skewed. The creation of accessibility metrics has been attempted by web accessibility experts using automated evaluation tools. These automated reviews are conducted using software tools running algorithms. They check the screen design that is usually a website, and whether it is compliant with a set of accessibility guidelines. However, even at their best they often lack in accuracy and will always require human judgement, for they only have such a limited range of criteria they can interpret. (Lazar et al. 2015.)

Automated review tools cannot evaluate ease of use, so they can only indicate whether the test case is compliant with the predefined guidelines from a technical point of view. The value to the real end-user is non-existent, when the tool can only check for the presence of a feature but not how useful it is (Lazar et al. 2015).

The third approach is to use an expert to review the design. It should be noted that an expert is not representing the user. While the user, as a tester, knows the tasks, the expert reviewer knows interfaces very well and vice versa. There are several ways of conducting expert reviews. Heuristic review covers only the most common problems by checking the interface against some known design heuristics, such as the eight golden rules. A consistency inspection involves an expert reviewing the interface widely for consistency in language, type face, colour etc. A guidelines review can become a lengthy inspection because organisational guidelines can consist of hundreds of items and cover multiple types of disabilities (Lazar et al. 2015). This is the most time consuming of all the review types and is what Village Software will attempt to take on.

4.8 Accessibility laws in the United Kingdom

In the United Kingdom, the accessibility standards for web sites and other technology are specified by the Disability Discrimination Act, that focuses mostly on government websites and other government provided technology services. Since 2010 it has been updated by the Equality Act 2010, which attempts to reinforce the impact of the previous legislation, making the law now proactive. This means organizations cannot wait until a person with special needs attempts to use their service to comply with the law, instead they must determine in advance what should be done to provide equal accessibility for everyone. The law applies to both, public and private sector for web sites and other technology that could cause discrimination if there is a lack of accessibility. (Buie 2010.) The Equality Act 2010 defines disability as “a physical or mental impairment that has a substantial and long term adverse effect on a person’s ability to carry out normal day-to-day activities” (Office for Disability Issues 2011).

5 Inclusive design

5.1 General

There are many ways of approaching disability as a concept; however from a designer point of view, it should be viewed less as a personal health condition and more as a mismatch of human interactions (Microsoft 2016). While it cannot be predicted who uses the created products, an attempt can be made to accommodate most people’s needs with inclusive design. Inclusive design or universal design is a concept intended to benefit all users by levelling people of all abilities. Handicapped accessible facility and a facility that shows evidence of inclusive design have their differences. The simply accessible facility might have aesthetically awkward design decisions compared to the other one or it can even segregate disabled individuals by its location or look (Smith 2013, Ch. 3). In loose terms inclusive design aims not to segregate different levels of abilities but accommodate and empower seamlessly everyone regardless of their skill level or familiarity without ignoring design aesthetics or having to compromise for advanced users.

5.2 Exclusion can be situational or temporary

Sometimes being handicapped can be temporary or situational. Depending on environments, people’s abilities can change greatly. Even if only for a short time, a short-term injury or context will affect the way people interact with the world around them. Hearing becomes harder in a loud environment, being a new parent means you might be doing plenty of daily tasks one-handed and being in a car can restrict your vision. Ordering food in a foreign country can also be an example of situational impairment (Microsoft Design 2016).

Microsoft use the Persona Spectrum (Figure 3) to explore the spectrum of permanent, situational and temporary scenarios and the mismatches and motivations that arise from them. It is described as “a quick tool to foster empathy” (Microsoft Design 2016).

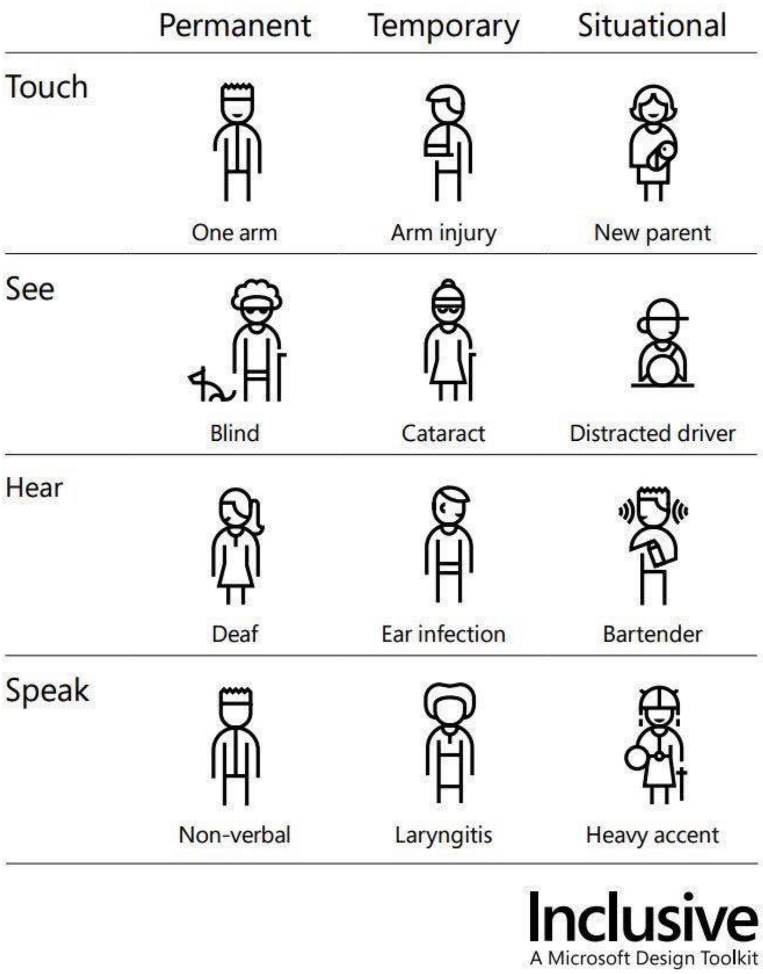

Figure 3 The Persona Spectrum by Microsoft Design (2016)

