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Usable electronic voting for elderly people

Vishal Thapa

Department of Computer Science

Faculty of Technology, Art, and Design

Preface

This study is about the usability of a user interface for electronic voting for the elderly people so that they can practice their democratic rights. This research is carried out as a part of a master's program under the department of Computer Science in Oslomet University. Through this research I was able to explore the usability in the user interface and suggest possible solutions for making the user interface of the voting system usable. This study might be helpful for the future researcher to design and implement a usable voting system.

I would like to thank Oslomet University for giving me the opportunity to be a part of this University and allowing me to pursue a master's degree in this University. I am indebted for this opportunity to study in Oslomet University which helped expand my horizons and helped me to gain world standard education and also increase my value as both a University Graduate and an individual. My sincere appreciation goes to my supervisor Norun Christine Sanderson for her continuous guidance, support, and regular constructive feedback throughout this period for helping me in the completion of my master’s thesis.

I would also like to express my gratitude to all my friends, colleagues, and the participants who agreed to be part of my thesis program.

Vishal Thapa

Master’s student, Oslomet University

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Abstract

The research objective is about the investigation of the usability of the user interface to provide a usable voting interface for the elderly people so that they can be a part of inclusive democratic society. The usability of the interface is researched based on the 10 Usability Heuristics of the User Interface Design by Nielsen Norman Group. The Usability testing was carried out with 4 participants using three prototypes under the 'within subject design' research design to diagnose the usability of the prototype. To find the user satisfaction and additional information regarding the prototype, a post-test session interview was conducted. The data collected through usability testing and interview was analyzed via Content analysis.

It is agreed that without the acceptance of the people the electronic voting cannot be implemented. It can be agreed to some extent with the previous study that usability heuristics like Visibility of the system status, Match between the system and the real world, Consistency and industry convention of design, User control and freedom, Minimalistic design is necessary feature that contribute to usability of the system which was included in their study.

The analysis of this research showed some mixed results but promising with some usability issues. Though the prototype was not completely able to meet the participant's needs in terms of usability. Still, the result from usability testing and post usability interviews can be used to design the interface completely different from these and make it more usable. Since this prototype does not match any country's ballot design, designers can design the interface in their own terms and creativity considering the usability issues and requirements that we got from the result in this research.

Keywords: E-voting, Electoral system, usability, E-governance, universal design, accessibility, security, usability testing, prototype design.

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List of Acronyms

Acronyms	Phrase
AT	Assistive Technology
P1	Prototype 1
P2	Prototype 2
P3	Prototype 3
ELMER	Easier and more Efficient Reporting
WCAG	Web Content Accessibility Guidelines

1.Introduction

The electoral system is the fundamental building block of democracy. Quoting the definition of democracy from oxford's dictionary, "A system of government by the whole population or all the eligible members of a state, typically through elected representatives" (Stevenson, 2010). It is apparent how integral the voting process is to establish and maintain a democratic government system. Another notable point from the definition is the prerequisite "by the whole population or all the eligible members" which entails the democratic government is nominated by implicit or explicit participation of the whole eligible population.

An electronic voting system is defined as any system that allows the eligible voter to cast their vote through the media of a computer normally connected to the internet or intranet from anywhere i.e. Home or office (Musa & Aliyu, 2013). Electronic voting in comparison to paper voting can increase the speed of vote counting, decrease the cost of the election while increasing the overall accessibility and usability of the system (Dhillon, Kotsialou, McBurney, & Riley, 2019). According to (Dhillon et al., 2019), electronic voting is termed as a mechanism of voting through the help of electronic media which categorizes it into two types namely online and offline. In offline voting, electronic voting machines are placed in polling stations where Electronic voting machines (EVM) make the counting as well as the collection of the votes faster thus minimizing the staffing cost and making the outcome more accurate. Online voting on the other hand has widened the possibilities of voting by providing the facility of voting from anywhere around the world with a device connected to the internet (Dhillon et al., 2019).

The faster vote counts, the fewer errors compared to humans, as mentioned earlier increased convenience for voters, increased accessibility is some of the advantages of electronic voting systems (Wolf, Nackerdien, & Tuccinardi, 2011). In addition, the system is able to warn the voter about the invalid votes which

helps in the reduction of spoilt ballot papers and though it seems expensive and complicated in the initial phase, it is cost-efficient in the long-run as it saves the poll worker time and also because of the reduced cost for production and distribution of ballot papers (Wolf et al., 2011). Disadvantages are also accompanied by advantages as well. With the implementation of electronic voting, there is a need for increased security requirements for protecting the voting system during the election, and failure to acquire which might result in a lack of people's trust in e-voting based elections. Also, it might be complicated for non-experts because of the limited understanding of the system.

As we are aware of the fact that secrecy of the *ballot* is one of the core themes of the democracy, where the voter should be allowed to vote in private without the involvement of another person and nobody should be allowed to alter the anonymity of the vote, which is something accessible electronic voting can ensure (Saglie & Segaard, 2016). An accessible system for voting means providing an interface that is accessible and usable for all people through which people can cast votes independently, without the help of any other person. In addition to this, in this digital world where we can control and exercise our daily activities by the tip of our finger, this paper-based voting is standing as a cause for digital exclusion (Goodman, McGregor, Couture, & Breux, 2018). With the growing interest in e-voting systems, problems with the domestic election system were found which includes timeframes and physical accessibility of polling stations, which progressively prevent citizens to cast their votes at these places (Buchsbaum, 2004). As a result, a new electronic voting system with a touch screen that assured reliable voting was introduced which, however, had shortcomings in terms of voter usability and accessibility. Though the system performance was satisfiable still, it had issues regarding concerns of people with disabilities in terms of accessibility (Herrnson et al., 2005).

The focus of this research is on electronic voting by elderly people, and since people in Norway are considered elderly from the age of 65 and above, the focus of this research will be this age group (Raaflaub, Ober, & Wallace, 2008). The

growing age can bring some age-related impairments such as a decline in memory and loss of cognitive function that can impair a person's ability to perform their everyday activities. When this progress, people require assistance in some activities, and voting/polling is one of them (Karlawish & Bonnie, 2007).

Though most measures have been implemented for the purpose of increasing voter participation with the help of assisted voting, it does not guarantee that voting is according to the voters' preferences (Karlawish & Bonnie, 2007). In terms of software applications, usability can be termed as the easiness at which the new user can use the software or the website to achieve the target (Churm, 2020). Generally, usability consists of learnability, efficiency, satisfaction, and errors. The main issue is conducting research including both accessibility and usability may require more time. For the purpose of this research, it was, therefore, opted to go for investigating the usability of the interface so that once the results from the required tests were acquired, appropriate suggestions and feedback could be given regarding the usability of the interface. This way, if time allows, further work and research may be conducted to make the proposed design accessible.

1.1 Problem Statement

Based on the data published by the World Health Organization, the world population that lives with some sort of impairments is around 15% (WHO, 2018). It is inevitable that the human body cannot function optimally throughout one's entire lifespan, the body's functioning deteriorates with the growing age and most probably brings some sort of age-related impairment. As a result, many elderly people cannot cast their vote independently without the help of another person. According to the United Nations Population Department, by the year 2050, the number of people over the age of 60 will be around 2 billion, and 25-30% of people aged 85 and above will have cognitive decline (UN, 2017).

Over the last few decades, little importance seems to have been given towards the usability of the voting systems, while there has been more focus on the

security issues of these systems. Because of the lack of accessibility and usability, the users with impairments and elderly people are excluded from practicing their democratic rights which prevent them from presenting their views in society when casting their votes. Electronic voting needs more accessible and usable platforms so all the people along with those with disabilities can cast votes to select a candidate independently. In this thesis, a possible solution for making a usable voting system for elderly people will be provided so that the system for casting votes in a voting process includes all the people without exclusion.

1.2 Research Question

Based on the problem statement a research question is developed which will be helpful to carry out the research work.

Q. How can an electronic voting system be more than just accessible but also usable, so that it can facilitate digital inclusion in society for elderly people to practice their democratic rights?

1.3 Research Aim

The focus of this research is the usability of the user interface to provide a usable voting interface for elderly people so that they can vote independently in an election or any other poll to present their own opinions without the help of any other person. Usability Heuristics of User Interface Design have been used in this research, covering visibility of system status, user control and feedback, error prevention, Recognition rather than recall, Aesthetics and minimalist design, help users recognize, diagnose, and recover from errors, Help, and documentation (Nielsen, 2020).

The research in Usability testing, in general, is focused more on the interface rather than the users, which also includes other elements such as personas, user profiles, etc. The usability research is particularly carried out with the target user and the specific task intended to identify the interaction of the user with the interface, even though the aim of the testing might not be about improving the

interfaces but in fact to study the users and their interactions. Therefore, the objective of this research is to investigate the usability of the interface with the help of target users provided with specific tasks.

2.Literature Review

This chapter focuses on the investigation of the research and the surveys from the past research for the identification of the gaps related to electronic voting for elderly people. Electronic voting plays a crucial role in the digital inclusion of the people in the country. Therefore, this chapter has been constructed in a way to deliver an understanding of the concepts like usability, accessibility, universal design, e-governance, e-voting, and security.

Security and transparency in e-voting have been growing concerns since the introduction of the system (Neumann, 1990). Because of the above-mentioned political and social reasons, research related to e-voting is focused mainly on the security aspects. A very recent example of such research is where blockchain technology was implemented due to its high security (Ayed, 2017). On the contrary, not much research has been done on the accessibility, usability, and universal design implementations in e-voting systems (Ayed, 2017).

