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Universal Design in Public Transport Ticketing Systems: A case study in Oslo and Amsterdam

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Abstract

Just like the swift development of ICTs has revolutionized every sector, it has also changed how public transport systems are recognized, and mobilities are performed. The progression has now reached the point where public transport services are ensured to be accessible as far as possible to everyone. One of those public transport services includes the 'ticketing system' which mainly constitutes of various communication devices, known as ticketing machines, smart cards, websites of public transport companies and mobile ticketing apps.

These different forms of ticketing system are an essential part of every public transport system and are used by people to get tickets for their journey. Many people, especially those with disabilities are not able to participate in various activities happening in the society simply because the environment, policies and various technologies are not designed to be easily understood and used by them.

Today, when we are striving to adopt universal design solution with built-in adaptability, affinity and capability to accommodate people with diverse capabilities; it is essential to know that whether we are close to achieving this goal of 'design for all' and 'accessible design'. In terms of this, this research is concerned to evaluate the current design and performance of ticketing system from user's perspective and to find what features of the ticketing system can be improved to make them adapt to user needs.

By design and performance, it means to find that whether the ticketing machines, websites and mobile ticketing applications are fulfilling the needs of everyone. For instance, how people find them in terms of interactivity, interface and navigation. The research also includes finding

which of the ticket purchasing method is most preferred by people and why.

Furthermore, this research is directed at two cities of two countries: Oslo and Amsterdam in order to conduct a comparative study on the ticketing system of the public transport sector of these cities. The reason for selecting Oslo and Amsterdam is that: Oslo is the place where I study, and Amsterdam is my home city. Therefore, I have used the ticketing system of both cities and my observations and experience during my daily trips in public transport have inspired me to work on this case study.

Using qualitative study approach, i.e. survey, I evaluated the ticketing system of both cities and found that people in both cities preferred to purchase tickets through the mobile application. However, there was a difference in their least preferred ticketing system. People in Oslo least preferred to purchase tickets through the website while people in Amsterdam least preferred ticketing machine. The reason behind the least preference was found that people were not satisfied with some of the features. The result was further confirmed by Pearson’s correlation test, which concluded that being satisfied or less satisfied with any of the feature is associated with the overall experience of people with that ticketing system.

Contents

List of Table and Figures:

Chapter 1:
Introduction

1 Introduction:

When it comes to improving accessibility of the public transport system using the universal design concept, the most general opinion is that universal design in public transport is only connected to the design of public space and transport infrastructure. For instance, most work is on improving accessibility of bus stops and stations like offering step-free access to wheelchair users and enhancement of public transport vehicles to include low-floors, ramps, indicators for blind passengers and versatile information systems [1] [2]. However, improving accessibility of Information and Communication Technology (ICT) system, i.e. Ticketing system of public transport through adopting universal design is also crucial. There are numerous researches focusing on individual elements of ticketing system, i.e. ticketing machine, website and mobile application [3] [4] [5] [6] [7] but none focus on the evaluation of all of the elements of ticketing system of public transport.

Universal Design and ICT:

Public transport management and transport companies have the responsibility and are legally bound to provide equitable and affordable access to ICTs for people with disabilities under the New Urban Agenda [8]. The Conventions on the rights, states that ICTs and other technologies must be made available and accessible to all in particular persons with disabilities. In order to achieve the ambitious 2030 Agenda for Sustainable development, meaningful participation of People with Disabilities (PWDs) and their organizations as agents and beneficiaries is required throughout the development process [8]. Furthermore, to realize accessible ICTs and inclusive development for all, governments and other stakeholders should support the development process of ICTs including mobile applications, government websites, ticketing machines, ATMs and other ICT services as part of their rural and urban development plans [8].

Universal design or user-centred design is the most widely used approach applied worldwide to provide equal access to all users. Universal design is not only a matter of solution to the problems of people with disabilities but also, is essential for improving the quality, accessibility, usability and safety of the entire public transport system. Universal design refers to designing products, programs, systems and services that could be used by everyone without creating any unique adjustment or superior design [9]. Universal design supports the assistive devices that are used by a particular group of people. Ron Mace introduced the term Universal Design in 1985. The primary purpose of incorporating universal design in the systems and facilities is to simplify the life of as many people as possible. There are several principles of Universal design which were developed by an expert U.S. team [10]. Furthermore, research conducted by the Centre for Universal Design between 1994-1997 presented some guidelines to further the development of Universal design [11]. The principles and guidelines are as follows:

1. Equitable Use: The design must be useful to people with diverse capabilities, and the general guideline is that design should be made to appeal to every user, it should not be segregating users and must ensure privacy and security to everyone.
2. Flexibility in Use: The design must be flexible to accommodate a wide range of user' preferences. It can be made possible by providing choices where possible, granting the right or left-handed use, and ensuring adaptability.
3. Intuitive and Straightforward: Design should be simple so that it is understood by every user regardless of their knowledge, experience or skills. It can be achieved by eliminating complexity

accommodating diverse literary backgrounds and skills and providing feedback after every task is completed.

4. Perceptible Information: The design must convey information effectively to every user regardless of their diverse abilities. It is possible by using different ways (pictorial, verbal, tactile) to convey information and providing compatibility with assistive devices.
5. Tolerance of Error: The design must be able to tolerate errors and minimize unintended actions. The errors can be avoided by providing warnings of consequences and errors to the user and also arranging elements such that errors can be minimized.
6. Low Physical Effort: The design must be such that it requires minimum physical effort from the user, which can be achieved by eliminating the steps that require repetitive actions.
7. Size and Space for Approach and Use: The design must ensure that appropriate size and space is provided to every user regardless of their body size, posture, and mobility. This guideline can be ensured by making all of the elements of the design visible to both seated and standing user and providing space to the user for assistive devices.

Regarding these principles and guidelines, the recent development in the universal design concept is that it is updated with eight goals that explain the cultural, social, economic and physical context [12].

Ticketing System:

Ticketing System constitutes of ticketing machines, website and smartphone applications that are used to purchase tickets to travel in public transport. Ticketing machines enable users to interact with the information and get the services they need. These ticketing machines have evolved to meet the needs of the modern world. Ticketing machines are used by people 24 hours a day and 365 days of the year, and still, there are usability issues found in them [13]. Considering the significance of the ticketing machines, the aim of designing a ticketing machine must not only be providing information and services but also it should focus on improving the communication and interaction process [14]. Embracing simplicity yet intuitive methodology forms the core of the design process of ticketing machines as some users find it difficult to use those devices that require complicated operations and is based on high technology [15].

In addition to ticketing machines, websites and smartphone applications are also significantly used by the users to purchase tickets for their daily trips. Moreover, in this perspective, numerous guidelines were presented to enhance their accessibility and usability [16] [17] [18] [19].

1.1 Problem Statement:

Public transport is used by the majority of the population for their daily trips. In order to travel via public transport, every person needs to purchase and validate their tickets. The tickets are majorly brought from ticketing machines, websites, mobile applications and convenience stores. Because of the immense use of the ticketing system, the ticketing system must be designed appropriately.

Today when everybody is so much consumed in fulfilling their responsibilities. They need to travel for various purposes to carry out their businesses. In that respect, the time factor is very crucial. In addition to the people who are in a hurry, there is a great deal of diversity among the people travelling via public transport and using the ticketing system. The diverse user group includes elderly citizens, wheelchair-bound, visually-impaired, hard of hearing and people with motor and cognitive limitations.

In this modern era, where novel information and communication technologies are introduced every other day. New, updated and better technologies are introduced in the market to replace the previous ones; there is growing awareness among the designers and manufacturers to develop a universally-designed technology that is accessible and usable to everyone irrespective of their abilities. Numerous efforts have been made to improve the ticketing system over the years as indicated in the literature study; however, we see people facing problems while interacting with the ticketing system especially during the purchase of tickets where they interact with the ticketing system at most. So, this research aims to evaluate the ticketing systems used for travelling via public transport and based on the results; recommendations will be made on what could be improved to enhance the accessibility and usability of the ticketing systems.

1.2 Objectives, Research questions and hypothesis:

Since users interact with the ticketing system at most while purchasing tickets, so the aim is to evaluate the ticket purchasing process of both cities more precisely and make a precise comparative analysis. Through the evaluation, it would be possible to see what areas of ticketing system (ticketing machines, website and mobile application) have accessibility and universal design problems. In order to achieve the objective, the following research questions are developed.

- Which platform is more accessible among the three most commonly used platforms: ticketing machine, website or smartphone application?

- What are the key features/differences in terms of user experience of these ticketing systems in Oslo and Amsterdam?

At the end of the evaluation, the above research questions would be answered and would be confirmed further with a statistical test. Following are the null hypothesis (H0) and the alternative hypothesis (H1) of the significance test for correlation:

Two-tailed significance test:

H0: $\rho = 0$ ("the population correlation coefficient is 0; there is no association")

H1: $\rho \neq 0$ ("the population correlation coefficient is not 0; a nonzero correlation could exist")

1.3 Methodology:

To answer the research questions, qualitative study approach, i.e. survey would be used (explained in chapter 3) The questionnaire for the survey is designed in Google Form, and the results would be analysed in Statistical Package for the Social Sciences (SPSS).

1.4 Organization of the Thesis:

The next chapters of the thesis report constitute of background and related work (chapter 2), designing methodology (chapter 3), results and analysis (chapter 4) and discussion and conclusion (chapter 5).

Chapter 2: Background and Related Work

2.1 Background:

2.1.1 Overview of Public Transport System in Oslo and Amsterdam:

This thesis is about the evaluation of the ticketing system of the Public Transport of Oslo and Amsterdam. So, I collected some useful information regarding the website, smart card and mobile application generally used in Oslo and Amsterdam, which is described below and summarized in the table (table 1).

2.1.2 Observation of Website of Ruter, Oslo:

Ruter is the website used to get tickets in Oslo. The website has a simple interface. The complete information about tickets and departures are available on the website. It also contains search, help and contact option to facilitate the new users. The information is given in both English and Norwegian languages. However, the 'MinSide' page where people can purchase their tickets is only available in the Norwegian language.