5.3 The seven pillars of inclusive design

In 1997 a group of architects, product designers and environmental design researchers developed the Seven Pillars of Inclusive Design. The pillars were developed to guide the design of environments, products and communications, not just interfaces. They can be applied to help evaluating existing designs and guide the designers or even educate the designers and consumers alike about the aspects of universal design (National Disability Authority 2014).

1. **Equivalent use**
   The design should be useful and marketable to individuals with abilities of all levels. To avoid segregating or stigmatizing users, the means of use should be the same for all users. Arrangement of privacy, security and safety should be objectively available for all users (National Disability Authority 2014).

2. **Flexibility in use**
   The design should accommodate a wide range of individual preferences and abilities. This includes facilitating for right- and left-handed users, user's accuracy and precision and the user's pace (National Disability Authority 2014).

3. **Simple and familiar**
   User's experience, knowledge, language skills or current distractions have no effect on understanding the use of the design. This can be achieved by eliminating unnecessary complexity and being consistent with the user's expectations. Providing prompting and feedback during and after the task completion will make the design more intuitive to use (National Disability Authority 2014).

4. **Perceptible information**
   The necessary information is communicated to the user effectively, regardless of the surrounding conditions or the user's auditory and sensory abilities. The use of different modes of presentation, such as verbal, pictorial, tactile and audio-visual to communicate essential information maximises the legibility of the necessary information (National Disability Authority 2014).

5. **Tolerance for error**
   Elements should be arranged in a way that helps to minimise errors. The most used elements should be the most accessible ones while hazardous elements should be either eliminated, isolated or shielded somehow. Unintended or accidental actions by the user should be less likely to cause hazardous or otherwise unwanted consequences. This can be done by providing warnings before the user is about to make something that could potentially be irreversible. (National Disability Authority 2014.)

6. **Low physical effort**
   Using the design should not require an effort that would make the users uncomfortable or cause them fatigue. It should allow the users to maintain their normal body position, and they should be able to use the design without unreasonable operational body force (National Disability Authority 2014).

7. **Size and space for approach and use**
   Convenient size and space should be provided allowing the user to approach, reach and use the design regardless of their body size, stature or mobility. Clear line of sight to important elements should be achievable for any seated or standing user. All the elements should also be comfortably reachable whether or not the user is seated or standing (National Disability Authority 2014).

6 Defining the disabilities in the scope

Disabilities like abilities have numerous definitions. It is not entirely a binary concept where people are lumped into one of the two designations, the one with disabilities and the ones with no disabilities. Sometimes it could be assumed that all members of a certain disability group share the same characteristics. (Smith 2013, Ch. 2.)

This chapter defines the disabilities in the scope and introduce means of how inclusive design can be applied to the TVM products of Village Software. Since VSEL is only involved in the development of the kiosk software, the study excludes disability characteristics that may affect the access to the physical machine itself, including physical outlets, access paths, and other structural features.

6.1 Visual impairment

For the sake of the study, visual impairments is categorized into two groups: blindness and low vision, and colour blindness.

The World Health organization classifies visual impairments as shown in the table below.

Table 2 Categories of visual impairments based on the best corrected vision classified by WHO

Category	Visual Acuity
Mild vision loss, or near-normal vision	20/30 to 20/60
Moderate visual impairment, or moderate low vision	20/70 to 20/160
Severe visual impairment, or severe low vision	20/200 to 20/400

Profound visual impairment, or profound low vision	20/500 to 20/1,000
Near-total visual impairment, or near total blindness	More than 20/1,000
Total visual impairment, or total blindness	No light perception

This definition by WHO was set in 1972, and there is an ongoing debate whether the definition of blindness should be adjusted to officially include refractive errors (Change the Definition of Blindness). According to the statistics of Royal National Institute for Blind People, in the UK out of 2 million people (3.12% of population) living with sight loss, around 360,000 are registered as blind or partially sighted (Royal National Institute for Blind People 2016).

Colour vision and color blindness

The retina at the back of a human eye has two types of receptor cells: rods and cones. The cone receptors detect colour, and there are three types of cones sensitive to red, green, and blue light. In some measure human's colour vision works similar to video cameras and displays that either detect or project colours through combinations of red, blue, and green pixels. Those with colour-blindness may have fewer than three cone types, however it does not mean a person cannot see colours. Red-green is the most common type of colour-blindness while other ones are much more uncommon. Regardless of the name it does not mean a person with red-green colour-blindness cannot distinguish between only red and green light, but are unable to distinguish between all colours which have been mixed with red light or green light. For example, a sufferer will confuse blue and purple because they are unable to detect the red light of the colour purple (Figure 4) (Johnson 2014, Ch. 4).