2.1 Background

From the birthplace of democracy in ancient Greece and Rome, to the present-day democratic constitution, the core concept of allowing the eligible general population to nominate government representatives has resonated through times (Raaflaub et al., 2008). But as much as democracy expects the participation of all eligible voters, the question remains whether rightful and responsible citizens can participate in the poll against their physical, mental, and situational odds.

There are several examples of the adoption of electronic voting by the countries and making continuous enhancement for improving the system for easy casting and counting of votes. Belgium implemented e-voting in 1994, and Venezuela started electronic voting in 2003 which shifted from e-counting to e-voting (Hao & Ryan, 2016). Switzerland implemented electronic voting in its state-wide elections and Norway in its Council election soon after Estonia adopted electronic voting for the national election (Ayed, 2017). Recently India carried out the largest e-voting in the world with the eligible voter over 900 million (Zalte, Gajare, Gujarathi, &

Pawar, 2018). Though Norway adopted electronic voting in 2011 for the Council elections with the similar technology that was used in Estonia, it discontinued electronic voting in 2014 because of security issues (Ayed, 2017). Since then, people in Norway have been exercising paper-based voting which is worse in terms of accessibility and usability (Everett, Byrne, & Greene, 2006).

2.1.1 Electoral system and Voting

When it comes to the medium for casting the vote, the *ballot* has been the predominant solution from the inaugural ages of election (Jones, 2003). Ballot derived from the Italian word for ball, *Ballota* and early votes were literally cast on small balls. Although voters in ancient Greece used pieces of broken clay or metal token and deposited votes in clay pots for later counting. Paper replaced other physical ballots gradually after paper became more affordable which is still universally used today.

Despite its popularity, the paper ballot system inherently creates usability barriers for people with a varied range of abilities. Since we are aware of the fact that the world population is increasing, and this constitutes the person with disabilities as well. Voters with the limited visual ability for example might not be able to read the ballot paper and cast their vote independently and anonymously. Citizens with limited mobility due to physical barriers might not visit the polling station and cast votes safely. And cognitive impairments affect the ability of thinking, concentrating, and reasoning, and remembering, and paper-based voting can hardly provide all the assistance they will need.

The electoral system is not limited to casting votes only, even when the poll is over, and it comes to counting the votes, the administration team in turn must take the rigorous task of counting each and every paper ballot individually for determine the winner. Counting votes can be so laborious, recently around 270 election staff died in Indonesia because of fatigue by counting the millions of ballot papers by hand. The election was conducted on April 17 where 80% of the total 193 million voters were estimated to have drawn. As per the data 272

election persons had died due to overwork, while 1878 people have fallen ill (BBC, 2019). On the lighter side, due to the rapid digitalization of everything and all the convenience it provides, it also makes sense to move towards the digitalization of the electoral system.

Accessibility in digital voting is crucial as exemplified in Norway in 2003 where testing electronic voting was carried away in three municipalities with touch screen technology but was not accepted by general voters due to accessibility issues (Committee, 2006). Even when research is done about a universally designed interface for smooth running of the election using the multimodal interface which provides multiple input modes while casting votes (Dawkins et al., 2009), still most of the systems are focused on addressing the problems of the people with visual impairments only.

Several e-voting devices have been introduced in the previous years, but they had accessibility and usability barriers for people with cognitive and low vision impairments (Kascak, Liu, & Sanford, 2015). Though universal design guidelines were developed by Kascak et al. (2015) to lower the barriers related to aging where the usability testing showed no difference in the efficiency and the effectiveness of the performance. Despite several studies focusing on the accessibility and usability for people with disabilities other than visual impairments, it is not so much explored. Even though they tried to include all people, still most of the research focused only on those with visual impairments and some who tried to focus on others could not address the problem of the people. In sum and substance, comparatively few studies and approaches have been done regarding the usable voting system design for elderly people.

2.1.2 Elderly

Since the elderly population is a heterogeneous group, there exists diversity within this group. Heterogeneity means the composition of diverse parts (Fletcher, 2007). When we mention the diversity in elderly people, it is characterized by diminished vision, hearing loss, physically weak, and reduced mental capacity

i.e., reduced attention, memory, and learning abilities, etc. (Enßle & Helbrecht, 2020). Because of the declines associated with old age such as perception and cognition, managing everyday life for elderly people becomes harder (Orso et al., 2017). Though there has been much research regarding electronic voting, most of them ignored this group.

Among all the diverse characteristics, I opted for reduced mental capacity to carry out my research task since I wanted to test for intuitiveness. Because of the design complexity, people are unable to complete the task while going through the interface. In our case as well, if people cannot complete the task of voting, then it would not count, and their vote would not be included in the result. And this would be against their right to practice their democratic rights to present their opinions to choose the candidate of their preference only because the voting system is not being usable enough for those elderly groups.

With increasing age, people grow more and more different from each other, so the older adult population has a greater standard deviation (Vaportzis, Giatsi Clausen, & Gow, 2017). For this reason, older adults are a great population to study because there are a lot of variations in the population. For instance, if you give a test to a room full of 30-year-olds and a room full of 80-year-olds, then an 80-year-old group would have a much wider range of responses whether you give them the memory test or the personality test.

Important factors that contribute/add to the heterogeneity are time and experience. Vaportzis et al. (2017) carried out a study with older adults who participated in discussions about perception of technology and barriers to interacting with tablet computers. Though the participants were positive about willingness to learn new technology and learn to use tablets, it posed some barriers such as lack of instructions and guidance, lack of knowledge and guidance, too complex technology etc. Hence it was evident from the study that older adults were willing to adopt the new technology if the barriers could be removed. An Experiment was conducted among the elderly people regarding the influence of design elements in mobile applications on user experience

comprising of the user interface usability and accessibility attributes such as effectiveness, efficiency, learnability, accessibility, safety, usefulness, ease of use, attractiveness, user interface usability (Kalimullah & Sushmitha, 2017). The research focused on understanding the opinion of elderly people about the use of growing technology. It was observed that the elderly people were reluctant towards adopting new technology because of different complexities but could be changed if a usable and accessible user interface is provided.

2.2 Related Research

2.2.1 Usability

Based on the case studies on accessibility, privacy, and voting by (Lazar, Feng, & Hochheiser, 2017), the usability of voting machines was not much concern until the ballot designs created a problem during voting in the 2000 U.S presidential elections. These difficulties led to concerns regarding the usability of voting machines and sought the need of evaluating the usability of traditional voting machines and newer touch-screen devices of voting systems. In spite of being very little research on usability that address the usability of voting systems for disabled people, direct-record electronic touch screen voting devices were considered as one of the most appropriate ones for these users. But the result came out to be mixed when compared to people with similar, undiagnosed, users with reading disabilities. The case study done with different users with different voting systems concluded that some users performed better on some voting interfaces and worse on others. Even though HCI studies concluded that machines being usable, still other investigations have identified usability concerns with available assistive technologies.

Fuglerud and Røssvoll (2012) carried out a web voting evaluation based on the usability and accessibility of e-voting prototypes for the electronic voting trials in Norway. The ELMER 2.0 (*only used in Norway*) and WCAG 2.0 guidelines were used to evaluate the usability and the accessibility respectively which aimed to address the cross-platform independence of the e-voting client, allow the flow of

information in order along with the easy access of the assistive technology, allowing the possibility to change the size of the text, contrast, and the language. And for the purpose of testing, three different approaches were used which are automated/semi-automated testing according to the guidelines, expert reviews, and testing with users. The prototypes were tested by creating an election scenario where the five prototypes were tested in the first iteration and three prototypes were tested in the second iteration and these prototypes were evaluated using technical, expert, and user testing where technical testing was carried out using the technical tools, expert testing was carried out using the personas whereas user testing was carried out using the users with impairments. And based on the testing scenarios, evaluation metric, technical evaluation, user testing, and participants, different accessibility and usability issues were found which might be because of the developers lacking grip of the technology for the purpose of making the technology more usable and accessible where the prototypes failed to fulfill all the WCAG guidelines. Despite the shortcomings of these difficulties, participants showed positive attitudes towards web-based elections.

The paper (Hsu & Bronson, 2018) tried to investigate electronic voting technologies from the perspective of usability. The paper tried to explore the brief history and evolution of voting technologies along with the major categories of electronic voting technologies and associated advantages and disadvantages of e-voting. The security issues of e-voting are discussed that seemed to concern the confidentiality of the individual voters, the tally of the finalized votes, the vulnerability of the internet infrastructure, the problem of proprietary software, etc. From the perspective of usability, some features were considered which include type and size of the display, variable display elements, activation method, interaction devices, audio, braille, languages, review screen, etc. The authors accessed usability based on three key measures such as correctness/effectiveness, efficiency, and satisfaction/confidence in the voting process. Hence the purpose was to explore e-voting technologies in terms of the perspective of usability, various aspects and concluded that further investigation

into usability features is needed. Despite the challenges, e-voting seemed to hold promise if all the security and usability issues are addressed.