The ticket section includes detailed information on types of tickets available, purchasing and usage instruction of smart travel card, RuterBillet application, zones and zone map and options for purchasing tickets through ticketing machines. Moreover, it also contains information about the wheelchair, pram and other facilities available on-board. (ruter.no)

2.1.3 Observation of Website of OV-Chipkaart, Amsterdam:

Website of OV-Chipkaart used to purchase tickets in Amsterdam also has a simple interface. The main home page contains an option of balance checker where a person can check the balance on their smart card by entering their card number. The main menu contains sections of frequently asked questions, recent news, search and help, links to information where a user can get information on purchasing card, renew card, view travel history, order balance and report lost cards. Moreover, it contains information on OV-chipkaart mobile app and link to user OV-chipkaart account since in order to use the application travellers, need to have a 'Mijn OV-chipkaart' account connected with an OV-chipkaart smart card.

In terms of universal design, the website is well designed. It contains information in both English and Dutch language and has easy navigation. The website offers an option of enlarging the font size, which can help people with reduced vision. Besides, the website also contains the audio version of each section to facilitate the hearing impaired. (ov-chipkaart.nl)

2.1.4 Ruter 'Reisekort' Smart Card, Oslo:

Ruter is the public transportation company in the Oslo region in Norway introduced e-ticketing through contactless smart cards in 2009, and since then, these smart travel cards have taken over paper tickets [20]. This smart card allows a passenger to have different types of tickets stored in their smart card. The smart card needs to be validated when a passenger checks in or checks out. The smart card is initially unregistered so a passenger can travel anonymously. However, Ruter recommends to register the smart card as then Ruter will be able to help the passenger in case a travel card is lost; otherwise, Ruter will not be able to assist the passenger.

Registering the Reisekort smart card offers several benefits to the passengers like if the travel card is lost, its contents can be transferred to a new card and access to MinSide is also granted where a passenger can view the contents of travel card and can disable it. Besides, registering smart card offers to enable the renewal of 30-day tickets or top-up of pay-as-you-go credit. (ruter.no)

Ruter smart card, 'Reisekort', can be registered through MinSide platform which is available only in the Norwegian language. When the passenger needs to top up their smart card, it can be done only through ticketing machines or Ruter service points while it cannot be done through the website or MinSide platform. (ruter.no)

2.1.5 OV-Chipkaart, Amsterdam:

The smart card mostly used in Amsterdam is OV-Chipkaart issued by Translink. OV-Chipkaart has NFC chip stored in it which communicates with the in-field validation equipment, and in the current OV-chipkaart infrastructure, the OV-chipkaart itself is the carrier of the most up-to-date information through an integrated 'OV-Module' [21]. The OV-Module comprises of information on ten latest travel transactions, the two latest top-up transactions, travel products (e.g. discounts for children, elderly, student products), rights granted to consumers (e.g. automatic top-up) and the traveller profile (date of birth). The top-up of the card can be done through ticketing machines.

OV-Chipkaart is available in different formats like a personal, anonymous, business and disposable OV-chipkaart. The Personal OV-chipkaart is linked to a single user. Only the cardholder is allowed to use the personal card. Personal data is visible on the card. Travellers using a personal OV-chipkaart can make use of travel products such as public transport subscriptions, automatic top-up and student discounts.

An anonymous OV-chipkaart is not connected to any personal data. Multiple users can travel with this card, although not simultaneously. However, with the anonymous OV-chipkaart, it is not possible to make use of travel products (season tickets, discounts) that are available on personal OV-chipkaart.

Businesses OV-chipkaart allows businesses to purchase the travel rights for their employees. The employees can make use of public transport subscriptions. In this type of card, businesses are sent invoices for the travel expenses of their employees.

2.1.6 Ruter mobile application:

According to International Rail Journal, in the last ten years, Oslo's population increased by 18% and during this period car traffic has fallen and Public transport ridership has increased by 60% in Oslo and 70% in province of Akershus. Oslo's public transport administrator, Ruter has adopted a pioneering approach to digitalization. Ruter has recognized that customers should be the centre of everything they do. This adopting of user-centred approach improved ticketing system and thus, overall performance. The CEO Reitan Jenssen, of Ruter, once said, "we are relevant to our owners because they want to create a city that looks different, without cars. To stay relevant to our owners, we have to stay relevant to our customers. We do not have any choice. If we continue to come up with inferior solutions, we will be gone in a couple of years."

Ruter initiated a meet-and-greet concept in order to know about what customers wanted and with the help of this concept, the successful smart card ticketing system was taken to the next level, and the company decided to move towards "smartphone ticketing system".

Smart card ticketing system accounts for 60% of the revenues and with the potential of further growth. However, according to CEO of Ruter, 200,000kg of equipment is in place to enable smartcard use, but with this, valuable resources are being wasted as compared to smartphones ticketing system in which smartphone, usage of which is virtually ubiquitous, are owned and paid for by the passenger, who "even blame themselves" if they do not work. Also, many passengers who do not want to carry various cards with them favours smartphone ticketing system.

The core of the new smartphone ticketing system is the “RuterBillett app”. This application is a mobile self-ticketing application available on iOS and Android. This application has a simple interface which encourages ease of use. It takes only two clicks and one second for a user to purchase their ticket. This app also supports various payment methods like a credit card, debit card, mobile phone bill payment, and the Vipps mobile payment solution, which is popular in Norway.

Smartphone ticketing provides benefit to both passengers and ticketing inspectors. All trains and busses have USB charging points, and ticketing inspectors also keep batteries in case passenger run out of battery, and their smartphone ticket needs to be checked. Inspectors also possess Android-enabled device which can recall a specific passenger’s usage history, informing the inspector of whether they should issue a fine or a warning. This new approach has redefined how customers view Ruter.

Smartphone ticketing app through passenger positioning system can monitor a passenger’s location and is used to provide travel information to the passenger directly. Ruter also observes the location of al the buses and trams on the network and the number of passengers on-board. They also have access to traffic cameras to monitor local road conditions, which is then used to predict traffic congestion and adjustment of bus routes accordingly by sending updated journey information directly to the driver’s tablet. The ultimate goal of Ruter is to communicate the news of delays and evasive actions directly to individual passengers while they are travelling. Ruter communicates the news of a new travel plan to the passengers through the infotainment system that they can check on their mobile phone [22].

2.1.7 OV-Chipkaart application:

The ticketing system of public transportation of Netherlands is complex operated by multiple stakeholders and parties. Variety of mobile ticketing solutions are in development. OV-Chipkaart is the leading electronic payment system being used for public transportation services in Amsterdam. The OV-Chipkaart supports single card usage eliminating the need for separate cards for the different modes of public transport. OV-Chipkaart is based on a prepaid system in which the trip fare is charged directly from the smart card. The travellers need to validate their tickets at check-in/check-out points through contactless technology which in this case is Near Field Communication technology. The online service provided by the OV-Chipkaart system includes website and mobile apps. The smartphone ticketing app is called the OV-Chipkaart app, which is available for Android and iOS devices. This application provides trips history, public transport service point locations and a section of frequently asked questions. However, in order to use the application travellers, need to have a 'Mijn OV-chipkaart' account connected with an OV-chipkaart. The app is a minimized version of the 'Mijn OV-chipkaart' web environment. The stakeholder of OV-Chipkaart system, Translink and the Nationaal Openbaar Vervoerberaad (NOVB), has provided several payment methods in order to provide more freedom of choice to the travellers. These developments include Account-based back-office, EMV-contactless bank cards, EMV-contactless on a mobile phone, OV-Chip Mobiel, Mobile Self-ticketing and Be-in/Be-out.

	Oslo	Amsterdam
Population	1,026748 (2019 report)	More than 7 million

No. of trips using public transport	Increased by 63% from 228 million to 371 million during 2007-2017	4.5 million trips are made by bus, trams and metro. 1 million by train
The most common mode of public transport used by people	Trams, buses	Bus, Tram and Metro
Payment	Passengers are charged based on the zone system they have travelled	Charged based on the number of kilometres
Website	Ruter	OV-Chipkaart
Language	English and Norwegian (However, MinSide page where people can purchase tickets is only in Norwegian)	English and Dutch
Text size	Both large and small size	Offers the option of enlarging text size
Text-to-speech	Not enabled	Enabled
Colour contrast	Colour contrast issues not found on WebAIM colour contrast checker	Colour contrast issues found on WebAIM colour contrast checker. Current ratio 3:96:1 Required ratio 4:5:1

Accessibility	84% total compliance was found through A-Tester by Evaluera Ltd (web accessibility evaluation tools)	82% total compliance was found through A-Tester by Evaluera Ltd (web accessibility evaluation tools)
Smart card	Ruter	OV-Chipkaart
Issued By	Ruter	Translink
Top up	Done only through ticketing machines or Ruter service points	Done through ticketing machines
Application	RuterBillet	OV-Chipkaart
Available for	iOS and Android users	iOS and Android users
Supported payment method	Credit card, debit card, mobile phone bill payment, Vipps mobile payment	Prepaid system- trip fare is charged directly from smart card
Validation	Validated by ticket inspectors by scanning Q.R. code or by checking the picture of the day. Also, ticket inspectors have an android-enabled device which can recall a specific	Validated through contactless technology, i.e. Near Field Communication validated in check-ins and check-out points

	passenger's usage history	

Table 1: Overview of Public Transport System of Oslo and Amsterdam

2.2 Literature Review:

The use of ICTs has been growing all over the world since the beginning of information age. Initially, ICT and transportation were seen to be different disciplines but were brought closer to each other as a consequence of improved infrastructures and the advancements in technology, and it is expected that their relationship will continue to strengthen in future [23]. ICTs have become an integral part of the transport systems as they are used widely in current ticketing systems and planning tools; thus, making it easier to share transport modes, make the payment, and to communicate travel patterns [24].

For people with disabilities to enjoy the benefit of the ICTs, and interact with ticketing system comfortably, the ticketing machines, websites and mobile applications need to be designed such that they are assistive technologies compatible and are in compliance with the Web accessibility guidelines so that they are usable by everyone irrespective of their capabilities [25]. However, even so, the phenomenon of universal design has gained momentum, many people who are facing any disability refrain from travelling on public transport because they feel insecure and expect that problems could arise for them along the way [26].