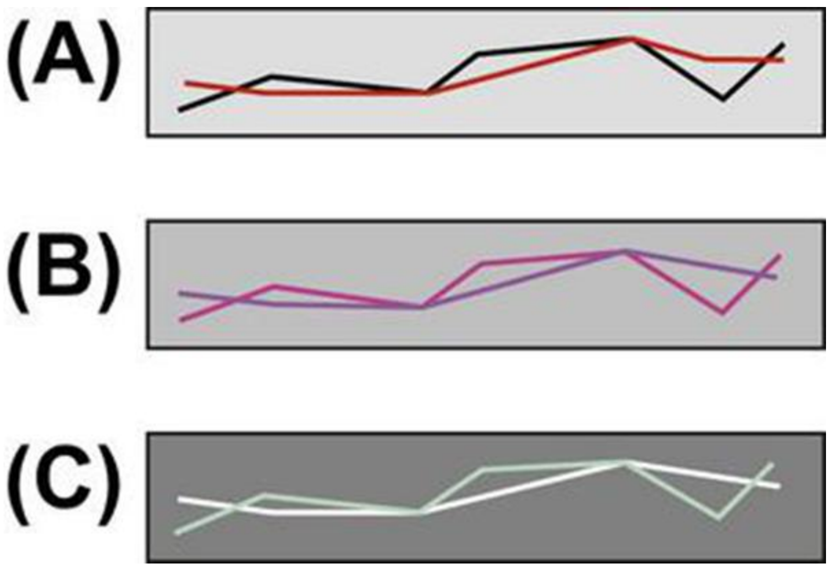

Figure 4 Combinations red/green colour blindness sufferers cannot distinguish (Johnson 2014, Ch. 4)

Accommodating visual impairments

Because kiosk software are static and in public use, the biggest challenge for a user with low-vision is that they cannot change the size of the text, the contrast of the screen, or the surrounding lightning conditions to suit their vision like they would do on their personal computer or handheld device in their own home. Accommodating for the visual impaired people would mean creating a separate style sheet with greater contrast and bigger size of the text. Doing that could compromise the look and aesthetics of the interface, which contradicts with the idea of inclusive design discussed in Chapter 5. Another prominent idea is to provide the user with a choice to adjust the size of the text from the interface.

To assure the users of the interactive software receive the information as intended, Johnson (2014, Ch. 4) provides five guidelines to follow when designing the colour-blind in mind:

1. **Use saturation, brightness and hue to distinguish colour.** A quick way to see if there is enough contrast between colours is to render them in greyscale.

2. **Use of distinctive colours.** The most distinctive colours are black, white, red, green, yellow and blue (See Figure 5). Each of them cause a strong signal on only one colour-opponent. All other colours cause signals on one or more

colour-opponents and because of this human minds are not able to distinguish them from the other colours as quickly.

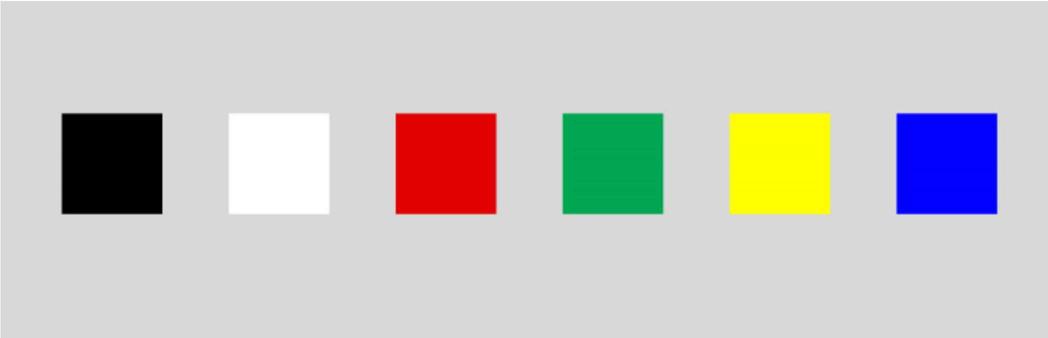

Figure 5 The most distinctive colours (Johnson, 2014)

3. **Avoiding the use of colour pairs the colour-blind cannot distinguish.** Such pairs include the ones presented earlier in Figure 4, dark red versus black, blue versus purple and light green versus white.

4. **Do not rely on colour alone.** If colour is used to mark something, it should be accompanied by something else too, a symbol for example (see Figure 6).

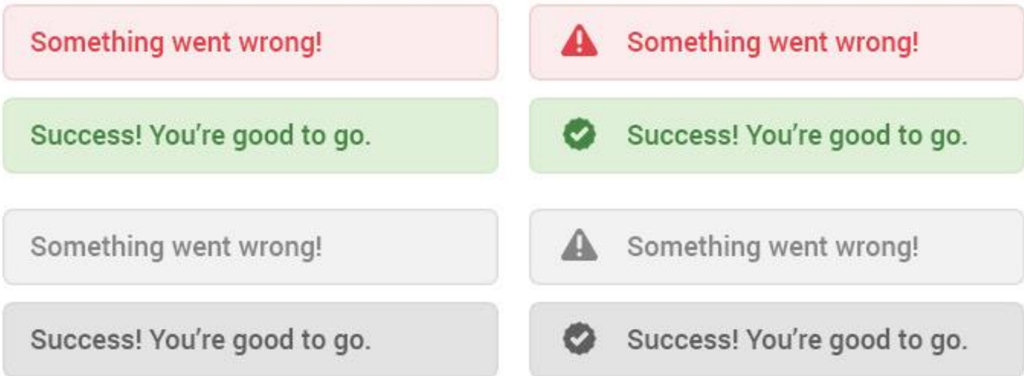

Figure 6 Symbols can help distinguish between two different alert messages if user is not able to perceive colour

5. **Separate strong colour-opponents.** Using colour-opponents on top of or right next to each other should be avoided as it causes a flashing sensation in our vision (see Figure 7).