Marky, Zollinger, Funk, Ryan, and Mühlhäuser (2019) enlighten the fact that voters play an important role in the easy execution of the electronic voting process where the usability of the system is crucial for completing the voting task by themselves (voter). Therefore, for this purpose, early investigation of human factors is a must for the implementation of usable electronic voting systems. This paper gave an overview of the user design challenges during the investigation of the electronic voting system. Hence the appropriate guidelines that support these challenges were provided with the design challenges in mind. The paper stated that usability of e-voting is equally important as security issues since both are co-related for easy execution of the voting process.

Marky et al. (2020) Conducted a study with 36 participants for the purpose of making the usability and the user experience of the interface better. The Swiss voting system focuses on providing individual verifiability which means the voters are meant to verify themselves with the help of different codes. This self-verification process makes the usability and the user experience of the system very crucial. The authors performed the evaluation of the interface with the help of 12 HCI experts to investigate the usability weakness of the Swiss Internet Voting System so that they could improve the usability. Furthermore, based on the experts' findings and the exploratory study with 36 participants, redesign of the system was proposed, and the study was carried out by another 49 participants. Finally, the redesign improved the performance and trust of the voters.

2.2.2 E-governance

Mofleh and Wanous (2008) presented the study about the need for government initiatives to provide services based on citizens' needs rather than launching services based on their own understanding of what citizens might need for the smooth operation of e-governance. Though the government in the developing countries are moving forward towards e-governance with the aim of

providing/improving the accessibility of the services and easy flow of information between the government and citizens, the government might have lacked to understand that it is the citizens' willingness and requirement that needs to be addressed rather than launching governments own services without properly knowing what they actually need. Therefore, the government must understand the variables that influence the citizens' inclination to adopt e-governance. An online survey with 660 Jordanian participants was carried to identify what government should consider before providing online services to their citizens. The result indicated that people still were not ready to trust services through the internet which is due to a lack of awareness and lack of access to the internet previously. Hence in case of implementing electronic voting, it requires knowing the needs of citizens rather than providing the services directly.

E-voting

With the aim of making the public sector more effective, customer-friendly, Estonia started an e-voting system in 2005 with three basic principles: an Id card for voter identification, the possibility of electronic re-vote, and the priority of traditional voting (Maaten, 2004). The Id card equipped with a chip containing electronic data, private keys protected with pin codes functions as an electronic identity which helps to use the online service easily and securely. The aim of allowing voters to cast their vote again was with the belief that if at the first time the voter cast their vote under the influence of threat or greed, the voter would still have a chance to vote again once the previous influence was gone which is expected to be fair. And in the third case if the voter goes to the polling station to cast the vote, then his /her previous e-vote will be deleted, which is giving the priority for the traditional vote as the process of electronic vote deletion is much easier. Because of the vote-buying incidents in previous elections, electronic voting with re-voting was considered. The primary motive behind the adoption of e-voting is to provide an extra opportunity to the voter because of increasing the voter turnout. Hence it was concluded that remote voting provides extra value and

ease to the voter and soon after the idea of e-voting became public, people of Estonia were positive about it and wanted it to be an integral part of the system.

Schaupp and Carter (2005) conducted a study with the aim of determining the characteristics that impact the acceptance of e-voting services by the citizens between the ages 18-24. The study is based on the model which is made of three things which are technology acceptance, diffusion of innovation, and web trusts model. The survey is done to 208 young voters. Though the research was conducted on one age group only, the results indicated that the factors compatibility, usefulness, accessibility, and trust had a positive impact on the intention to use the e-voting system. By emphasizing the benefits of electronic voting systems by the government, the convenience and easy accessibility of this technology can easily motivate the uninterested group to increase the voter turnout.

Alvarez, Katz, Llamosa, and Martinez (2009) carried out a large-scale pilot project in Columbia with the sole purpose of inspecting the attitudes towards e-voting among the participants with the use of different automated voting technologies. Four different voting devices provided by private vendors were used for the pilot test where all the prototypes were equipped with keyboards and headphones so that the visually impaired persons could interact with the voting device without any extra help. The first three prototypes were touch-screen DRE (direct-recording electronic) machines whereas the fourth prototype was an optical scan device. The respondents found that correcting the vote was much easier in prototypes 1,2 and 3 except in prototype 4 (where prototype 4 resembles closely the paper ballot system). If the voter cast the invalid vote, they had the option of correcting it or casting a vote again, but it required the supervising staff to provide a new ballot and start the process over again. From the data obtained from the pilot test, it received an undivided result that e-voting is much easier than the traditional one.

Mirau, Ovejero, and Pomares (2012) researched 850,000 voters in Argentina and presented the idea behind the implementation of information and communication

technologies into the electoral process. First, a pilot testing was done with the 410 voters which provided positive perceptions and guidelines for implementing e-voting in further elections. The few reasons behind the implementation of e-voting are increasing voter confidence in the voting system, increasing the speed of voting count, and providing flexibility in user voting practices. Moreover, according to the survey carried out among the 1502 voters during the election in 2011, most of the participants preferred e-voting over the traditional voting methods, and also the study suggested the modern practice being safe and reliable along with their challenges that might appear on the web as well.

Osho, Yisa, and Jebutu (2015) conducted research in Nigeria about the elections which used to be conducted using the traditional method prior to 2015. With no surprise, the elections used to be troubled by frauds, irregularities, and other forms of malpractices along with some loss of lives and properties sometimes. But according to the basic norms the elections are supposed to be transparent, fair, and free, which was missing. There was so much violence during the election that the situation used to be critical during the elections every time. Because of this, it was concluded that the traditional method of voting is corrupt, and another voting system was sought. The significant progress in the acquisition of the technology helped the adoption of e-voting for which the whole nation was yearning. The e-voting mechanism deployed in 2015 depicted the voters' positive attitude towards it and Nigeria's support for implementing e-voting in the country.

Johnson, Jones, and Clendenon (2017) present an overview of the voting systems utilized in the United States where these voting systems consist of various hardware, display devices, and methods for collecting and storing voting data. An optically scanned paper ballot system is a paper-based voting system where voter marks by filling in space in the paper ballot which is usually a box, oval, or circle are later optically scanned and tallied to calculate the total number of votes. Direct Record Electronic System includes touchscreens, dials, and buttons which capture votes directly into the electronic memory module. Some DREs contain printers that allow the printout of the paper record of the votes. But

not all the DREs are audible and do not have the capability to identify whether any of the votes missed, recounted due to inaccuracy. Ballot marking system disabled voters can have easy access to the system with the availability of the touchscreen and audio along with other elements such as gesture interaction, eye tracking, or other accessibility features. But the votes are captured on a paper ballot which is later tabulated and recorded manually. And the other one is Punch card and Mechanical Lever systems wherein voters were given a paper card and a small device that allows them to punch a hole where the user wants to vote. The paper is deposited in a box after the entire card is completed. In mechanical lever systems voters enter the booth and slide a mechanical lever making their choice to one side and a vote is cast when the lever is pulled back. But both the punch card and mechanical lever system are not in use anymore. Hence in terms of HCI consideration, the design of the interface should be simple enough to be easily understandable by the user which would surely increase public acceptance. Electronic voting is the future, and the simple intuitive user interface design would increase voter turnout without any doubt.

Brazil, being a pioneer in electronic voting adopted e-voting two decades ago and has been continuing till date constantly improving its flaws and loopholes (Aranha & van de Graaf, 2018). Despite having many remote outposts that can only be reached by plane, boat, Brazil started the transition in 1996 and uses Direct recording electronic voting machines (DREs). DRE is just like a computer with special peripherals and software dedicated to the voting task. Since a counter is implemented for counting votes, the corresponding counter is incremented whenever a voter casts a vote for a candidate. The voting process starts with voter identification through Id and fingerprint verification. Each candidate is assigned a different number to represent them so voters can enter the digits corresponding to the preferred candidate. Urna: DRE used in Brazil contains a photo of a candidate with the corresponding number, name of the candidate, and the party name. Along with the display, there is a physical key that is used to enter the digits corresponding to the preferred candidate. Though the DRE system brought election stability in Brazil, there are some serious security issues

in the system because of voter authentication and voting taking place in the same machine.

Zalte et al. (2018) proposed a new system in 2018 which is called a centralized electronic voting machine with an aim of dealing with the shortcomings of existing voting systems. In the past voting process using biometric authentication, the internet of things, Aadhar card technology for the authentication process, secure mobile-based e-voting system was implemented for making the process easier and more accessible but none of them addressed the issue completely. This system consists of a database of the user authentication with a fingerprint scanner where authentication of the user is done by matching the data with the previously made centralized data server. The user can cast the vote on matching the fingerprint and since the data is centralized, data from different locations are saved in the same region. The voter can cast the vote by clicking on the options available. The best part of the proposed system is it is designed in such a way that the voter can vote from any workplace (polling stations). It could be used to voter turnout where voters cannot vote stating the reason being away from home.

In the above cases, people's trust over the system was the first motivation to implement the system and the participants found electronic voting more beneficial than the traditional voting system due to various reasons as mentioned earlier. And the thesis is about electronic voting and reasons that would motivate participants and the government to adopt e-voting which makes it reasonable to mention it in brief.

Universal design is a must if we want to deliver an accessible system and without universal design to attain an accessible system is not possible.