The problem of most of the people is majorly concerned with the self-service ticketing system that includes website, mobile ticketing and ticketing machines and the reason may be because some of the subgroups in society are not adept at using latest technologies. The lack of technological expertise poses a hindrance in their mobility [4]. To solve some of the usability issues, Bailey in 2014 researched on incorporating personalization as a strategy to ensure accessibility and enhance the user experience of public digital terminals. This research uses an online wizard to implement a user-defined accessible interface in order to allow the user to configure the user interface according to their needs and preferences [27].

User can activate the personalized interface while using ticketing machines. The activation process requires minimal gesture from the user like touching the reader with contact or contactless card that contains the user needs and preferences. In this, user can change the size of the text, foreground and background colours, enabling audio output, sign language avatars and help content to support their interaction with the screen interface [27]. Personalization is, although, a great initiative towards accessibility, there is a need that ticketing system as a whole should be improved, i.e. websites, mobile application and ticketing machines. The personalized interface presented by this research uses an online wizard to store user preferences, but a problem could arise if and when anybody who does not have technological expertise tries to store their preferences on the card and gets intimidated by the whole process. In this way, this personalized interface option instead of empowering the users can end up causing them to lose confidence. The case with exemplary user interfaces is that they can accommodate a wide range of users, provides them empowerment and make them feel skilled at using the interface.

In contrast, user interfaces that do not support all different users contain incomprehensible, and mysterious features is an unsatisfactory interface [28]. The complexity of user interfaces was pointed out in research carried out by faculty of engineering of Oslo university college. According to it, most of the ticketing machines are designed with keeping in mind the wheelchair users. However, according to regulations and legislature related to universally designed environments, the screen interface should be improved so that it is usable by everyone. A prototype incorporating the concept of an intelligent user interface was proposed. The target users of this intelligent user interface include tall people, children, elderly citizens, visually impaired, and people with motor problems (like those having Parkinson's disease) physical and cognitive disabilities [29].

The ticketing machines with this type of interface adapts to the user needs. It addresses the challenges faced by people in using displays that are mounted at fixed heights by presenting a solution in the form of intelligent user interface that works in a way that when the user touches the display, ticketing machine will detect the touch and will position the screen interface on the initial point of contact. The second important point discussed in this research is the text size adjustments for people with reduced vision. The initial display of ticketing machines has text size usually more massive than what is necessary for most users. However, when information to be displayed is in larger quantity, the screen interface area becomes insufficient for all that information, so the text size is automatically reduced. In order to solve this problem, the intelligent user interface monitors the distance between user and display. If the user is leaning forward towards the screen interface, it is assumed that the user is facing difficulty in reading the text and his limitation for reading smaller text size has reached. Consequently, the intelligent user interface presents the text in large size in the next steps. This research also addresses the challenge of touch target size and accuracy as there are people with motor impairments like people who have Parkinson's disease [29].

People who have Parkinson's disease have 'shaking hands' (tremors) that makes it unable for them to hit small targets on the screen interface. Children also have uncontrolled movements making it difficult for them to hit small targets. Besides, most of the time, ticketing machines are used by people who are under stress or have an increased heart rate. So, any stressed person can face this difficulty of accurately hitting the targets, especially when they are in a hurry. This intelligent user interface calculates the accuracy of the touch. It works as if a user touches closer to the centre than the border; the target size is reduced. If the user touches closer to the border than the centre, the text size will remain the same, and if the user touches outside the border; the target size is increased. This procedure requires that all the object should be surrounded by adequate space in order to avoid erroneous clicks on other objects [29]. This research if implemented solves some crucial issues regarding accessibility and universal design for all. However, the current ticketing system not only lacks implementation of the solutions recommended for the target group of the research mentioned above, but it also lacks some robust solutions like incorporating audio, tactile feedback and sign language for people with hearing and vision limitations. In that respect, auditory and tactile feedback can be significant in improving the user experience of people with disabilities in their interaction with touch screens [30].

Apart from this, use of simple gestures like the dual interface proposed by Savidis and Stephanidis in 1995, can also make touch-based ticketing machines accessible to blind users without actually affecting the user experience of people with no visual impairments [31].

Furthermore, if the language used to convey information is improved, it can make their life great. For instance, in countries like Norway and the Netherlands, the most widely spoken language is Norwegian and Dutch, respectively. Some people understand only these languages, and among those people who are hard of hearing, the standard communication method is Norwegian Sign Language (NSL) and Sign language of Netherlands (SLN) respectively. So, these screen interfaces must have a recognition system to allow hard of hearing people understand the information quickly and get the services they need. Similar research was conducted in Tokyo, Japan [32]. They tested an information machine with Japanese Sign language (JSL) recognition system installed in a government office and survey was conducted to know about user's satisfaction. This recognition system recognizes hand gestures and a glove-based input device such as CyberGlove is used to input the hand gestures into the computer screen interface. This information machine was tested for three months, and impressions from 27 users were noted among which nine were hard of hearing people and fourteen were hearing people. Some twenty-three people answered that this type of system is necessary in the world, and about twenty of them said the machine was usable [32].

Use of ticketing machines is unavoidable because even if there are numerous options for purchasing the ticket, top-up of smart card requires ticketing machines. Seeking out a human representative who may prove evasive about their responsibilities; might be time-consuming and may not be an option in various situations. So, ticketing machines need to be accessible to people with diverse capabilities. When it comes to designing for accessibility, Web Content Accessibility Guidelines

(WCAG) provides guidance and understanding of how to make the web content accessible. It sets the foundation for making other digital interfaces accessible. Besides, WCAG accessibility concepts can also be applied to digital non-web interfaces through the use of WCAG2ICT guidance document. However, unlike web content accessibility which has well-documented WCAG, there are no internationally accepted ticketing machines accessibility guidelines. For this purpose, Jonathan Lazar, J. Bern Jordan and Gregg Vanderheiden from the University of Maryland identified eight standards towards unified guidelines for ticketing machines accessibility. They started the process of updating a new, very-detailed and unified set of guidelines for accessibility which contains references from the eight standards. These accessibility guidelines are related to visual output, audio output and input and output operations and are applied to the hardware and housing components of ticketing machines. This reason is that the accessible ticketing machines are those who have accessibility at both hardware and software levels [33].

2.2.1 Accessibility and Usability Problems and Proposed guidelines and solutions for Websites and Mobile Applications:

Accessibility and usability are two crucial concepts associated with the development of universally designed websites and mobile applications. According to the article published in W3C Web Accessibility Initiative, accessibility, and universal design are the concepts that can help in the development of a website that works for every person. Accessibility is a concept that explains prejudicial issues relevant to the user experience of people with disabilities. Similarly, web accessibility means that people with disabilities can interact with websites and tools without any barrier, and they do not face any difficulty in perceiving, understanding and navigating the information. The second concept, usability, deals with the user experience of the users and says that products should be designed such that they are efficient, beneficial and fulfilling to every user. It includes all of the aspects that impact any person, be it people with disabilities or people with no disabilities [34]. The most severe problems with regards to accessibility and usability happen with blind users and those with other visual disabilities. The Research investigated accessibility issues faced by visually impaired and normal vision users during their interaction with websites and mobile applications. The result of the evaluation suggested that out of 514 issues, 409 were reported by blind users and 105 by normal vision users [35]. This vast number of reported problems indicates the extent of the problem that needs to be addressed by the designers. An article published by UX research and consulting firm pointed out features of accessible design for people with disabilities. It explained that for people with visual disabilities like colour-blind users, if the different background and foreground colours are used in a website, then it would be virtually unreadable to them.

Similarly, the concept of ALT attributes, i.e. providing alternative text to images is quite common, yet many websites are still missing them. For people with auditory disabilities, audio clips of the transcripts must be available, which in some cases is not. Also, if videos are part of the website, then subtitles should be added to them. People with motor disabilities face issues that are related to the browser design or if the website includes imagemaps that require great accuracy in mouse positioning. Such issues can be solved by creating upgraded browsers and shifting to the client-side version of imagemaps. Furthermore, on the one hand, the internet has improved the lives of the people, on the other hand, it has become so difficult to use that it needs a person to be of high calibre to figure the thing out and it becomes challenging for people with cognitive disabilities. By adding sitemaps, proper headings, and hypertext anchors in long pages and including advance information retrieval can facilitate people with cognitive disabilities in some ways [36].

Assessing the accessibility of the website and mobile applications is extremely necessary as it would help the website developers and mobile application designers to find that in which area of the website or mobile application, users with disabilities are finding difficulties. The assessment is usually done by evaluating the conformance of the website or application to a specified criterion. For the assessment of the websites, World Wide Web Consortium developed guidelines referred to as Web Content Accessibility Guidelines (WCAG). These guidelines instructed to provide text alternatives for images, subtitles and text alternatives for videos. The guidelines also emphasize the creation of the content in diverse ways so that they can accommodate assistive technologies without turning content meaningless.

Furthermore, making the content simple and straightforward for visual and hearing impaired, allowing all of the functionality to be accessible from keyboard, inhibiting time limits so that everyone can read content comfortably, making navigation easy, making content easily readable and understandable by everyone and maximizing the compatibility with assistive technologies as well as with future tools.