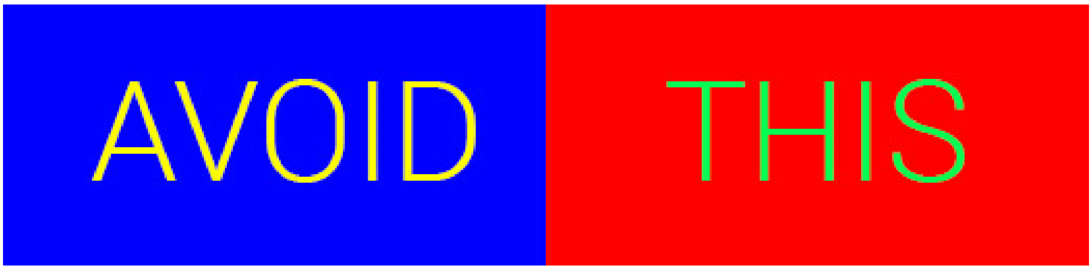

Figure 7 Colour-opponents cause flashing sensations in our vision

Proofing our work

There are several tools available to help to simulate different types of colour-blindness during the design process. For example Adobe Photoshop has an integrated feature, which can simulate colour-blindness inside the software. If design is carried out in a browser, the most agile tool for simulating colour vision impairments is a browser extension that can change the colours in the current view of the browser to simulate any type of colour deficiency. At VSEL a Chrome extension 'I want to see like the colour blind' has been recently taken into use. The extension can simulate between eight different colour deficiencies (see Figure 8).

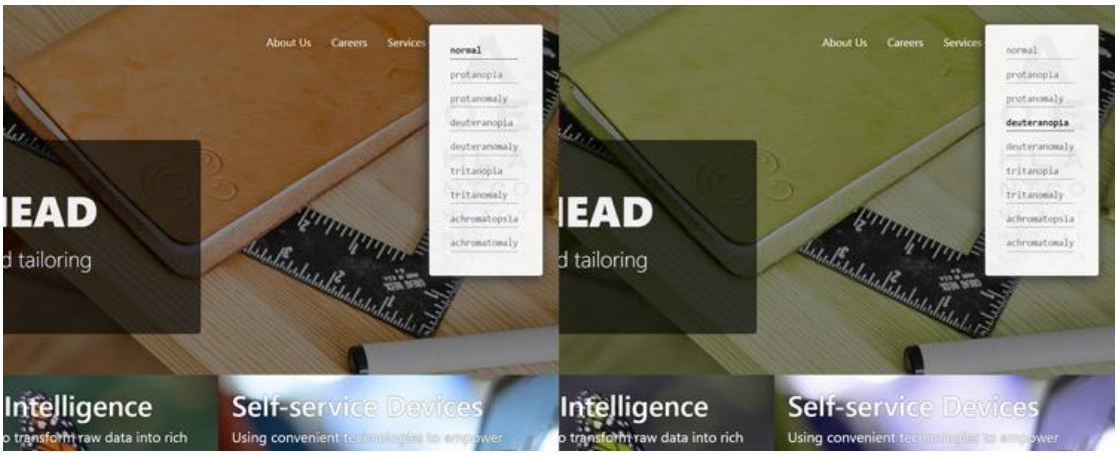

Figure 8 Google Chrome extension I Want to See Like the Color Blind

When it comes to being able to differentiate elements from one another visually, contrast is a very important factor. While rendering the design in greyscale is a useful technique, it might not sometimes be possible. WebAIM offers an online colour contrast checker in which it is possible to check the compatibility between a background and a foreground colour (see Figure 9). The tool checks the contrast between the colours and applies Web Content Accessibility Guidelines (WCAG) 2.0 to them. The tool will then inform the user if the colour combination is compliant to WCAG.

Figure 9 WebAIM's color contrast checker

6.2 Cognitive Disabilities

Any sort of cognitive disorder that impairs a person's understanding and functioning is considered a cognitive disability. The concept is extensive and always not defined thoroughly; however in loose terms those with a cognitive disability have a greater difficulty with mental tasks than the average person. (WebAIM, 2016.) Often the term "cognitive disability" is used people think of those with a mental handicap. However; just like any disability, cognitive disability is not necessarily a binary system or a linear scale. A brilliant example of this is a quantum physicist struggling to figure out how to use his new smart phone, while his teenage daughter has no problems in using one. (Emotional Design Elements, 2013.) Fluency in modern technology and an ability to adapt is clearly prevalent when it comes to millennials and post-millennials.

Cognitive disabilities can be classified at least into two categories: clinical and functional disability. Clinical diagnoses include autism, Down Syndrome, traumatic brain injury, dementia, attention deficit disorder (ADD), dyslexia (difficulty reading), dyscalculia (difficulty with math), and general learning disabilities. While clinical diagnoses are useful from a medical point of view, classifying cognitive disabilities by functional disability is more useful in the eyes of a designer (Web Accessibility in

Mind, 2016). Functional cognitive disabilities involve challenges in a person's problem solving ability, attention, memory, math comprehension, visual comprehension and reading (Disabled World, 2016).

Accommodating cognitive disabilities

Plenty of time the same design guidelines used to design the web can be applied when developing a TVM kiosk. WebAIM (2016) reminds that a list of design considerations for users with cognitive disabilities can often turn into a tedious list of general design principles aimed to aid everyone. The aspects listed in this study will not cover the subject as a whole but rather present some of the major principles.