Universal Design

In their paper (Fairweather & Rogerson, 2005), the authors focused on presenting the concerns about making inclusion for all the users into the democracy through electronic voting with the help of interfaces that support independent access to all the users remotely. And for the purpose of designing an interface that works for

all users, many design principles are meant to be followed. The ones that were mentioned in the paper is the design should eliminate the need for scrolling through nowadays, but people are used to scrolling down so it should be considered. The design should be built in such a way that computer illiterate should be able to use it and it should be usable with ease of use. The different font sizes and color choices should be made available on-screen so that the person with visual impairment can easily access the system without the need for extra assistance. It should have multilingual language for different ranges of languages. According to the paper color should act as a code so whenever the different option is selected, it should be indicated by the change in color which makes the user conscious of the change and the contents which are non-confidential can be represented by the audio as well. Moreover, to assist the person with disabilities the touch screen along with the other input devices should be made available. Therefore, the interface should be as simple as possible and should be able to work with different input and output devices. Hence the introduction of electronic voting requires consideration of diverse users with different interface needs.

Dawkins et al. (2009) put forward the need for a properly designed interface for smooth running of an election. The voting technology has not been able to address the issues related to person with disabilities. This paper is about the use of a multimodal electronic voting machine system that enables the voters to vote without any assistance. The prime iii voting system, virtual reality version of the prime iii system and speech only system are three systems discussed here. The prime iii voting system operates through touch and voice command with the help of its touch screen monitor and headset with microphone to facilitate communication where voters verify and confirm their ballot from the screen where only one race is displayed per screen to remove confusion. Also, it shows the final summary of the ballot which helps to verify or edit the ballot. The interface is similar to the virtual reality version with the addition of a VR headset and a point-and-click device. And for the voice-operated voting mechanism, voters can vote using telephone after the demonstrator enters the access code on the phone's

keypad which allows the voter to use and test the VUI. It concludes that with the help of a universally designed multimodal system, voters without and with different disabilities will be able to vote. But still voting over the telephone seems incompatible for the voter with disabilities.

Though the multimodal interfaces are developed, they require extra effort for disabled people to operate which contradicts the principle of accessibility. In this paper (Lee, 2014) designed a two-interface ballot using the universal design principles instead of improving the accessibility in the developed product. Here, the EZ ballot prototype is developed using the Universal design principles from the very beginning of the design so that it could address the problems for all voters. And the system was tested with 12 eligible voters where 6 were blind and the other 6 had low vision. All the participants were given tasks where candidates were asked to vote for one candidate, two candidates, change the votes. And based on their interaction with the system and the usability of the prototype, the resulting feedbacks were simple and intuitive process redundant confirmation messages, alternative navigation processes were recorded as positive feedback whereas too many confirmation messages, too much information in instructions, lack of control of visual and audio characteristics were negative feedbacks. Hence though the visually impaired person could vote using the prototype still lacked to fulfill the universal design principles completely which could address all the voters.

With the issues in usability in the mobile voting user interface for the old peoples, (Kascak et al., 2015) developed universal design guidelines to scale down the barriers associated with aging. The concept behind design for aging is to explore the factors that are limiting the interaction between the user and the system because of age-related disabilities and the limitations such as memory, cognitive, hearing, visual, dexterity and physical impairments. Though the main principle behind the design of interfaces for older users should be easy to use, meaningful, engaging and most importantly motivate to adopt the technology however current technologies do not meet these needs. To fulfill this gap, UD guidelines based on

the seven principles of universal design are described. Also, a case study with EZ ballot voting interface is carried out where different settings for audio speed, text size, contrast including the natural gestures (i.e. swipe and scroll), single tap was designed to make it compatible with older users. And usability testing was conducted with 9 young adults and 15 older adults at the Georgia Tech Research Tech where users were asked to perform a voting process like the one, they would do in a voting poll. It was concluded that there were no significant differences in terms of efficiency and effectiveness of the performance, which showed equal usability of the interface for both user groups since the completion rates of the voting task were 100%. But still, some users felt more simplicity in design could be better which could prevent the slow pace and assist in faster information processing by faster user interaction.

The paper-based voting has not been able to provide accessibility to users with and without disabilities. Also, since the inception of the election, the electoral process has not been able to include all the people especially those with disabilities (Gilbert et al., 2010). Without being accessible it is almost impossible to include those disadvantaged groups. Because of the lack of accessibility, one with disabilities cannot be a part of the system.

Accessibility

The research conducted by (Gilbert et al., 2010) investigated the e-voting accessibility for visually impaired people. They tried to focus on the fact that still, most of the population is being outcast from the right to vote because of the accessibility issue. The primary objective of the study is to provide equal access along with privacy and security using electronic voting. Though the invention of technology has tried to include people with disabilities still, these technologies are not being able to address all people. The research was carried out with the help of 35 visually impaired people where the participants used a multimodal voting system at the Alabama Institute of deaf and blind. And the result came out to be impressive as the finding suggested that the system is easy to use along with being trustworthy as well.

Knowing the voters with disabilities having issues in voting in polling stations, (Smarr, Sherman, Posadas, & Gilbert, 2017) presented a voting technology Prime iii which can address all the issues previously prevalent which allows all the voters to vote using one machine. The primary purpose behind the design of prime iii is to build an equal voting experience for the voters irrespective of the physical disabilities which are composed of a large touch screen, wireless QR scanner, wireless headphones, two buttons, and a thermal printer. Prime iii includes the required color schemes for the person with color-blindness as well the options for the visually impaired persons. Since all the blind people are not familiar with the braille input, the device with the more accessible input was created which allows the people with visual impairment to vote without the aid of another person. Prime iii allows voters to vote using touch, voice, or both. The voting process can be guided with the help of integrated text to speech and allow the voter to navigate using the two buttons if they cannot use the touch. The interface is designed such that it is easy to understand where voters can confirm the choice using visual or audio. In case of security issues later confirming the votes, it allows printing of a ballot in the required format. The system was tested with visually impaired people, the result of which came positive allowing them to vote independently and with secrecy.

Their paper (Summers & Langford, 2015) described the best practices for designing the ballot interfaces for the voters with low literacy rates. Low literacy here is implied as weak in skills such as understanding the structure of the sentence, ability to locate the piece of information in a text, connecting one piece of information to another. Generally, People with learning disabilities, moderate cognitive impairment, aging related decreased learning and reading ability, limited language proficiency and others are related to low literacy. Hence to cope with low literacy rate, guidelines to make the electronic ballot design are mentioned in terms of language, text content and structure, graphics, vocabulary and tone, navigation, visual designs, page layout, buttons, text format and font, help sections, two-way interaction, usability. The guidelines are based on the known behavior of the low-literacy rate users with user interfaces in the context of

electronic ballots with the aim of improving the accessibility and usability of the system.

van Eijk, Molenbroek, Henze, and Niermeijer (2018) investigated the accessibility of electronic voting to Dutch voters. This accessibility is accessed in terms of visually impaired, low literacy and elderly people. For the purpose of testing a series of different user interfaces is developed which consists of a card reader, a touchscreen, and a printer where audio support was provided via headset. The participants were given a task to make a choice on the screen and match with the printed result. Though vote-printer helped in the independent voting by the visually impaired people but still was not that efficient for low-literacy groups. But it was accessible enough for the elderly people. It was revealed that all three user groups reported electronic voting to be more accessible compared to paper-voting and co-creating in the initial phase of the development is a must.

Besides accessibility, the main hindrance to the implementation of electronic voting is security. The fear of unethical hacking with the motive of accessing the personal data of the voters, altering the voting result is one of the reasons which is a strong factor for adopting electronic voting.

Security

Neumann (1990) stated in his journal the existence of the recurring risks in computer-based elections because of the errors and frauds, the reason being continuous use of primitive computing technologies. The author seemed quite dissatisfied with the global use of punch cards, despite the presence of vulnerability of being easily tampered with. Some examples of erroneous results include the reports of uncounted votes in Toronto whereas doubly counted votes in Virginia and North Carolina which created doubt about the reliability of the system. The US Congress had the power to set the standards for federal elections, but because of their lack of action, the existing system seemed inadequate for a computerized vote-counting system. Also because of the lack of experts, sometimes vendors run the election hiding behind the mask of secrecy.

Maintaining the computerized election integrity is tough with the serious risk being the challenge. But the computerized election can be made promising by determining the methods/ways to system secure with the inclusion of meaningful constraints.

Mercuri (1992) published a paper about the need for secure systems for voting. This paper discussed the potential risk from the purchase of Direct Recording Electronic Voting machines because of its reliability issues which failed the environmental as well as functional requirements. The Pennsylvania Board of Election rejected the machine as it failed to satisfy the general requirements and also the fact that it can be placed in the mode where users are unable to vote for certain candidates. The author clearly mentioned the shortcomings of the voting machine in terms of security and also tried to draw attention to the lack of laws regarding convicted felons or foreign nationals from manufacturing the voting machine. Hence it was concluded that if computer industry vendors were responsible enough to provide reliable, tamper-proof, secure systems then it would not be much concern.

Ayed (2017) proposed a new design for an electronic voting system using the advantage of free blockchain technology and because of its high security the author is positive in the increase in voter turnout on its implementation. Since the blockchain is simply the chain of blocks for the decentralization of the data. Here each block will contain the information about the previous user and the data is spread over the blocks connected like chains which strengthen the security of the system. Users will be able to cast the vote with the help of a user-friendly interface where users should choose the candidate to cast the vote. One of the limitations of the system is that it is expected that the user will use a secure device even though the system security is trusted with the implementation of the blockchain.