When the websites conform to these standard guidelines, then it can make any website perceivable, understandable, operable and robust (World Wide Consortium, 2011). In the same manner, as far as the assessment of the accessibility of mobile applications is concerned, most of the previous work was concerning to ‘Mobile Web Access’, and this was because web browsing is also possible through mobile devices. Therefore, there was a need for accessibility of the web through mobile devices so that user experience and contribution of people towards web can be enhanced [37]. World Wide Web Consortium (W3C), furthermore, introduced Mobile Web Initiative [38] that developed several guidelines so that web pages can be made accessible through mobile devices and these guidelines were similar to those proposed in Web Content Accessibility Guidelines (WCAG) [39, 40]. In addition to WCAG 2.0, there are other two widely used guidelines for evaluating accessibility and usability, and these are User Agent Accessibility Guidelines (UAAG) and Technical Requirements for Different Accessibility Levels and Technical Methodologies (TRDA) [41]. These guidelines have usability in assuring the accessibility of web content for desktop users and are also applicable to mobile computing. The guidelines in the mobile context are described below:

- According to WCAG 2.0, it is vital to provide text alternatives for the non-text content as when non-text content of a web page like images and graphics are not viewable; then it can be a problem for blind and visually impaired. Also, it can obstruct a clear view of even non-disabled users depending on the context of use like during day time. Therefore, there is a need for synchronization of the alternatives for multimedia content.
- The guideline regarding layout ant text content of the web page is that they should be able to adapt according to the user interface in such a manner that there is neither loss of information nor objects are superimposed when, for instance, web pages are resized, the screen area is reduced or enhanced or characters are adjusted with default framework (TRDA).
- Users must be given access to the content (UAAG). This guideline is similar to WCAG 2.0 guideline that says that information at foreground must be distinguishable from the images or sound in the background. Furthermore, allowing users access to content

also includes giving them control on the time duration spent on reading the content of web page or general interaction.

- Mechanisms must be provided to users to assist them in finding content, aligning themselves according to the content and in navigating through it (WCAG 2.0). This guideline of WCAG 2.0 has a close connection to the UAAG guideline that directs on providing the navigation mechanism and Orienting the use of content.
- In the mobile context, there are limited and complicated input mechanisms and alternatives than provide on desktop computers. So, UAAG guideline that directs on the independence of input and output device holds great significance in this regard.
- Users must be allowed to do configuration and customization so that they use their mobile device(s) properly (UAAG).
- Users must be assisted so that they can avoid making mistakes and can correct them quickly (WCAG 2.0).

2.2.2 Usability Heuristics:

Usability Heuristics or Heuristic evaluation, as suggested by Nielsen and Molich is the evaluation of a product based on the guidelines or the heuristics of usability [42]. When there is a need to evaluate the usability of a touch-screen device, certain aspects of these devices should always be taken into account [43]. The reason is that the standard heuristics are applied on fixed devices such as desktop computers and ticketing machines and considers fixed devices location and use while mobile usability heuristics are applied on mobile devices and address mobile usage and context. The user interface design of mobile devices is influenced mainly by three essential factors that are: mobile devices are mostly in the hands of the users, they are wireless and can support various new applications and internet connections [44].

Furthermore, the size of the device is essential. Fixed devices like desktop computers usually follow the lazy design in which every feature is placed on the screen, and users have to make the effort of finding what is essential. In contrast, mobile devices have a small screen, and only the right input features must be placed. So, great responsibility lies with the designers, and there are several methods proposed to evaluate the usability of touch-screen devices [45, 46]. However, the widely understood usability heuristics are the ten usability heuristics proposed by Nielsen [47]:

1. Visibility of the system status: The system of mobile devices must always inform users about the status of the device. Users must be kept aware of what is going on through the mobile device feedback mechanism in a reasonable time.
2. Correspondence between the system and the real world: System should be designed such that the language used is familiar to the user. All of the words, phrases and concepts should not be system-oriented and should be those that are recognized and understood by the user.
3. User control and freedom: Users should be given freedom in their interaction with the device. In case, users encounter a situation that occurred because of their mistake; they should be able to exit that unwanted state without having to go through several tiresome procedures.
4. Consistency and standards: There should be an exact meaning to any action, words or situation so that users do not have to think hard that whether the specific action, word or situation have the same meaning.
5. Prevention of errors: The design should be such that it can prevent errors from happening in the first place. The situations

that can lead to errors must be eliminated, or confirmation should be asked from the users again before finalizing any action.

6. Recognition and forgetfulness: The design should support users by minimizing the memory load, making available all of the necessary information available or retrievable whenever required and reducing the need to remember information from one screen to another.
7. Flexibility and efficiency of use: There must be flexibility in the design so that it can accommodate both experienced and inexperienced users and it should allow users to tailor the arrangement of the options and actions according to their need.
8. Aesthetic and minimalist design: Minimalist design is something that is preferred by every user. Having too much information and features confuse the user.
9. Reducing Errors: Users must be assisted in recognizing and reducing errors. The dialogue box that is set to convey the user about the occurrence of an error must be in simple language and should precisely tell the user about the error and its solution.
10. Help and documentation: To support the users in performing their tasks with ease, help, and documentation should be provided to the users.

2.2.3 Compatibility with Assistive Technology (AT):

In order to overcome the challenges of equitable access to Information and Communication Technologies (ICTs) for people with disabilities, the two key issues must be addressed: making websites and application to conform with web accessibility guidelines and compatible with assistive technologies. Assistive technology (AT) is a term that is used, in general, in various fields wherever user requires some assistance. Although the goal of these fields might be different, the prime purpose is always amplifying capabilities, ensuring wellbeing and safety of the users [48]. Back in time, assistive technologies were developed to assist people with disabilities in using Information and communication technologies (ICTs). However, now, operating systems (O.S.s) of conventional computers and mobile devices have included features to ensure accessibility in their products [25].

Fuglerud et al. (2014) emphasized the importance of compatibility with assistive technology (AT). They pointed out that it is a precondition for universal design, while also mentioning that Universal Design (U.D.) is although, about designing products in such a way that they are usable by everyone, to the maximum extent possible without any need of adaptation [49]. However, assistive technologies are not included in this adaptation because many users are dependent upon assistive devices to access the Web content and mobile applications so these users must be accommodated without any discrimination. This guideline is also under the WCAG 2.0 guidelines that emphasize compatibility with current and future agents. Thus, Universal design is something that does not make the web content accessible but also supports the usage of assistive technologies.

The major challenge in making websites compatible with assistive technologies is that there is no strict way to ensure it to the greatest extent. Although there might be complete compliance with WCAG, UAAG and WAI-ARIA guidelines, some assistive technologies can still be incompatible with the website. The reason is that all A.T.s brought from different vendors have a different working mechanism. If one screen reader is compatible with the website, then screen readers brought from different vendors might not be compatible at all. Therefore, a universally designed ICT solution must be tested with different AT brought from different vendors to ensure accessibility [50]. However, the reason why the challenge of making websites compatible with assistive technologies is not solved is that most of the ICT developers do not test their ICT solution with AT from different vendors. The Assistive technologies are expensive, so they usually test it with one AT. For instance, it has been seen that Jaws for Windows is the best screen reader, so usually, compatibility with AT is checked only with this screen reader. Another problem is that AT itself does not offer any debugging options, so even if errors are found during testing, the reason for the error is complicated to recognize [49].

-2.2.4 Accessibility:

While general thinking might be that availability and accessibility, have the same meaning, but actually, they do not have the same meaning in regards to ICT. For instance, Websites are generally available to everyone with few exceptions of websites requiring login and those behind firewalls, but they might not necessarily be accessible to everyone. Accessibility means providing equitable access and utility to everyone or at least giving equal opportunity to everyone so that they can achieve their desired goal [51].

Among the users, those who have any disability suffers the most with accessibility, and their problems could be solved to the greatest extent possible when Universal Design (U.D.) approach is applied. U.D. is about designing the products such that they are usable to everyone irrespective of their age or capabilities [52]. While a great deal of work regarding accessibility is being done at both research and developmental level. However, still, accessibility has not reached the corporate establishment and community awareness. Explaining the concept of accessibility and universal design to all users, not just those with disabilities, is challenging but extremely important. Community awareness brought about through the guidelines, and legal mechanisms might significantly influence the uptake of universal design and accessibility.

Gonçalves et al. (2009) researched on WCAG 1.0, WCAG 2.0 and U.S. accessibility guidelines section 508 and evaluated websites of 250 largest enterprises enlisted in Forbes. It was found that almost all of the websites were filled with accessibility errors to the point that websites have not even conformed to the minimum accessibility requirements [53]. According to World Wide Web Consortium (W3C) definition of universal design, it can be interpreted that whenever attempts are made to make a universally designed website, the purpose is to make the website usable and accessible for all users to the greatest extent possible, irrespective of their situation and without any need for adaptation [54]. However, Kelly et al. (2009) state that improving only technical aspects does not solve accessibility issues. In that respect, web adaptability is also an evolving school of thought that focuses on every user, unlike other concepts that focus solely on people with special needs and embraces curb-cut phenomenon that benefits all users [55].

Chapter 3:

Designing Methodology

3 Designing Methodology

For this study, a qualitative methodology was used to evaluate the ticketing system of public transport. In the light of previous studies that indicated that ticketing system is designed from the perspective of one group of people, and after establishing the requirements of different groups of people (i.e., people with impairments related to vision, hearing, mobility, cognitive and people without any disability), the questionnaire of the survey was designed. The vision was to point out that the satisfaction with ticketing system' features affect the ticketing systems' overall experience, and consequently, preference for purchasing tickets.

3.1 Qualitative Approach:

The qualitative study approach, i.e., surveys and case study, is used for this thesis study. The data was collected on accessibility and usability features of ticketing machines, websites, and smartphone applications currently being used for Oslo and Amsterdam's public transport system.

Surveys are one of the most frequently used research methods typically used to describe populations, explain behaviours, and explore uncharted waters [56]. The public transport and ticketing system are used by innumerable people daily. They belong to different age groups, have different backgrounds, and have different abilities, so conducting a survey is a useful option for getting an overview of the population's opinion. This study also aims to evaluate the ticketing system and predict the problematic area in terms of accessibility and usability in the ticketing system; users need to be involved directly in the study.

The type of survey used for this thesis is 'online survey'. In order to conduct the survey, a questionnaire was developed with the help of Google Forms. The reason for selecting an online survey as a method for this research is that online research can help give access to pools of participants that otherwise would have been unavailable. This reason is particularly valid for people with disabilities, who may find travelling to the researcher's place to be logistically unfeasible [57], and domain experts, who may be hard to find in sufficient numbers in some locales [58]. The online survey also removes scheduling with the participants and allows participants to complete tasks in their leisure time. Besides, Surveys [59] and usability evaluations [57] [58] have all been completed online. Recent examples of online usability studies have shown that both synchronous studies with domain experts [58] and asynchronous studies with disabled users [57] have yielded results comparable to those that were found in traditional usability studies.