Ticket purchase processes can often become lengthy, especially for those who have problems reading or remembering. To accommodate those with a memory deficit it is a good idea to have a constant reminder of what the user has done, what part of the process they are in at that moment, and what is yet to come (WebAIM 2016). Such a feature has not been seen previously in the TVM products developed by VSEL, and it is submitted that introducing a progress bar (see Figure 10) displaying the previous, current, and future steps of the process would be beneficial not only for users with memory deficits but to everyone.

Figure 10 A simplified example of a progress bar

A general rule exists in interface design and it is to answer user's expectations. In practice, this means to have consistency in navigation and content in such way that a certain event from a certain action is always expected. Consistency is the number one key to aid those with short-memory difficulties. Presenting the essential information in short capsules and making it more interesting with relevant graphics can make the information more accessible to those with a short memory span and users with attention deficit disorders. (Jiwnani, 2001.)

The most critical factor affecting people who are suffering from dyslexia when it comes to perceiving colour is contrast. Research has suggested that when the colour contrast is reduced, the reading difficulties suffered by dyslexics are relieved (Pedley, 2006). If this rule were to be taken into action, it would greatly contradict the design guidelines for the visually impaired discussed in the previous chapter. Pedley (2006) argues that reducing the colour difference threshold by 10-20% should not show a significant negative impact on visually disabled users. A solution suggested by Pedley includes two different style sheets, one with a lower contrast and another one with a higher contrast that the user can change to their own accord. If this is not an option, the suggestion is to drop the WCAG compliant contrast slightly. Nonetheless, there are more ways of accommodating dyslexic users than just colour and contrasts. White space in the margins and vertical white space between headings, paragraphs and tables are beneficial to those with dyslexia. If possible, sans-serif typefaces should be used instead of decorative serif letters with hooks in them (see Figure 11), as overly decorated serif fonts can create additional problems recognising a word. (Pedley, 2006.)

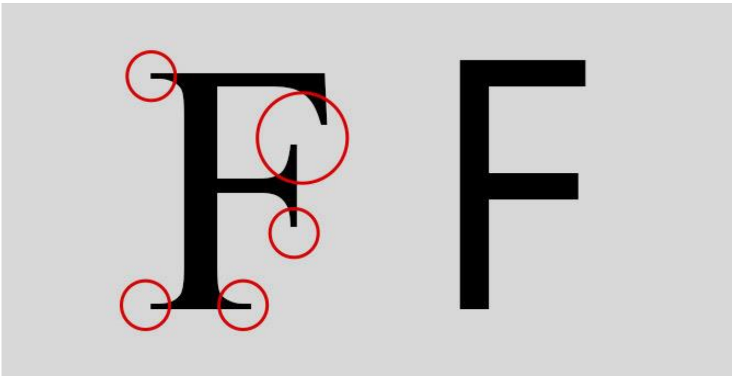

Figure 11 Serif fonts (left) are recognised by the hooks at the end of the letter strokes

It is normal human behaviour to commit errors such as tapping on a wrong button or misspelling a word. For some individuals, this tendency can be exaggerated due to a disability so they make even more mistakes. No matter what the frequency of the mistakes is, everyone likes to be able to correct himself or herself, which is why error messages need to be explicitly self-explanatory and communicate what the user did wrong and how to fix the problem. If the error messages fall short on that information the user is likely to leave the machine and find an alternative way of buying a ticket (see Figure 12, Oona Salla's photograph of an intangible error message). To further accommodate those with a problem-solving deficit, it should be noted that actions that are irreversible, such as quitting a ticket booking session midway, the user should be warned and prompted for a confirm that this was an intended action. (WebAIM, 2016.)

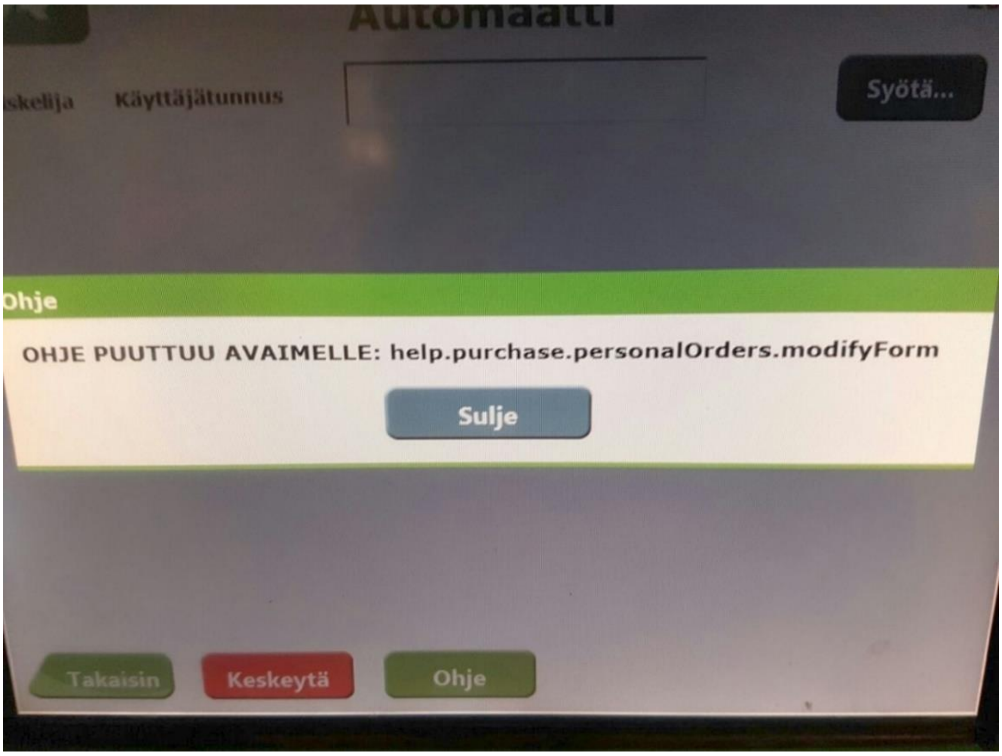

Figure 12 An intangible message on a train ticket vending machine in Helsinki, Finland (Photo by Salla, O. 2016).