The increasing digital technology has helped the people in the present with its ability to provide assistance in every step with its implementation in the electoral system (Hanifatunnisa & Rahardjo, 2017). Because of the centralized database

system in the conventional voting system, there exists a threat of transparency and security. To overcome this issue, (Hanifatunnisa & Rahardjo, 2017) proposed a blockchain based electronic voting system that mitigates the risk of getting hacked easily with the intention to alter the data because of its decentralization system where the entire database is maintained/owned by many users. After Estonia conducted the electronic voting system in 2005 and 2007, since then several other countries Switzerland, Norway, Netherland implemented the electronic voting system but gradually canceled because of its security issues. The proposed system works similarly to the blockchain technology contained in bitcoin and used for the purpose of recording databases. The main aim of this system is to make the database public i.e., the database owned by many users so whenever there is a difference it will be easy to compare. Before the start of the election, the process starts with the creation of a private key and the public key by each node where the public key is sent to each node and as the election starts it will collect the election result from each voter. Each node will wait for its respective turn to create a block and after the confirmation of the validity, it will be added to the database. Unlike in linked lists, it does not have a previous node pointer instead of the hash of the previous node. Hash is nothing but simply a function that takes input and converts it into encrypted output with the help of the algorithm. Because of the hash value being linked to other nodes, it is more secure. Based on the results obtained it was concluded that the system is successful in implementing electronic voting using blockchain technology.

3. Research Methods

3.1 Data Collection Methods

The primary purpose behind the qualitative analysis is to extract the unstructured data into the detailed description or useful information where the description can be in the form of texts, graphical representation, summary tables (Lazar et al., 2017). The qualitative approach deals with the feelings, attitudes, opinions, and thoughts of human beings. For the purpose of collecting data under the qualitative approach, I chose three different methods: questionnaire, usability testing (think aloud protocol) and interviews. Since questionnaire is used for demographic data collection which is easier means without need of person being physically present, usability testing best suited for identifying the needs of use via ‘think aloud’ protocol and interview method to extract the information regarding their experience about the prototype.

Questionnaire: A questionnaire is a research tool with a series of questions assembled in order to gather the responses from the participants (Gault, 1907). Obviously, there are several advantages of questionnaires over other types of surveys. It is easier to collect data and comparatively cheaper since the questioner does not have to go through the verbal or telephone to get the responses and the questioner does not compulsorily need participants to be available in person (Gault, 1907). Since every coin has two sides, advantages are followed by disadvantages as well. Sometimes the participants might encounter problems answering all the questions when they find the questions confusing and those cases might be frustrating for them.

Generally, the questions in the questionnaire can be of two types open-ended and closed-ended. The participants can design or answer in their own ways in case of open-ended unlike closed-ended which asks the participants to choose the answers from the given set of options without providing options to formulate their own answers (Mellenbergh, 2008). Since this research is about elderly people, using open-ended questionnaires would not be a good idea since they

get exhausted easily. So, going through the easier and faster one would be a wise decision as acquiring their opinion is the primary motive. Hence a closed-ended questionnaire with the given options would be the appropriate and easier technique to collect the information and implement it in this research.

Usability Testing: Usability testing termed ‘user research’ is concerned with investigating the interface and making the interface better (Kuniavsky, 2003). Generally, usability testing normally involves the particular user using the specific task of the prototypes of the working version of the interface at the different stages of the development which in detail includes (Lewis, 2006):

1. Testing paper prototypes (i.e., prototypes built on paper)

2. Testing screen mock-ups or wireframes which have no functionality.

3. Testing screen layouts that have partial functionality.

4. Testing prototype after the final design

The above-mentioned points can be useful for one project or multiple projects. It is not always sure that all the points will be useful for a project. In my case, I made the paper prototype in the first phase of the development to figure out the best design. After making changes in the initial design, the working prototype with functionality just enough to carry out the test was made. With this prototype, usability testing was conducted among the participants which helped in data collection through think-aloud protocol. I tried to research the usability of the interface based on the usability Heuristics of User Interface Design (Nielsen, 2020).

1.Visibility of system status: When the user is going through the system, they should be informed about every change or event with the help of visual feedback such as a change in color, pop-up messages etc. without overloading the information. In the prototype, the user is notified of the change in the color, checked symbol after the candidate is selected.

2. User control and feedback: The prototype is provided with the back and forward buttons to satisfy the user controls.

3. Consistency, industry convention and standards: The placement of each such components such as buttons, navigation are designed in such a way that it maintains the consistency and industry convention to reduce the cognitive load.

4. Error prevention: The warning message will appear while going through the interface and it might be helpful in preventing the errors.

4. Recognition rather than recall: The components are designed in such a way the user does not have to recall anything from the memory thus eliminating the mental load and instruction is placed in the visible position.

5. Aesthetic and minimalist design: The design is kept simple and avoids unnecessary elements to support the goal of the design.

6. Help users recognize, diagnose, and recover from errors: The error messages are shown in plain language without using any codes to notify them of the problem which suggests a possible solution.

7.Help and documentation: A help section is placed at the top of the interface which will provide necessary instructions to the user if needed.

Though I used the usability Heuristics for research purposes, all the explanation done under each point above is about my prototype.

The goal behind usability testing revolves around improving the quality of the interface by identifying the general flaws associated with the contents rather than color or styles (Lazar et al., 2017). Generally, usability testing is done with the screen layouts (i.e. computers, laptops, tablets, mobile devices, and other different devices) where the user interaction between the user and this device takes place directly so that they can have easy and desirable interaction without any difficulties. The usability testing might include hundreds of users, having a number of control operations and the researcher sitting next to the participants

and investigating the difficulties that the participants are going through while the user is going through the interface (Lazar et al., 2017).

Usability testing is primarily focused on users, which is normally carried out with the help of a group of representative users trying some set of tasks (Lazar et al., 2017). Though user-based testing could be carried out throughout the development stage still, it is not possible every time. It is often thought that the designers involved in the development of the interfaces try to fulfill the needs of the user, but designers are not sure what users want since users are not always clear what they need. Though it is said that the usability testing takes place in the early stage of the development including wireframes or prototypes, it might also take place when the high-level design choices have already been made or sometimes it takes place right before an interface is released (Lazar et al., 2017).

Interview: Interview can be termed as the normal communication between two people (i.e. interviewer and the interviewee) with the purpose of pulling out some information from the interviewee required for the research of any other work (Longhurst, 2003). Qualitative interviews have been categorized mainly into three parts as unstructured, semi-structured and structured (DiCicco-Bloom & Crabtree, 2006). In unstructured or open-structured interviews, the interviewer has some limited open-ended questions with enough room for multiple follow-up questions which allows the interviewer to carry out the research in-depth about the intended subject. In contrast, a structured interview consists of a set of predefined close-ended questions with no room for follow-up questions. While semi-structured interviews are the ones with some open-ended questions which allows some follow-up questions. I chose a semi-structured interview with some open-ended questions in this research so that I could have follow-up questions whenever I felt the need.

3.2 Selected Approach and Methods used in this research

In this thesis, a qualitative research approach has been used for the study of the research topic. The decision to opt for this approach was taken on the basis of

some characteristics such as focuses, goals of the research, design characteristics, and data collection. The quantitative method deals with numerical data which is completely different from the qualitative method which deals with texts, observations etc. (Lazar et al., 2017). I wanted to focus on the user experience and try to understand the nature of the human experience for which qualitative approach would be best whereas in contrast, the quantitative approach would focus on the quantitative measure such as how many, how frequently etc. But the quantitative approach would aim towards predicting, controlling, and testing the hypothesis which would be against my research goal.

Since the research design used in the qualitative approach is more flexible and evolving, which suits my goals rather than the quantitative research approach which is more structured and predefined design. Though the reason for the qualitative and quantitative approach is explained in brief, I tried to look for how it (qualitative approach) would serve my purpose. The first reason being relating to the human experience that will not require counting and expressing in numbers while collecting the data.

For the collection of demographic information, I used the help of a questionnaire since it would be easier and time saving. Think aloud protocol was used for collecting the data where participants went through the prototype (usability testing). Usability testing refers to the testing of the product done by the representative user with the purpose of evaluating it (Lewis, 2006).

In ‘Think Aloud protocol’ participants verbalize their thoughts, feelings, perceptions during the task (Lazar et al., 2017). In addition, think aloud protocol is commonly accepted by the usability community as the best way to identify the usability issues with websites. During this process, participants are given a task and they speak aloud about what they are going through on the website. And if they feel stuck or confused as they move through the interface, they simply speak their feelings/thoughts. Moreover, there are answers that I wanted to know about the interface and its contents which I thought might be missed or could not be addressed through usability testing. To uncover those answers, I opted for

interview methods which I thought are best since it is two way and allows me to construct and add the follow up questions and discover more information regarding the interface.

To carry out the research, the following steps were done:

- Three prototype websites were designed to identify the best design based on usability.
- In all prototypes, two common tasks were designed based on one activity i.e. a goal driven task.
- A user testing session (prototype evaluation, questionnaire, and interview) was conducted with the participants.
- Data was collected through usability testing (think aloud protocol) and from their opinions using post-session interviews.
- Finally, a result with future work will be suggested at the end of the study.

3.3 Data Analysis

Content analysis refers to the process of representing text or image data to a highly organized structure (Lazar et al., 2017). Generally, the Content analysis applies to textual data along with the multimedia data such as images, videos which helps in extracting the messages from the data. To maintain the quality of analysis, it is advised to follow the standard procedure since a qualitative approach is vulnerable to bias when compared to quantitative data. Content analysis can be used to characterize the responses in open-ended survey questions, observation, interview transcription. It can also be used in the evaluation of content trends in journals, magazines, public records, newspapers, text papers etc.