3.2 Participants:

The survey's target population included those people who use the ticketing system of Oslo and Amsterdam's public transport. Since people of all ages use the ticketing system and public transport, there was no age requirement to participate in this survey. Also, people with impairments regarding vision, hearing, cognitive, and mobility were included as part of this study, and they too could belong to any age group. However, the majority of the participants were between 18 to 65 years of age. The participants were recruited by contacting various organization working for accessibility in the public transport sector and by sharing Google Form on Facebook groups of specific communities, organizations, and universities. All of the responses were collected through the online Google Form.

3.3 Questionnaire Design:

The questionnaire used for the survey was written very carefully. Questions were rechecked again and again so that complicated, one-group focused or hurtful questions are not included. The questionnaire consisted of simple Multiple-Choice Questions (MCQs) that can be understood by every participant regardless of what their educational background is. It was also made sure that questions have options like 'none' and 'not important for me' to give participants autonomy to select something that is their genuine opinion rather than compelling them to answer something that is not their genuine opinion. Participants were also allowed to leave the question unanswered if they do not want to answer a particular question. The questions asked just required a single-click from the participants to avoid taking a long time. The questions that demand detailed answers from participants consume much time, and it might be difficult for most of the participants to give that much time. People also tend to get tired if they see a long survey and lose focus immediately after a few questions. They would then want to finish the survey quickly, resulting in responses that might not reflect participants' honest opinions.

The questionnaire consisted of the following sections, mainly.

- Personal Information
- Ticketing Machine
- Website
- Mobile Application

A consent form was given to the participants before the questionnaire that requested participants' consent to participate in the survey. Participants in this section were first explained what this survey was about and the main objectives of this study. Secondly, the rights of the participants were mentioned in the consent form. The participants' rights included that their participation was voluntary, they are not pressured to participate, and if they decide not to participate, there would not be any consequences. Thirdly, if they cannot fill the questionnaire in any certain circumstances, they can give authorization to someone else, and that person would be considered ‘subject by proxy’. Lastly, participants were reminded that their answers would be recorded anonymously, and no email addresses would be collected.

In the first section, some general personal information was asked by the participants. Since this survey is about a case study of Oslo and Amsterdam to draw comparative results later on in analysis, it was necessary to record the city from where participants belong. Furthermore, public transport is used by people of all ages, so for this thesis, it was essential to include opinions of people of all age groups. Similarly, to understand the participants more, they were asked if they have severe difficulty in any area of life, their purpose of travel in public transport, and their preferred medium of purchasing tickets and ticket format.

After personal information came the questionnaire’s three main sections, i.e., about the ticketing system (ticketing machines, website, and mobile application). The pattern of the questions in these three sections was kept similar to avoid confusion for participants. The questions included participants’ experience of using a particular medium, colour contrast, information, language, text size, accessibility tools, navigation and ticketing system validation process.

Apart from sectioning the form, pictures related to the ticketing system (Ticketing Machine, Website, and Mobile Application) were also included for both participants from Oslo and Amsterdam to have a clear idea about the subject of the discussion. Before starting the data collection process, a pilot study was conducted using the questionnaire with two students from my university to find if the questions are open-ended and easily understandable.

3.4 Ethical considerations:

3.4.1 Informed Voluntary consent:

The basic principle for ethical research is that prospective participants can decide whether they should or should not participate in the research. The general rules of ethical practice in online research are the same as traditional research involving human beings, including autonomy, justice, and beneficence [60]. Following this guideline, the consent form was given to the participants that listed their rights and survey objectives.

3.4.2 Maintaining privacy, anonymity, and justice:

Anonymity refers to the notion that each individual has the right to privacy and dignity that should be protected at all times [61]. Within the context of online research, it requires researchers to protect the internet users' personal information and refrain from disclosing anything that would allow their personal information to be inferred [62].

The principle of justice implies that all research participants should be treated fairly, equally, and nobly during the entire research process [60]. The research procedure requires that the researcher's identity and the research methods are transparent and that no segment of the community is unfairly burdened or faces discrimination. It also imposes obligations towards the individuals who cannot protect their interests, therefore, should be protected from any exploitation for the sake of research and the progress of knowledge [63]. The instructions for the entire questionnaire were kept the same for every person to maintain the principle of justice. Participants were told that their personal information, i.e., email addresses, will be protected and not used in this research. Also, the questions like age group and occupation are anonymously collected and will only be used for research purposes, and all of their opinions will be recorded anonymously.

3.4.3 Maintaining confidentiality of the data:

The ethical principle of beneficence needs researchers to evaluate all physical, social, psychological, or medical harms or risks that their participants may face by being in the research, and making every possible attempt to minimize these harms and maximize their benefits [64]. Within the context of online research, the risk of harm arises when there is a disclosure of participant's identity or any other sensitive information that may expose them to the risk of embarrassment, reputational damage, or legal prosecution [65]. This guideline was maintained by keeping the information collected from the participants confidential and recording the data anonymously.

3.5 Data Collection Process:

Different organizations that are working for accessibility and usability of systems were contacted to collect the data. These organizations were sent the Google Form and were requested to help fill the survey form. These organizations of Norway and the Netherlands are listed below:

- General Dutch Disability Organization - the Netherlands
- MEE: Support and help for living with a disability – Netherlands
- Network for the chronically ill and disabled (Formally known as CG-RaaD) - Netherlands
- Accessibility Foundation: Accessible internet for all - the Netherlands
- Valys: Regional assisted transport - Netherlands
- NCTT: Dutch centre informing on public accessibility - Netherlands
- Handilinks: A useful portal with lots of related links – Netherlands
- Dutch Autism Network - Netherlands
- Down Syndrome Foundation - Netherlands
- Deaf/Blind Support - Netherlands

- Children/teenager Support - Netherlands
- The Norwegian Association of Youth with Disabilities - Norway
- The Norwegian Association of Disabled (NAD) - Norway
- The Norwegian Federation of Organizations of Disabled people (NFU) - Norway
- The Norwegian Association for the Blind - Norway

Furthermore, various Facebook groups of Norway and the Netherlands were requested to share the Google form. These groups are described below:

Norway Facebook Groups:

- NFU Haugesund: Works for people with developmental disabilities, relatives and other interested parties from Haugesund, Haugalandet and Norway in general.
- Parkinson Norge: This is a support group for anyone who has a relationship with Parkinson's. A group for ill, who love someone with Parkinson's and for who want to be a supporter, motivator and friend.
- Ledige stillinger og karrieretips for OsloMet-studenter: Group for OsloMet career! Here vacancies are shared, questions related to career are asked from career counsellors and employers, useful career tips are obtained.

Netherlands Facebook Groups:

- Doof & Zo: For Deaf and peoples with some disability.
- Accessible NL: Accessible_NL works to provide solutions to accessibility issues inside the Netherlands.
- Access Consciousness Nederland: Access-related creations and personal experiences.

- Parkinson en DBS: This group is intended for sharing experiences around DBS. Positive as well as harmful.
- ParkinsonProatgroep: This group is for people with Parkinson's.
- blinden slechtzienden activiteiten groep: For blind and partially sighted activities are shared in this group for the fun sportive holidays
- Jong & Slechthorend/Doof - Zuid-Nederland: The group Young & Hearing / Deaf - South Netherlands is a group where events are shared for the target group of young people who are hard of hearing or deaf.

Chapter 4:
Results and Discussion

4.1 Results

4.1.1 City of the participants:

The results obtained from Google Form indicated that about 90 people responded to the questionnaire, and among these participants, 71.8% of the participants were from Oslo, Norway, and 28.2% participated from Amsterdam, Netherlands (Figure 1). The lower percentage of Amsterdam participants is that many people could not be contacted in-person because of the recent coronavirus (COVID-19), and the questionnaire had to be sent through email. So, only those participants who were available completed the questionnaire.

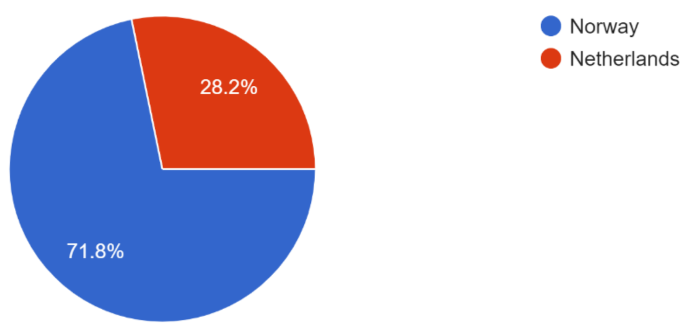

Figure 1: City/Country of the Participants

4.1.2 Purpose of Travel:

41.7% of participants travelled in public transport to go to their universities (study purpose), 38.1% of participants for work purposes, and 20.2% of participants travelled in public transport to visit places (Figure 2)

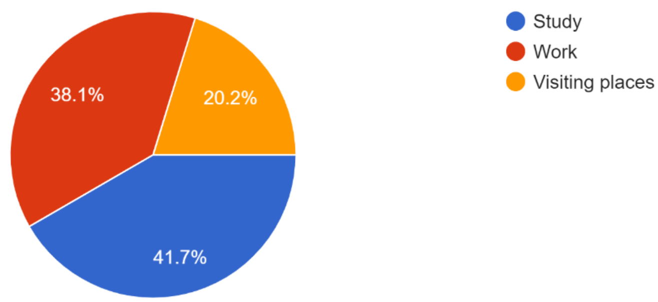

Figure 2: Purpose of Travel

4.1.3 Ticket purchase preference:

61.2% of the participants prefer to purchase tickets for travelling in public transport from the smartphone application. 29.4% from ticketing machines, 5.9% from the website, and 3.5% from convenience stores (Figure 3). A higher percentage of participants preferred to purchase tickets through smartphone applications because it is more convenient to use than other mediums, and they have smartphones with them all the time. The lower percentage of participants preferred to purchase tickets through convenience stores, and the reason for it is that no one in Amsterdam purchases tickets through convenience stores, while some participants from Oslo preferred to purchase tickets through convenience stores.