6.3 Hearing loss and deafness

Village Software is yet not involved in making decisions about sounds produced by the kiosks, however, the topic will be covered lightly for future reference.

Hearing is one of the traditional five senses. Hearing loss can be categorized by its severity, similar to the way how severity of visual impairment can be measured. The grades of hearing loss are shown in Table 3.

Table 3 Levels of hearing impairment classified by WHO (2016)

Grade of hearing loss	Hearing level in decibels (dB)
Slight/Mild: Person will have trouble hearing and understanding soft speech, speech from a distance or speech against background noise.	26-40 dB
Moderate: Person will have difficulty hearing regular speech, even at close distances.	41-60 dB
Severe: Person may only hear very loud speech or loud sounds in the environment, such as a fire truck siren or a door slamming. Most conversational speech is not heard.	61-80 dB
Profound: Person may perceive loud sounds as vibrations.	over 81 dB

For some deaf and those suffering from partial hear loss the use of a self-service device can be an empowering experience, as it means the person will not necessarily have to rely on written notes or an interpreter when trying to buy a ticket.

While hearing might not be the most critical sense needed to operate a self-service kiosk, there are aspects which should be taken into account. Firstly, given the nature of the self-service kiosk software VSEL develops, they are most likely to be found in environments with much background noise, such as travel centres, train stations, and other busy outdoor locations with surrounding traffic. Provided that sounds are accompanied with appropriate imagery or text alerts on the screen, the error of user forgetting to pick up their change or tickets for example is minimized. In general, it is a bad idea to leave an alert to be perceived by hearing, or by any single sense alone since it can be missed when the user might be distracted by something else.

6.4 Mobility impairment and limited dexterity

Mobility impairment is a wide category of different physical disabilities including upper limb and manual dexterity disabilities, loss of fine-motor control and some conditions such as cerebral palsy and carpal tunnel syndrome. The disabilities can be of temporary or permanent nature and range in severity (Wahlbin, 2012). Loss of muscle strength, stiffness and spasticity are common traits in those with physical and mobility impairments. Loss of muscle strength and restricted mobility takes place naturally as people age. Loss of mass and stiffer joints and changes in one's gait can significantly compromise the person's balance (Disabled World, 2015).

People with dexterity disabilities can have problems with one or more touchscreen functions. The most prominent one likely is having issues with pressing hard or accurately enough to interact with the correct buttons or a virtual keyboard on the screen (Touchscreen Use and Accessibility Issues, 2014). For example, users with Parkinson's disease have tremors in their limbs. The tremors cause "shaking hands" which can make hitting a button accurately on a touch screen challenging.

Here the focus is mostly on those who have limited arm or hand movements, able to use only one hand, have tremor and those who have difficulty with fine movements.

Accommodating issues of dexterity

In a study conducted by Chen et al. (2012), the group investigated the effects of button and the size of distance between them on performance by users with diverse motor abilities. The performance was measured in such metrics as miss, error and the time taken to complete a task. Participants with motor impairments included those diagnosed with cerebral palsy, multiple sclerosis and Parkinson's disease among some other diagnoses. Participants from both categories completed a digit entry task with ranging button sizes. The results indicated that for the non-disabled the performance did not continue to improve with button sizes above 20 mm. In comparison, the disabled group continued to demonstrate improvement past 20 mm, up to button sizes 25 mm and 30 mm. Making the buttons any larger than this can actually slow the user down, because the finger has to move a bigger distance.

The gap size between buttons did not seem to have any significant impact on how often the participant missed a button (Chen et al, 2012).

Another study done by Chaparro and Stumpfhauser (2001) found out that users with hand tremors would sometimes inadvertently touch the screen twice thus resulting in repeated letters or deselecting activities they meant to select. After adding a forced delay after each touch registered, multiple touches were ignored by the machine and accidentally repeated touches would no longer cause confusion or record erroneous data.

Furthermore, ticket vending machines in public spaces are used by people under stress. As the user’s heart rate increases, their targeting accuracy is reduced. If the user is in a hurry, he/she might find hitting buttons accurately difficult (Hagen & Sandnes 2010, 9-10).

7 Redefining accessibility design in Village Software

This chapter is a documentation of how the incorporation of a new type of accessibility design took place in Village Software. To gain a comprehensive understanding of the course of development the author interviewed Ian Bufton, the technical director of Village Software.

7.1 General

With the findings made in the previous chapter one can get a rough idea of the many ways how better and more empowering self-service kiosks can be designed. To make sure the accommodations make their way into the product, a checklist of Village Software accessibility standards was created. In addition to the points made earlier, it includes a series of standards set by the Department for Transport that must be fulfilled in a design. In a situation where these standards may be vague or of broad nature, then supporting, more detailed standards will be provided to make sure the government standards are brought to completion. It should be noted the Village accessibility standards are built for and within the limitations of current technology the company and its clients hold.