The process of content analysis goes through identifying the relevant data, coding and generating themes based on the underlying meaning of data, and using themes to address research questions (Elo & Kyngäs, 2008). There are two approaches of content analysis for addressing the research questions: inductive research and deductive research. Inductive research is the examination without

preconceived notions or categories and deductive research is carried out with predetermined keywords, categories, variables whether they are present in the text or not. The content for the analysis will be examined by focusing on two approaches i.e., either we focus on manifest which looks only in the visible meaning at the surface level in the text (such as coding and keyword searches) or the second one on latent which look at the deeper meaning in the text (i.e., more interesting, and debatable). Coding and classification are one of the important steps that we should go through when we do content analysis. Coding is simply segmenting where data is divided into meaningful analytical units and we start to code them making the segments of data with symbols, descriptive words, or category names and classification means categorization of those descriptive words.

3.4 Selected Approach and Method used in data analysis

Qualitative research has been in practice for years and there are various techniques of analyzing the data in qualitative research. Some techniques among them such as grounded theory, conversational analysis, discourse analysis, thematic analysis and content analysis are used for analyzing the qualitative data (Cairns & Cox, 2008). In this research, a qualitative content analysis method has been used for the data analysis purpose. Since the usability testing is carried out based on usability heuristics, I had the keywords/terms that would best address usability. And this method had one approach called the deductive approach which is carried out based on the predetermined keywords which would best suit the analysis in this case. Also, the data collected revolved around usability and it would have lots of data common to the usability heuristics. Therefore, I chose a content analysis method over other available ones for doing the analysis process.

3.5 Research Design

In usability testing, qualitative data poses equal importance as quantitative data. While carrying out the usability testing, users are encouraged to talk about the system when they go through the system, they’re being tested which is termed as ‘think aloud’ protocol (Lazar et al., 2017). In the case of “think aloud” protocol

users express their feelings about the system they are using, which will be very useful feedback. Most of the time when users are going through the process, it is expected that they state their feelings, their frustrations and their progress out loud, deliver valuable feedback while using the qualitative methods where the user might say things such as ‘where is the menu choice? I would like to have it there’ or ‘I would not use this site again. It is so confusing.’ (Lazar et al., 2017). The user experience with the websites contributes to providing useful feedback irrespective of their age with the help of this approach.

The characteristics below are chosen as the research design for the thesis:

- The qualitative data will be acquired through questionnaires, testing and interview.
- Based on the results suggestion will be given for future works regarding the shortcomings of the prototype in terms of the usability heuristics for User Interface Design
- I will assign two different tasks to participants (three different prototype websites

3.5.1 Within Subject Design Approach

To carry out research is not an easy task and to get the participants is more difficult. Generally, In the “between subject design” the participants are exposed to the one subject/treatment whereas in the case of “within subject design” the participants are exposed to all the subjects/treatments in the study (Keren, 2014). If we look at the psychological literature, it depicts that the studies related to perception, psychophysics, memory and learning virtually implement the “within subject” design, whereas the studies related to social psychology, personality and decision making use the “between-subject” design (Keren, 2014).

In this thesis, there are three prototypes, so a participant is supposed to test all the prototype websites in terms of usability and pick the best among three and speak out what they felt about each prototype (i.e. good points, bad points, frustrations, some additional features they wish for etc.). But if a participant is allowed to perform a test on a single prototype, then they would not be able to

comment on the other two prototypes and hence an equal result cannot be expected. Hence when a participant gets to test all the prototypes and they can easily compare the differences between them and can comment easily. Because of this reason I choose the “within subject design” approach in this thesis. There are different advantages of choosing this approach based on the study area (Lazar et al., 2017).

1. It does not require to have more participants which make the process easier when there are a lesser number of participants.

2. It allows me to monitor each participant in detail since I will be taking notes for the data collection process and for all the participants the data collection will be carried out when they are performing the task.

However, advantages are accompanied by disadvantages as well. When users are exposed to all three prototypes, they might master themselves in the process after each prototype which is called “learning effect” and which in return affect the test result (Lazar et al., 2017). Therefore, randomization was used among the participants to overcome this hurdle. Randomization in any research is where the participants and testing conditions are chosen randomly (Glen., 2016). To be more precise participants were assigned random prototypes and the random task groups while implementing the randomization in case of testing a prototype. In my research 4 participants were randomized into three different prototypes and three different task groups. If the first participant started with prototype 2 and assigned one task group, then another prototype was assigned with a different task group so that no prototype was assigned the same task group. Also, this condition was implemented between the different participants with none or almost very little similarity between the prototype and the task group (see appendix C for the randomization).

3.6 Usability Testing Session

After the research design was planned, I contacted the participants through acquaintances (through SMS) for the first time. After that, an invitation (with

consent) was sent to the participants through email to recruit them for the upcoming session to confirm the location and time. The invitation form consists of brief information about the research, purpose of the research, data privacy of the participants and participant's consent at the end (see appendix D). The purpose of the invitation form was to get the consent of the participants about the coming session and know whether they want to be part of the session or not. The invitation was sent before the testing session was scheduled and the working condition of the technologies (needed during usability testing) was confirmed before the session started. I was fully aware of the rights of the participants and informed all the participants about their rights so that they were also aware of them.

In this session neither audio nor video was recorded, the data was collected by taking notes on paper. The participants were kept anonymous, so that nobody could identify them. The interface as well as the data collected on paper did not contain any confidential information, it did not require any confidentiality agreement with the participants. While the participants went through the interface, they were encouraged to talk about how they feel about the system. Initially, they felt shy, so I kept encouraging them and eventually, they became comfortable. Since "think aloud" is expected to give valuable feedback when users go through the frustrations and the sentiments that come while they are using the system will be advantageous. For the purpose of variations in the task, two different tasks were designed for the usability test using three prototypes. If more than two tasks were designed, then it would be similar to previous tasks which would not be very helpful, and it would take longer time for participants.

4. Prototype Development

The model which is built to test a concept or the basis for the future model is generally termed a prototype (Houde & Hill, 1997). The prototype assists in evaluating a new design as well as in enhancing the modification to the existing workflows (Houde & Hill, 1997). I contacted different elderly Nepalese people residing in different countries through messenger and extracted information about their voting experience i.e., paper, or electronic. Based on the problem statement to provide the solution for research questions, a prototype is developed with the aid of literature and the experience of those potential users. Basically, a prototype is just a design through which a user can easily interact and explore the information. The proposed prototype does not match any country's electoral system. It is just a *prototype* to test how to make an easy voting interface by removing the redundant contents and use only things that are needed so that it can be more usable and less distractive. Since the research is based on the usability of electronic voting, the primary purpose behind the design of this prototype was to provide the participant with the prototype which could be used as the tool/ medium for conducting the research.

While working on the prototype, I took references from the literature related to electronic voting (Fairweather & Rogerson, 2005). Based on the related literature, I came to know that it was not completely user friendly (Aranha & van de Graaf, 2018). After that, I started working on the paper designs and while I was working with the paper designs, I took advice from the universal design experts and Nepalese elderly people residing in different countries. The universal design experts were from my fellow masters' students from the same University, and we scheduled an informal meeting and had a discussion on the subject matter where I made notes helpful for my prototype development. The Nepalese elderly people residing abroad are friends and families I knew for a long time who were in contact with me. I contacted those Nepalese elderly people through messengers and made notes about their prior experiences, struggles regarding the voting system. Based on the literature, advice from the experts and elderly people,

Nielsen’s heuristics, the final layout of the prototypes was designed. Initially, one design was finalized and after considering the feedback from the experts, elderly people, and other literature, the design was given variations and ended up creating three final designs with the intention to figure out the best design.

After various iterations of the paper architecture, three different designs were finalized and based on the paper design, a prototype was developed using different web technologies i.e., JavaScript programming, HTML, CSS, Bootstrap. I could have used any technologies for the development but adapting the ones that I am already familiar with helped in cutting the development time with fewer difficulties. So that the time saved in the development of the prototype could be used in the documentation. The prototype consists of two pages where we can see the screen shots of the prototype. The home page consists of a list of candidates from where users need to select the candidates of their preferences. After selecting the candidates on the first page, users will be sent to the second page which consists of a list of user selected candidates from the first page.

4.1 Prototype Design Procedure

As mentioned earlier the physical as well as mental abilities tend to decrease with the increase in the age of the person. And this increased age-related mostly gives rise to problems such as having trouble remembering, learning new things, concentrating, making decisions that affect their everyday life, decreased physical capacity. So, the basic principle i.e., designing the intuitive interface so that it has to perform as few clicks and less page transitions as possible is considered during the design process. It is also kept in mind that the user should not have to memorize a lot of things throughout the task.

Even though pictures are said to increase readability and reliability, still most of the time pictures have little relevance to the context (Xiong, Zhang, Wang, & Feng, 2017). But this can be the opposite when it comes to the daily lives of the people where people are more willing to believe the information delivered through pictures (Xiong et al., 2017). Hence sham news might spread in society with the

use of specious pictures for the sake of attracting the public which might mislead the public (Xiong et al., 2017).