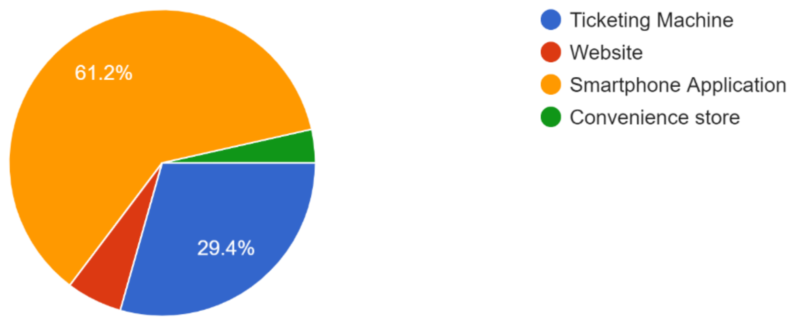

Figure 3: Ticket purchase preference

4.1.4 Severe difficulty:

When asked that whether any participant has severe difficulty in any area like vision, hearing, mobility, and cognitive, 82.1% of the participants mentioned that they do not face any severe difficulty, 9.5% had vision-related issues, 2.4% had hearing problems, and 6% of participants had severe difficulty in mobility (Figure 4). Here, the graph indicates that a higher percentage of participants had no severe difficulty. The reason is that most of these participants were students, and most of them had no issue, except for vision limitations. Furthermore, although numerous organizations that work for accessibility and universal design were contacted, and the questionnaire was shared in their community groups, a lower percentage of participants with severe difficulty responded. The reason is, again, the current circumstances of COVID-19.

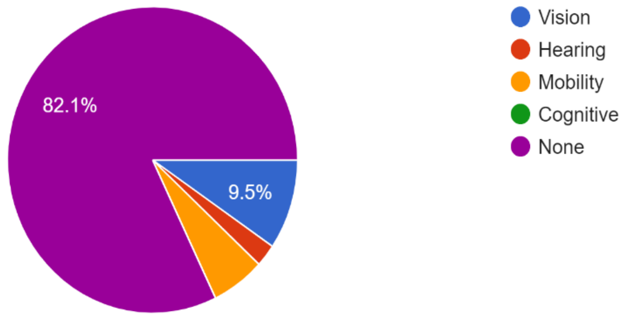

Figure 4: Severe Difficulty

4.1.5 Tools for accessibility:

86.9% of the participants marked that they do not use any tools for accessibility, 11.9% use mobility aids, 2.4% cognitive aids, and 3.6% use Computer software and hardware aids such as voice recognition programs, screen readers, and screen enlargement applications (Figure 5).

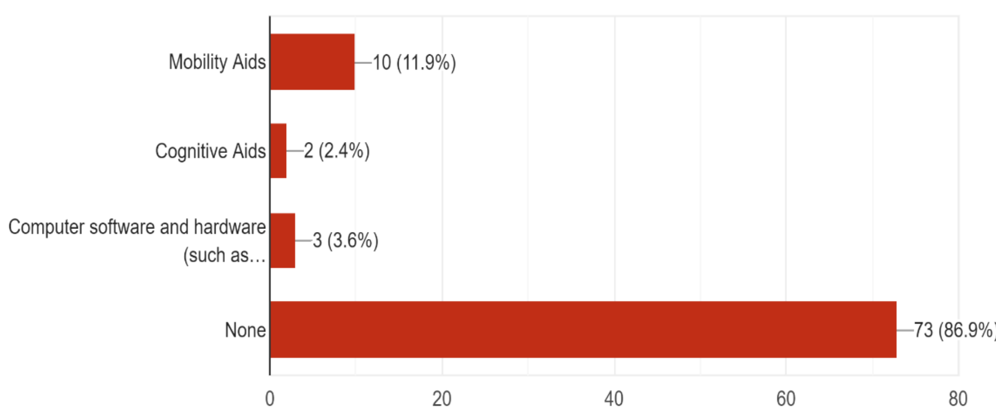

Figure 5: Tools for accessibility

4.2 Analysis Regarding Accessibility

In order to evaluate that which one of the mediums of the ticketing system (ticketing machine, website, and mobile application) is more accessible, the experience of participants regarding them is compared.

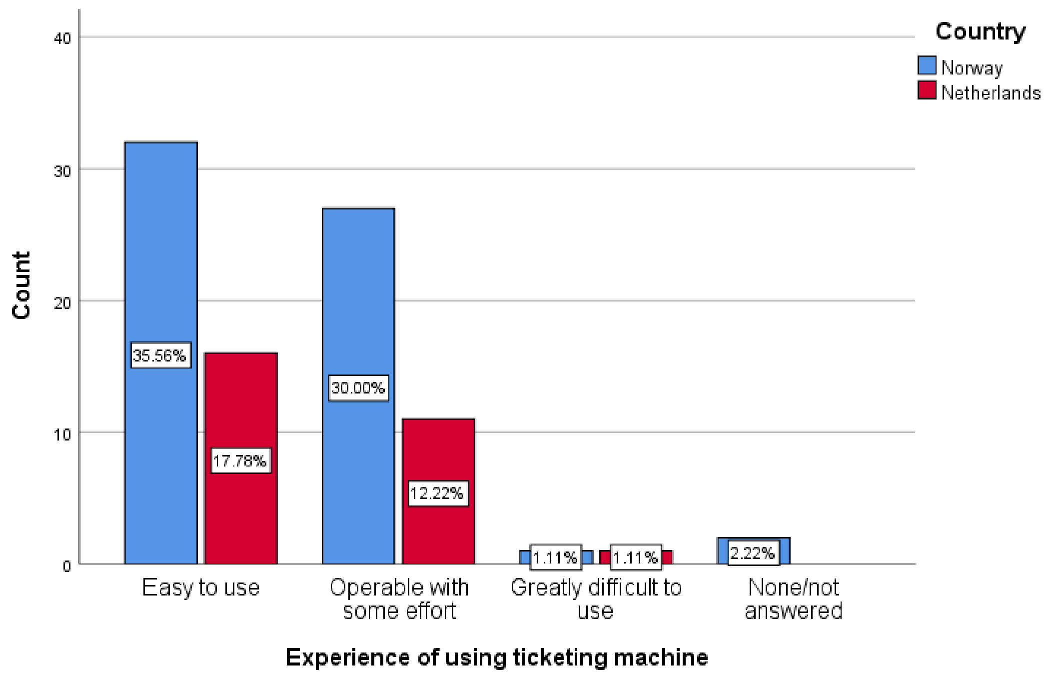

Figure 6: Experience of Participants of Oslo and Amsterdam using Ticketing Machine

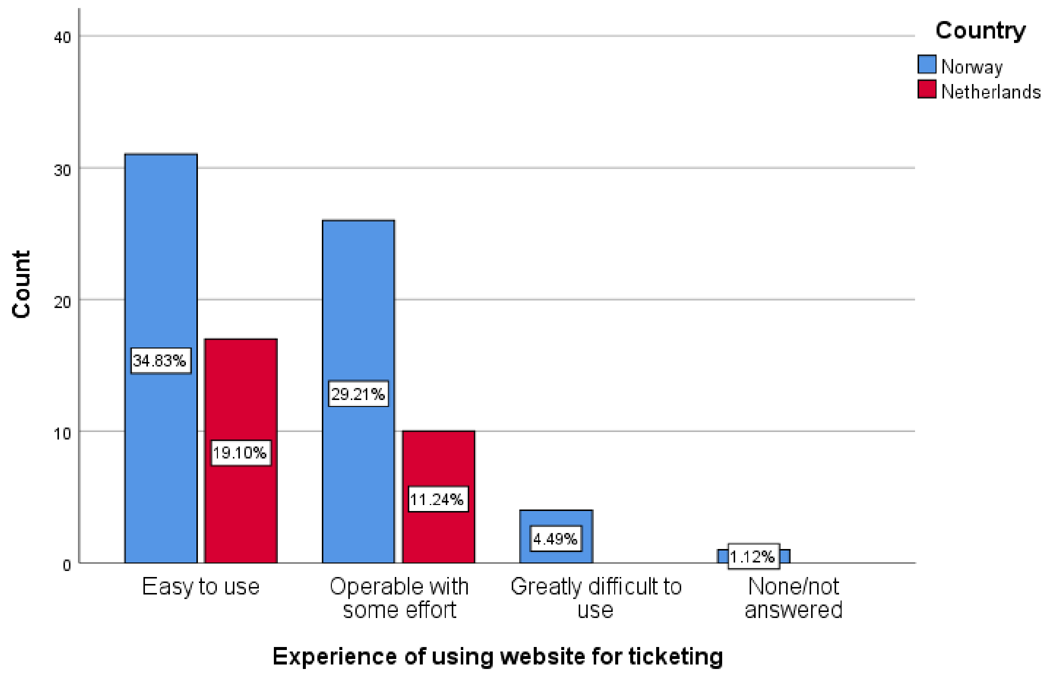

Figure 7: Experience of Participants of Oslo and Amsterdam using Website

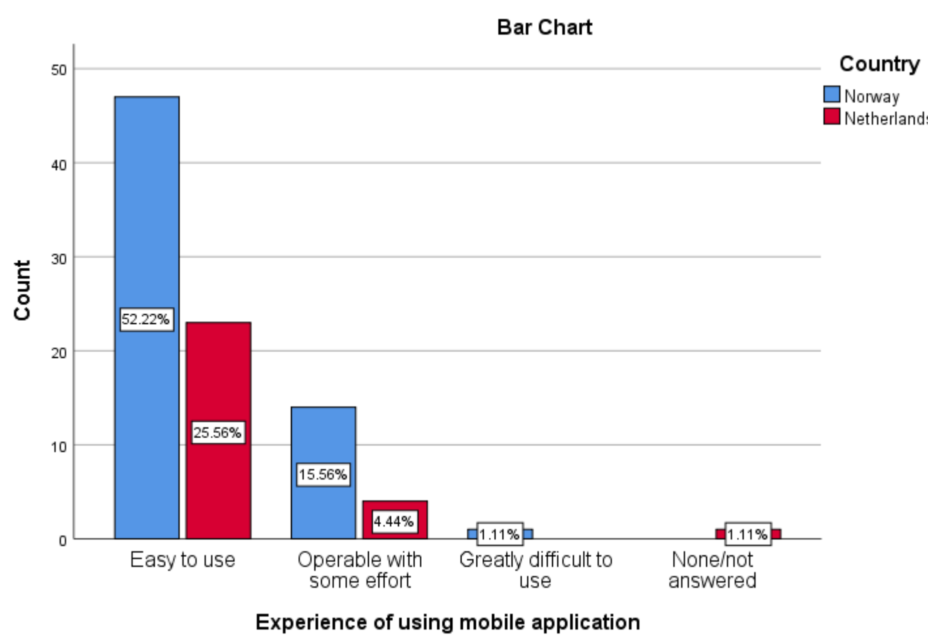

Figure 8: Experience of Participants of Oslo and Amsterdam using Mobile Application