7.2 How accessibility has evolved in Village Software

An interview was held with Village Software Ian Bufton, the technical director to gather knowledge on how the development of TVMs started and how has it since evolved. The interview is attached as an appendix (see Appendix 1). The full interview is classified as confidential and will not be published.

7.3 TVM Design principles

VSEL has a set of TVM design principles and they can be found in the company Wiki, and they are accessible to every employee in the company.

The TVM design principles broadly account for a product user's need and the business goals of Village. They are meant to articulate the fundamental goals and communicate the key characteristic of the product to clients, colleagues and team members alike. They do not go in-depth about the issues, but rather indicate that the company is able to address them. It is submitted they exist to serve the stakeholders and less the end-users. (Tvm User Interface Principles 2016).

What the design principles do not account for are the TVM user's accessibility needs. To do that, much more detailed standards or guidelines are needed.

7.4 Advantages and limitations of standards

For most web developers established accessibility standards like W3C Web Content Accessibility Guidelines (WCAG) and US Section 508 are already known. In Village Software's case, other legislation is also applicable, such as the previously mentioned Equality Act 2010.

Basic design principles and some pass/fail test criteria are amongst some advantages accessibility standards provide. The limitations, however, are that they usually only address compliance at few phases of the development and provide no guidance on how to address them at all of the phases. In some cases, it is possible this gives the development team a false sense of having just made an "accessible" product. For example, the decisions made by developers and system architects before the design phase has even started can make the ability to implement standards impossible. The product might abide by all the standards, yet, still be inaccessible (e.g. text size and colour is correct, but content of the text is wrong). (Au & Curtis-Davidson, 2009.)

7.5 Creation process of Village Accessibility Standards

The Village accessibility standards are chosen from the findings described earlier in Chapter 6. They are categorized by each of the disability groups. Their role is to gather together all the essential knowledge so it can be accessed by everyone in the company, at any time. It can also help new employees to incorporate with the TVM products and get familiar with how accessibility should be approached in the company. It is purely a guideline document and does not assess questions of why, but rather how things should be approached. The document is attached as an appendix to the thesis.

The author has no previous experience in writing standards, which is why some aid was used. ISO’s How to Write Standards (2016) brochure was referenced during the creation process. Even though the Village Accessibility Standards will not be up to ISO’s measure, using ISO’s guide as a reference felt only appropriate. It provided guidance on language usage, presentation and scope.

Originally the guidelines were designed to cover all the disability groupings discussed in the previous chapter, however, it was decided to exclude auditory impairments as they would not serve much purpose at the moment. If Village Software is later involved in the decision making of sound effects and implementing them in the design, the guidelines will be updated to accommodate that.

The guideline document is not a complete one but will change and evolve during time as best practices change and more information is gathered.

8 Conclusion and reflection

Ever since beginning the research the initial presumption was that accessibility as a subject is so wide that some personal choices in including and excluding topics had to be made to keep the paper from being excessively large, and yet, neat and relevant to the research questions.

The findings suggest that a disability of any kind, permanent or temporary, can affect the ways people use interactive kiosks. However; for the sake of clarity they were bundled into four different groups: visual, auditory, cognitive and motoric. It was also concluded that it is not always disabilities that exclude users, but situations can contribute to exclusion too.

A small scale of this study has most likely echoed parts of earlier research, suggesting that accessible self-service devices empower the user and introduce a belief in oneself to achieve the goal on their own, without help from others. To be able to cater this experience for as many groups as possible, audits for accessibility should be made. Automation and self-service devices are rapidly replacing the traditional interaction between a customer and a customer service personnel, however it is still a long way to achieving an as “humanly” as possible user experience without the use of actual human beings. At the moment the best we as designers can do is to be empathetic of our users and conveying that empathy into our designs.

Bringing Village Software’s accessibility proficiency to its full potential is going to be a multiple-step process and all in all, this research has been a good starting point. The limitations set by the standards can be overcome by integrating accessibility into the full development cycle, and it will hopefully be the next milestone in this movement. The interview with Village Software’s TD (Bufton, I. Personal Communication, 16.3.2017) suggests the company is interested in creating relationships with local disability groups to give their thoughts and feedback about the company’s TVM products. Creating relationships like this where the company creating the product and a minority group can exchange information is important and could potentially be an advantage in tenders in the future for clients that want to invest in accessibility.

A part of the problem seems to lie in the clients however. According to the interview with Bufton it was revealed that most of them are not interested in pushing accessibility or testing with real users as a priority (Bufton, I. Personal Communication, 16.3.2017).

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Appendices

Appendix 1. Appendix 1 is classified as confidential.

Appendix 2. Village accessibility guidelines

...thinking ahead

villagesoftware.co.uk

VILLAGE TVM ACCESSIBILITY GUIDELINES

Version:	1.0
Date:	10/04/2017
Author:	Anni Veijalainen
Contact:	author@villagesoftware.co.uk

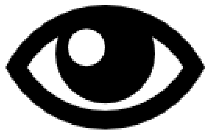
CONTENTS

MERSEYSIDE innovation AWARDS official sponsor

This document is to guide Village designers and developers in the steps to achieve an accessible TVM product. Other stakeholders are also welcome to explore the document to see how we approach accessibility at Village Software.

To start off we will define the three physical impairments that can affect behaviour at a TVM station.

VISUAL IMPAIRMENTS



Those with difficulty reading small fonts, distinguishing colours, or other problems with vision.

COGNITIVE DISABILITIES

Those with inability or difficulty understanding. Causes not only restricted to a disability, but age, languages spoken and being distracted by something else.