Ögren, Nyström, and Jarodzka (2017) carried out a test among students to investigate if adding multimedia effects in applied mathematics changed the overall results. Though the result showed no multimedia effect, still the students gave less attention to the text and the problem statement when a graph was present. Moreover, the students who looked at the problem statement more, performed better as revealed by the further analysis. The result was highly influenced by the graphs on how they process the information which might mislead the students into believing the information. Hence above research concluded that brains first process the pictorial representation compared to textual ones though textual representation is more authentic in most cases.

In the current study, the responses from the participants suggest they preferred visual representation compared to textual representation so we can use party logos instead of candidates' photos which will help in mitigating misguidance that might be created by the candidate's photos. Generally, party candidate can change over time and the image can be different, but the party logo is a symbol that will be constant since it represents the whole party.

Technology Used

In this section, the resources used for the development of the prototype are discussed in brief. Lenovo laptop with Windows Operating System with i5 processor having 8GB RAM was used to develop the prototype. This prototype is developed for testing purpose, so the test was carried out by running it locally without being available online.

Following tools were used for the prototype development:

- HTML
- CSS
- Bootstrap

- JavaScript
- jQuery

HTML, CSS, and Bootstrap were used to design the Home page and Vote confirmation page whereas JavaScript and jQuery are used for the selection of candidates and pop-up modals and message box etc. The interface was designed with the help of HTML, CSS, bootstrap, and JavaScript.

4.2 Voting Scenario

The prototype itself is not a whole system but will be only a part of the larger system. The login details are not included here. When a user sees the prototype, he/she will see the home page with the list of candidates. When the user selects the candidates and clicks the vote button, they are redirected to the next page. The second page i.e. Candidate selection page consists of the list of candidates that the user selected on the home page. The choice of candidates' names, image and parties have been randomly chosen among public people and parties not based on any knowledge about the political opinions or affiliations of these people. The user can click the confirm button to complete the voting process or click the cancel button to re-select the candidates again. Once the confirm button is clicked, the votes cannot be changed. But the cancel button allows the user to change the votes by redirecting to the home page. The voting process will be complete after the user selects the confirm button.

4.3 Home Page

The design of the prototype is based on the Usability Heuristics for User Interface (Nielsen, 2020). The page name is placed on the top left corner, the help button is placed on the top right corner, vote button is placed on the bottom right corner for all designs. The placement of these components is based on current design practice which follows heuristics number 4, i.e., Consistency, industry conventions and standards. The design follows the visibility of the system status (Heuristics no.1) to provide visible feedback when the user hovers around the

candidates' list and selects the candidates. The cancel button helps to exit the current status so that candidates can think about their choice again which follows User control and freedom heuristics (Heuristics no.3). The pop-up error message is used in the prototype for error prevention (Heuristics no.5). The prototype is designed in a way that minimizes the user's memory load by making the actions and options visible (Heuristics no. 6). The words, phrases used in the design speak users' language which follows a match between system and real-world heuristics (Heuristics no.2). The design is simple without any extra information which follows the aesthetic and minimalist design (Heuristics no. 8). The error messages are expressed in simple, plain language which follows the Help Users, recognize, diagnose, and recover from errors heuristics (Heuristics no.9).

The home page for all the prototypes consists of a list of candidates, a help button, and a vote button. The help button on the top right corner provides instructions needed for the voting. The vote button at the bottom right page redirects users to the next page after required selections are done. The placement of the respective buttons is to follow the current design practice which is widely accepted nowadays (Juviler, 2020). The choice of color and fonts are made such that it is assumed to be clearly recognizable for the user and open for modification if needed (Kiat & Chen, 2015).

4.3.1 Prototype 1

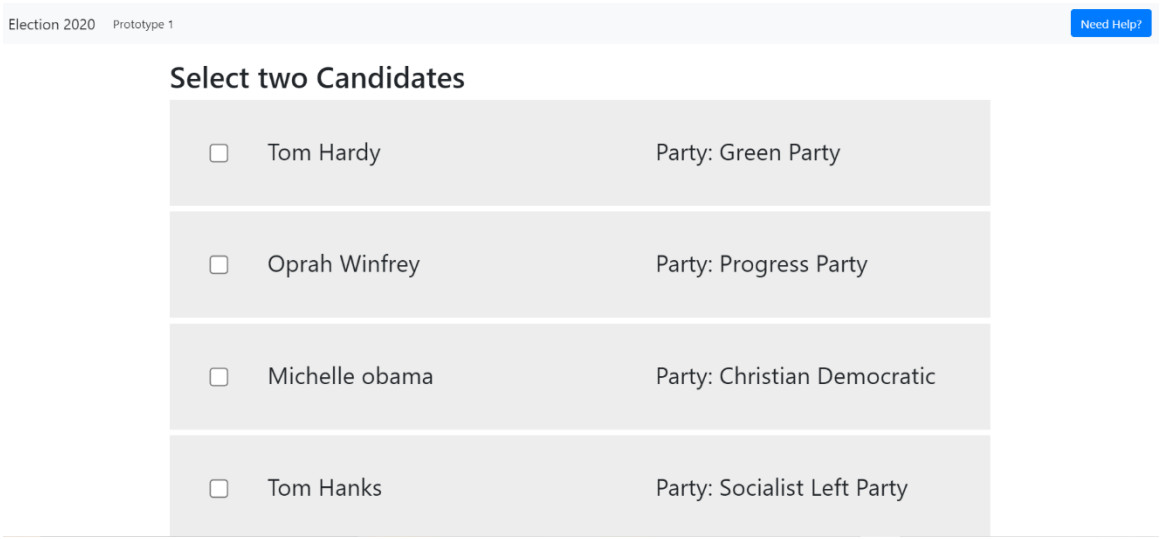

Figure 1: home page for the prototype 1-a

Figure 2: home page for the prototype 1-b

This is the homepage for prototype1 which consists of the name of candidates and party. The light background color is used for each candidate which separates neighboring candidates so that there is no visual confusion while selecting the

candidates. The intention is to keep the design clean with the use of as much less information as possible with minimalism in consideration. The minimalistic design comes forward for the sake of functionality which excludes extra text, unnecessary animation and extra effect in the design (Bennett, 2011). The key features of minimalism are to include only essential parts in the design. Therefore, including the names of candidates and parties only, the intention of the design was to investigate if it was enough to identify the candidate without using extra images and visual effects.