The data shows that 52.22% of participants from Oslo responded that mobile application is easy to use, 35.56% responded it for ticketing machine, and 34.83% for the website. So, based on the above graphs, it can be seen that participants had a preference in the following sequence:

Mobile application > ticketing machine > website

While 25.56% of Amsterdam participants responded that mobile application is easy to use, 19.10% responded to it for the website and 17.78% for ticketing machines. So, the above graphs indicate that participants had a preference in the following sequence:

Mobile application > website > ticketing machine

It can be interpreted from the above graphs that the participants least prefer the website for Oslo and Ticketing Machine for Amsterdam. The reason behind this is that several accessibility issues are found in these ticketing systems. To get more clarity about the findings, individual features (colour contrast, information, language, text, navigation, and validation) that contribute to the development of accessible and usable systems are analysed.

In the analysis of Oslo's website, it was found that although the majority of the participants were satisfied with the colour contrast, language, navigation, and validation features, there was a still more significant number of participants that were not satisfied. About 30.65% of participants were not satisfied with colour contrast, 24.19% thought that language is understandable only with difficulty, 37.10% find website navigable with difficulty, and 16.13% believed that website took a too long time for validation. These all are the reasons because of which participants were least satisfied with the website.

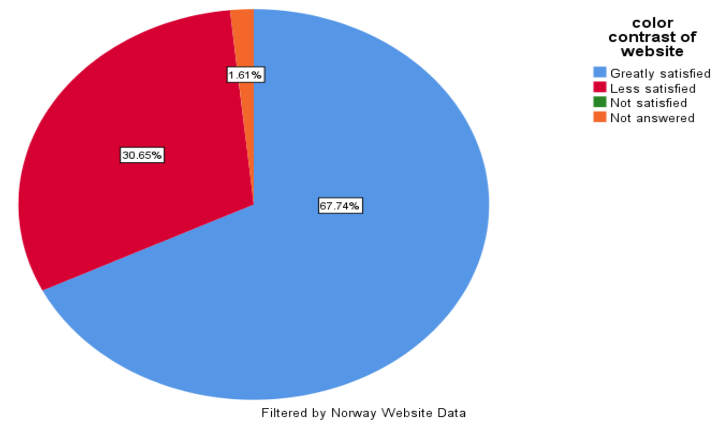

Figure 9: Colour contrast data of website of Oslo

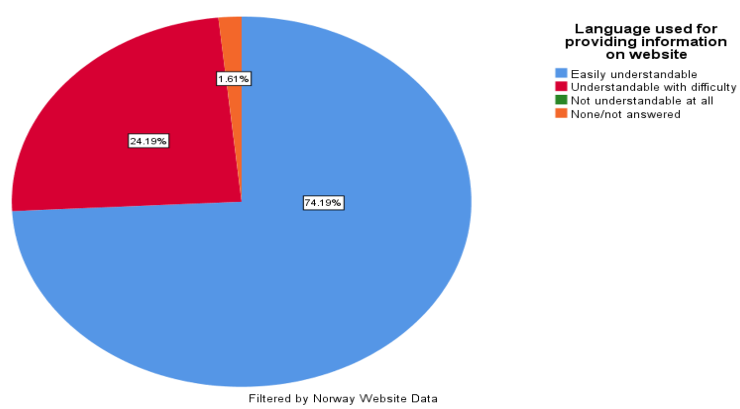

Figure 10: Analysis of Language used in Website of Public Transport of Oslo

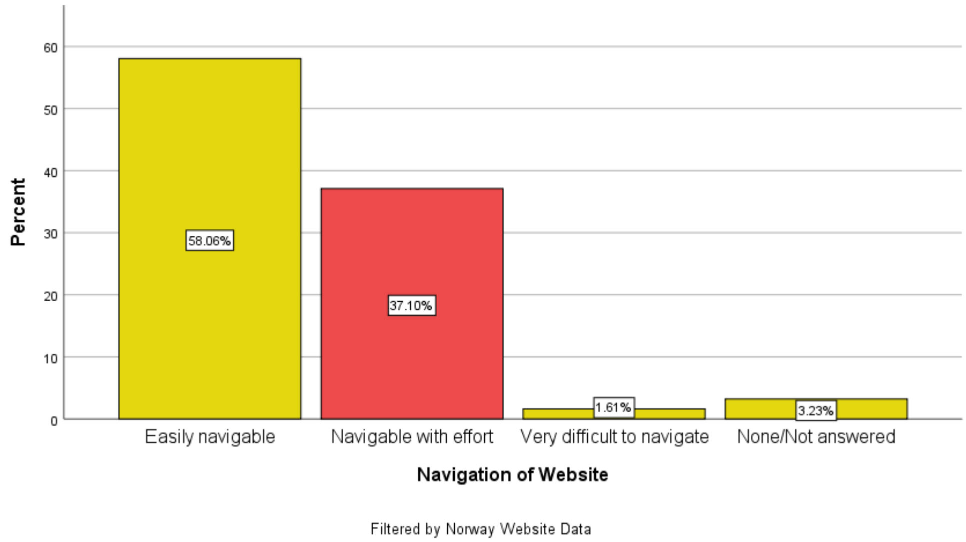

Figure 11: Analysis of Navigation of Website of Public Transport of Oslo

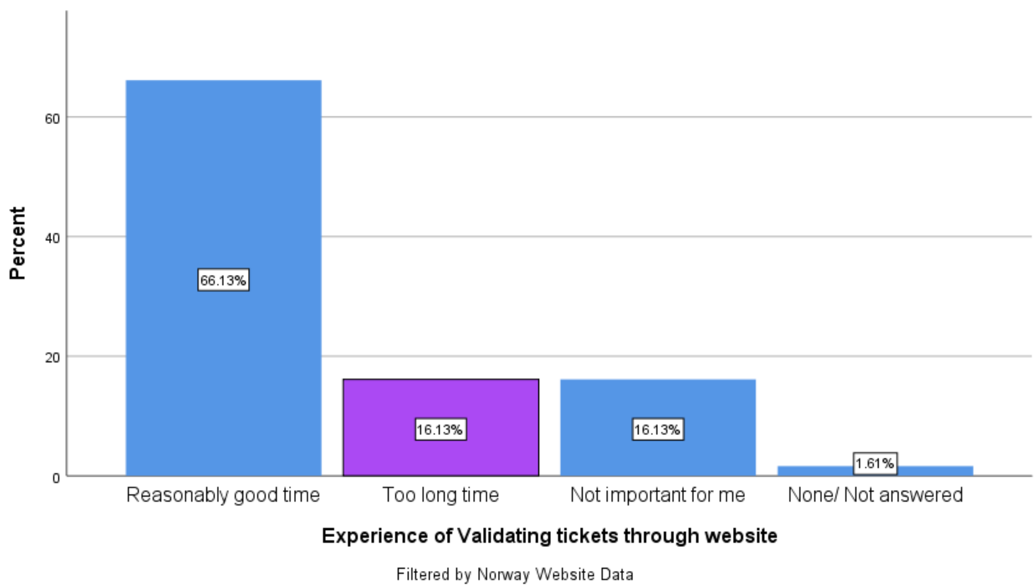

Figure 12 Analysis of Validation process of Website of Public Transport of Oslo

In the analysis of the Ticketing Machine of Amsterdam, it was found that although the majority of the participants were satisfied with the colour contrast, language, navigation, and validation features, there was a still more significant number of participants that were not satisfied. About 25% of participants were not satisfied with colour contrast, and 33.33%

(half of the participants) find navigation in ticketing machines difficult. These problems are the reasons because of which participants were least satisfied with Ticketing Machines.

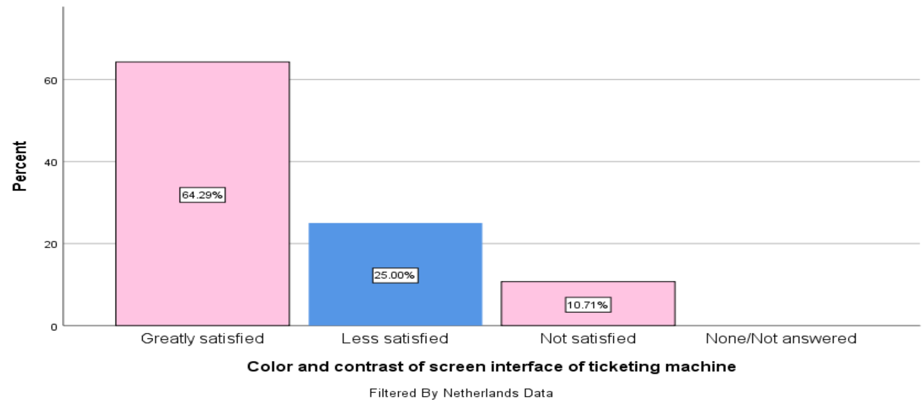

Figure 13: Analysis of Colour Contrast of Ticketing Machine of Public Transport of Amsterdam