MOBILITY IMPAIRMENTS

Those with difficulty or inability to touch a fixed area on a touch screen or limited hand movements. Causes not only restricted to a disability but right/left-handedness, temporary loss of use of an arm.

Focusing on one impairment per chapter, we will outline the best practices to accommodate users whose impairments or physical limitations fall into the category. Use the Comply column as a checklist to see if the system tested complies with the standards. This document will evolve over time and the development team will be notified of any updates to it.

VISUAL IMPAIRMENTS

TYPE AND TYPOGRAPHY

#	Description	Comply?
1.1	Type size should not be smaller than 9-12pt (average x-height* of 2.5mm). For usual readers font size 12pt is enough, but for the visually impaired 16pt is recommended.	
1.2	Type size for long block of text should be medium or semibold. Bold is acceptable in headings. Thin and very light weights should be avoided if possible. The counters** of the letters should be clearly visible for legibility.	
1.3	Using capital letters of continuous text should be avoided. One or two word set in capitals do not create reading problems.	
1.4	Numbers should be as distinct as possible. If brand guidelines use a typeface where numerals potentially be confused with each other, choose another. 3, 5 and 8 are easily misread, as are 0 and 6. Number 1 can be confused with l, I, and even !. If possible, choose a type with a ‘hooked’ 1.	
1.5	Line length should be ideally in the range of 50-65 characters for easy reading.	
1.6	Headings should be clearly differentiated from all the other content with some combination of size, weight and colour.	
1.7	Words should not hyphenate at the end of lines.	

COLOUR DESIGN

#	Description	Comply?
1.8	Make sure buttons in active state (pressed down) have enough contrast to a button in a normal state. It should not rely on colour change only, but some combination of contrast, stroke and colour.	
1.9	Do not use colour only to convey information. If possible within the boundaries of branding guidelines, use iconography or patterns in combination with colour.	
1.10	If unsure about whether a text and its background have enough contrast, conduct a test using WCAG 2.0 luminosity ratio tester, for example on. http://webaim.org/resources/contrastchecker/. For large text aim for at least 3:1 ratio and 4.5:1 for main text.	
1.11	If no design or design guidelines are provided, try to keep the colour scheme at 2 to 3 colours.	
1.12	Simulate the design in colour-blind views and make sure no critical information is hidden. Logos, photographs etc. are exempt from this. https://chrome.google.com/webstore/detail/i-want-to-seelike-the-co/jebeedfnielkcjlcokhiobodkjjpbjia?hl=en-GB	
1.13	Status indicators (e.g. buttons, active, disabled. etc.) must be visually distinguishable from each other.	
1.14	Black or very dark background colours are not recommended as they can highlight fingerprints and increase glare.	

1.15	Lines, boxes and colour can be used to group items together for association, but should be used moderately.	

Footnotes:

*) X-height is the height of a lowercase x.

**) Counter of a letter is the area of a letter that is entirely or partially enclosed by a letter form or a symbol, e.g. the enclosed area in the letter P.

COGNITIVE IMPAIRMENTS

#	Description	Comply?
2.1	Symbols should supplement words to indicate specific activities or concepts, where appropriate, as they are more readily understood by people with cognitive impairments and people whose first language is not English.	
2.2	However, symbols should not be used without text unless it is known that they will be understood by the customer.	
2.3	Unless client branding guidelines state otherwise, use a sans-serif font for all the typefaces in the TVM (excluding client branding).	
2.4	Error messages must be as self-explanatory as possible. Tell users what did they do wrong and how to fix it.	
2.5	Indicate progress with relevant titles or a progress bar, if possible.	

2.6	Make sure the interface is predictable, i.e. similar interface elements and similar interactions must produce similar results.	
2.7	Big blocks of text must be aligned to left.	
2.8	Regarding any message of the TVM, make sure the wording is efficient and concrete. It must not contain sarcasm, hidden meanings or metaphors.	
2.9	Avoid having moving or flashy images where they are not necessary.	
2.10	Use movement and animations sparingly, preferably only for functionality. If it serves no function, it should be reconsidered.	
2.11	Alert users when a time-out may occur and allow them to request more time by disrupting the alert.	
2.12	Labels must be placed in close proximity to the item they are labelling. For buttons, preferably use label inside them, unless there is a reason to do otherwise.	
2.13	For numeral inputs, use a telephone layout keypad instead of the calculator layout. Using the telephone layout will ensure the most consistency with other terminals.	

MOBILITY IMPAIRMENTS

#	Description	Comply?
3.1	Operating buttons should be at least 20 mm in diameter and must protrude sufficiently to be used by those who rely upon palm pressure. (A joint Code of Practice by the Department for Transport and Transport Scotland)	
3.2	Unless specified otherwise by client in their design, place back and forth buttons next to each other, instead of placing them in the different ends of the screen. This requires less hand movement if the users wishes to fix a mistake.	
3.3	A repeated action, e.g. a button to move forth should be placed in a way it does not cause the user discomfort or arm fatigue having to hold their arm up for an extended period of time.	
3.4	Data entry should be kept to a minimum, offering e.g. predefined values and auto completion in wayfinding/transportation kiosks.	
3.5	Make sure the buttons are spread far enough apart to avoid accidental inputs.	
3.6	If designing for a vertical screen, consider adding the ability for user to move the interaction area closer to their preference. E.g. a wheelchair user or a person of short stature might want to bring the interaction area further down.	

Sources and further reading

Accessible Railyway Stations: design standards. Department for Transport and Transport Scotland. https://www.gov.uk/government/publications/accessible-railway-stations-design-standards

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