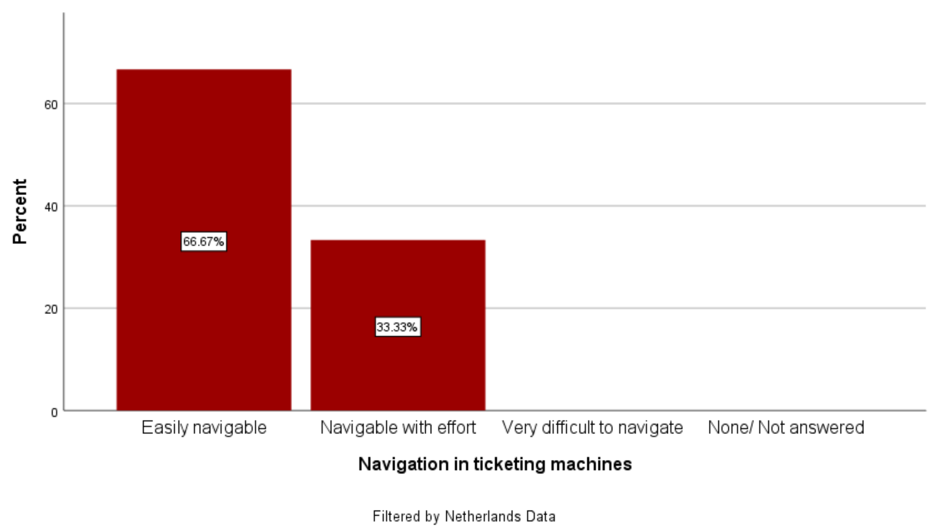

Figure 14: Analysis of Navigation in Ticketing Machine of Public Transport of Amsterdam

4.3 Analysis of Ticket Purchase Preference concerning the severe difficulty

Results obtained from Google Form indicated that people facing severe difficulties in vision, hearing, and mobility prefer to purchase tickets through smartphone applications in Oslo. In contrast, people who do not have any disability prefer to purchase tickets through convenience stores. On the other hand, in Amsterdam, people with severe vision and people with no difficulty prefer to purchase tickets through smartphone applications. In contrast, those with hearing impairment purchase tickets through ticketing machines. Those with mobility impairment prefer to purchase tickets through the website. This further points out that in Oslo, for people with disabilities, the smartphone application is the most preferred ticket purchase method, and in Amsterdam, people with disabilities purchase more or less through all mediums, which emphasizes the need to make these systems more accessible for them. The analysis obtained in SPSS is illustrated below (figure 15).

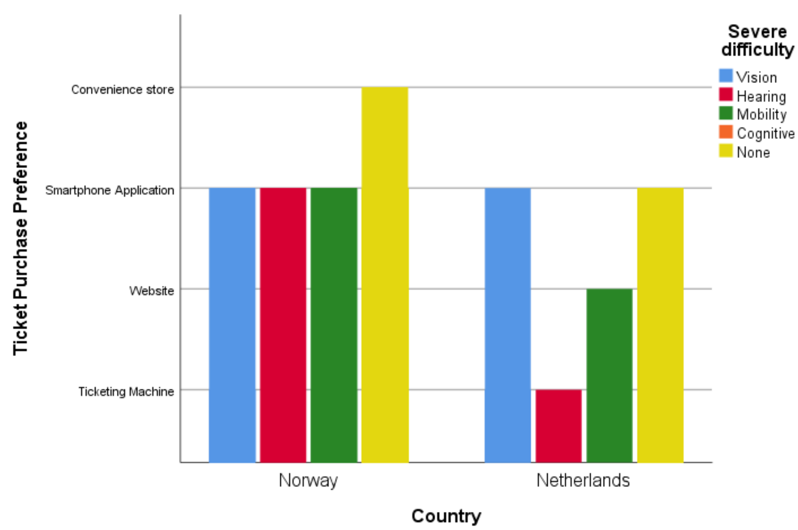

Figure 15: Clustered Bar of Ticket Purchase Preference by County by Severe Difficulty

4.4 Statistical Analysis

Since the qualitative study approach was used for this survey, the Google Form's data is categorical. Categorical data is the data elucidated by category and classified by characteristics and is designated name instead of a numeric expression. There are two main types of categorical data, nominal and ordinal. Nominal variables are those groups that are specified a name rather than a number, and no order exists in these groups. Ordinal data is similar to nominal in having distinctive groupings; however, there is a definite order in groups to create a scale [66]. Tremendous is often required to create an ordinal variable with a scale that has similar intervals or similar approximate distance such as ('strongly disagree', 'disagree,' 'neutral,' 'agree,' 'strongly agree') is one such set of response [67] [68].

4.4.1 Parametric and Non-parametric tests:

Rana et al. elaborated on the parametric and non-parametric statistical tests. It states that a non-parametric test is a type of hypothesis testing that is distribution-free. It does not require specifying the distribution form of the population under study. Non-parametric tests apply to nominal and ordinal data. It can also be applied to interval data that do not have a normal distribution. In contrast, a parametric test is used when assumptions are made about the population, and when the information is made known through its parameters, it is a parametric test [69].

This study's objective was to evaluate the relationship between the colour contrast and ticket purchase preference through correlations and make assumptions about the population, so the parametric test was most suitable. Although non-parametric tests could also be applied to this study but were not used because of the following reasons:

- Parametric tests have been seen to have greater statistical power than non-parametric tests, and it is easy to interpret the conclusion drawn from parametric tests [69].
- The sample size of the population with different capabilities was small, so it was not easy to make assumptions about the population. That is also why the Independent sample t-test, ANOVA, or Chi-square test was not used as there needs to be a greater sample size to conclude a significant difference.

4.4.2 Pearson’s Correlation Test:

Pearson’s correlation test is used whenever there is a need to understand the association between two variables. This test requires that these variables have an equal status which means no independent or dependent variable. Furthermore, the variables are continuous [70]. There are cases like when the Likert scale is used, where the ordinal variable with scale is treated as a continuous variable. [71]

Based on the hypothesis testing, the variables between which association was to be evaluated have equal status and were continuous. The result of the correlation was as follows:

Correlations

		Color and contrast of screen interface of ticketing machine	Experience of using ticketing machine
Color and contrast of screen interface of ticketing machine	Pearson Correlation	1	.328**
	Sig. (2-tailed)		.002
	N	90	90
Experience of using ticketing machine	Pearson Correlation	.328**	1
	Sig. (2-tailed)	.002	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2 Result of Pearson's Correlation Test

The null hypothesis (H0) and the alternative hypothesis (H1) of the significance test for correlation were as follows:

Two-tailed significance test:

H0: $\rho = 0$ ("the population correlation coefficient is 0; there is no association")

H1: $\rho \neq 0$ ("the population correlation coefficient is not 0; a nonzero correlation could exist")

The two-tailed significance tests indicate that the population correlation coefficient is not zero, which means that the association exists between variables. In other words, being satisfied or less satisfied with the colour contrast of the ticketing machines affects the overall satisfaction level with the ticketing machine.

Chapter 5:

Discussion and Conclusion

5.1 Discussion:

The primary purpose of adopting a universal design and improving accessibility is to remove barriers that prevent users from accessing the ticketing system. It seems evident from the results obtained that smartphone application is the medium most used by people both with and without disabilities in both countries. All participants responded positively regarding the application features like colour contrast, language, text size, navigation, and validation, which means that smartphone application is most accessible in the ticketing system.

The comparative analysis done on the data collected from both cites indicates that people in Oslo least used the website, and people in Amsterdam least used the ticketing machine. Participants were not satisfied with the individual features that show conformance to universally designed guidelines and determine the accessibility of the ticketing systems. Therefore, the designers and developers must work on the features to achieve accessibility and enhance the ticketing system's usability.

Another significant difference in Oslo and Amsterdam' ticketing system is that in Oslo, many participants prefer to purchase tickets through convenience stores while in Amsterdam, nobody purchased tickets through convenience stores.

5.1.1 Participants and Limitations:

One of the main limitations of this study is that many participants with disabilities could not be included, although the survey was shared with numerous organizations and community groups. The COVID-19 led to unprecedented circumstances that hindered the progress of the survey.

Furthermore, this study used a qualitative study approach for data collection; the data gathered have provided insight into the preferences of the participants and their opinions on individual features of any medium of ticketing system, but conclusive statements could not be made regarding people with disabilities as the sample size was small.

Because of the arguments made above, one could question the significance of the results obtained, yet the results are promising in certain areas. For instance, it gives a precise comparative analysis of Oslo and Amsterdam's ticketing system and could be considered an indication of what areas of the ticketing system could be improved to enhance accessibility and usability.

5.2 Conclusion:

Public transport is the most vital sector of any country, and most of the population uses public transport for their day to day trips, which depicts the immense significance of the ticketing system. The ticketing system's design needs to be in the best form, affecting the system's usability and accessibility. The literature review recommended that adherence to universal design and accessibility guidelines like WCAG 2.0 ensure the system's maximum usability. Oslo and Amsterdam's public transport ticketing system were evaluated in light of these guidelines, and the following answers were obtained for the research questions.

- Which platform is more accessible among the three most commonly used platforms: ticketing machine, website, or smartphone application?

It was found that smartphone application is the medium preferred by most participants, and participants both from Oslo and Amsterdam were incredibly satisfied with the colour contrast, language used, text size, navigation, and validation of the mobile application.

- What are the key features/differences of these ticketing systems' user experience in Oslo and Amsterdam?

The similarity in both cities' ticketing system was that participants from both countries were satisfied with the mobile application used for purchasing tickets, and there were two significant differences. First, Oslo participants were not satisfied with the website, and the reason is the website's features. Participants were not fully satisfied with colour contrast, language, navigation, and validation areas. In contrast, Amsterdam participants were not satisfied with the ticketing machine, and the reason is the ticketing machine's features. Participants were not fully satisfied with colour contrast and navigation areas. The second difference is that some participants from Oslo purchased tickets through convenience stores while none from Amsterdam purchase tickets through convenience stores.

Furthermore, the result obtained that individual features do impact the overall experience of the ticketing system was further confirmed through Pearson's correlation test.

5.3 Future Work:

The future vision is that, should there be any further attempt to analyse Oslo and Amsterdam's ticketing system in the future, it is suggested that the study should gather a more significant number of participants with disabilities to get a more in-depth insight into the usability and accessibility of the ticketing system concerning people with disabilities.

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