4.3.2 Prototype 2

home page with list of candidates and vote button for P3

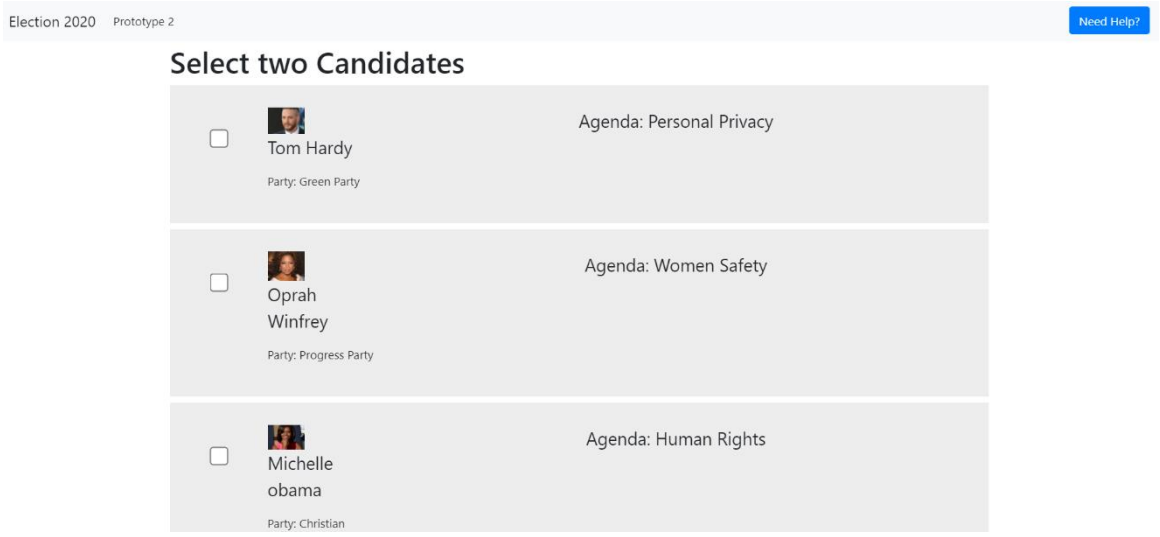

Figure 3: home page for the prototype 2-a

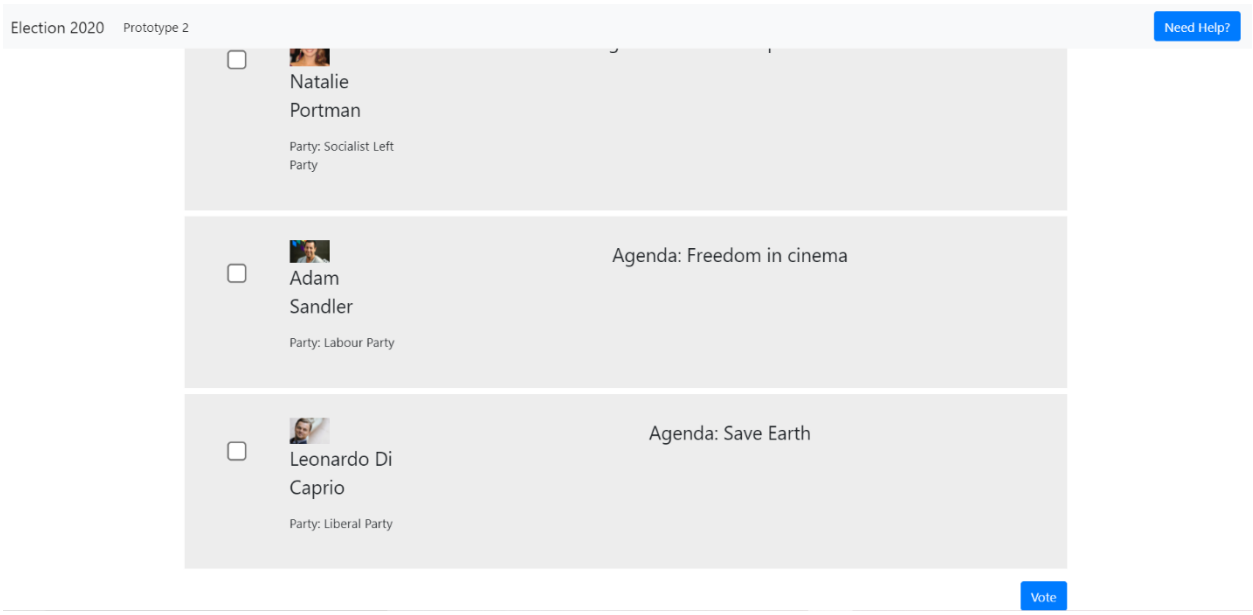

Figure 4: home page for the prototype 2-b

This is the home page for prototype 2 which consists of a list of names and images for each candidate along with some more information. The inclusion of photos (Images, 2020) along with the name in the interface ensures the selection of the desired candidate which helps in reducing ambiguity (Aranha & van de Graaf, 2018). The background color is used for each candidate block which will separate easily from other candidates. The typical user attention flow follows a left to right pattern therefore the important components are placed on the left side of the interface followed by the extra details on the right side of the interface (Syzonenko, 2019). The right section and left section are created for providing more information so that it helps to mitigate the confusion while selecting the candidate. Therefore, the intention was to investigate if including extra information is helpful in identifying the candidates and contributes towards the usability of the interface.

4.3.3 Prototype 3

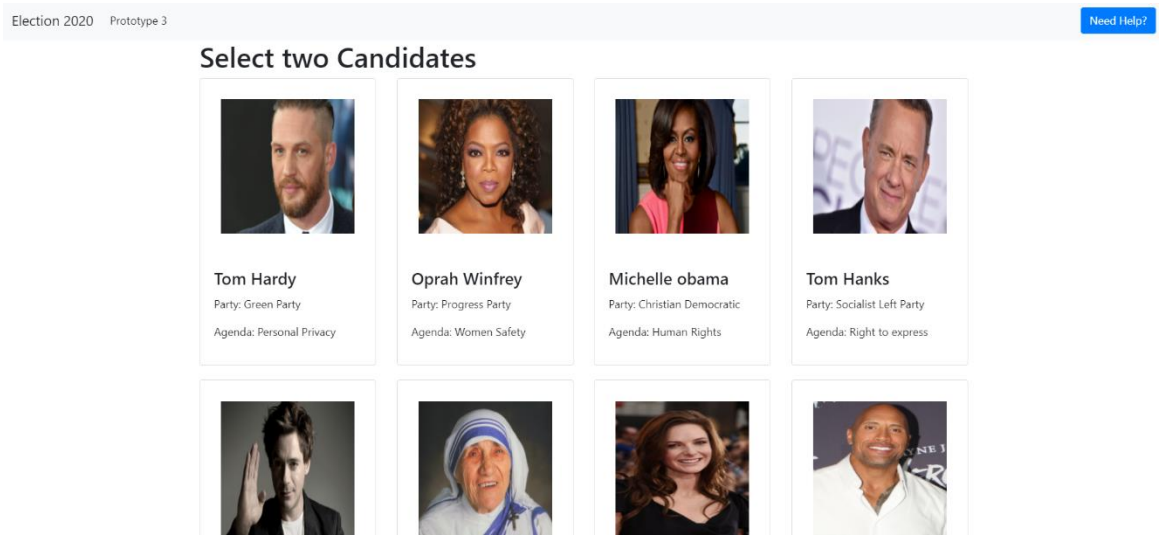

Figure 5: home page for the prototype 3-a

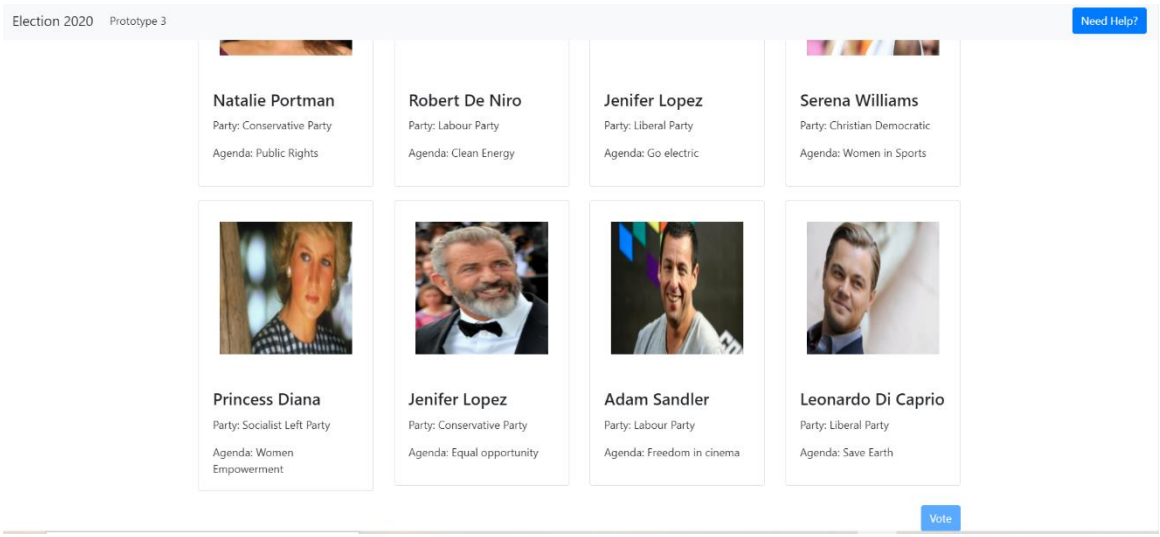

Figure 6: home page for the prototype 3-b

This is the home page for prototype 3 where images big enough in size are used so that it is assumed to help in easy identification of the candidates. The pictures are not properly resized here since resizing the images correctly was not a priority for the prototype as it does not influence what we wanted to investigate. The person can be identified with the help of an image since the process of

recognizing the image and retrieving the image from the memory is different and recognizing an image is much easier compared to retrieving the image from memory (BBC, 2020). Here, the bootstrap image card is used to make the design whereas JavaScript is used for the pop-up help message, and error control messages. In this case, the vote button will be disabled until the user selects two candidates. The button can only be clicked after they select two candidates. This feature is included with the intention of overcoming the error that voters might create while selecting the candidates.

4.4 Candidate Selection Page

In all three prototypes, after the user has selected the candidates and clicked on the vote button, they will be redirected to the next page where they will be seeing the list of candidates that they selected before on the home page. The layout of the page is almost identical to the home page in all three prototypes. The purpose behind keeping the overall look of the interface similar across all the pages is to keep the navigation consistent, since color, fonts, backgrounds etc. are the areas of consistency that has a positive impact on usability and user experience (Juviler, 2020). If the users are sure about their selection, then in all three prototypes they can click confirm and a message will appear saying ‘your vote has been registered successfully’ to confirm the vote. Also, if a user wants to change his/her votes then they can click back and go to the home page where they will get all the list of candidates.

4.4.1 Prototype 1

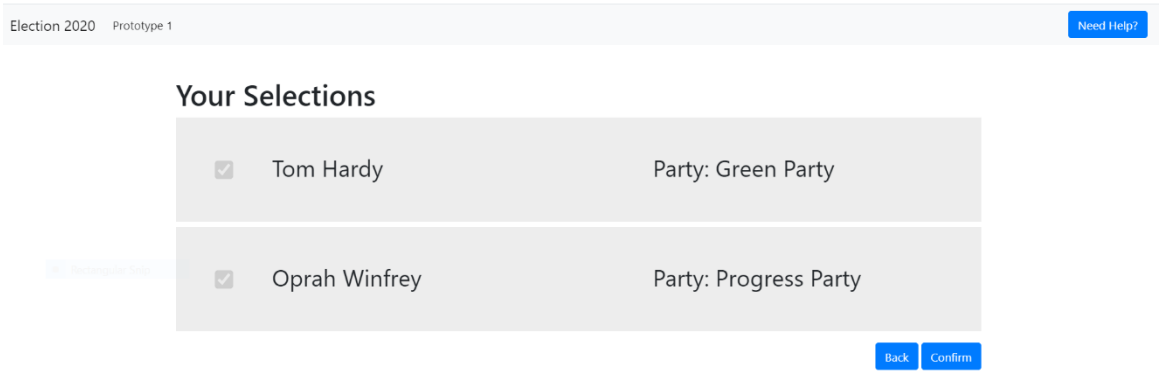

Figure 7: candidate selection page for prototype 1

This is the candidate selection page for prototype 1.

4.4.2 Prototype 2

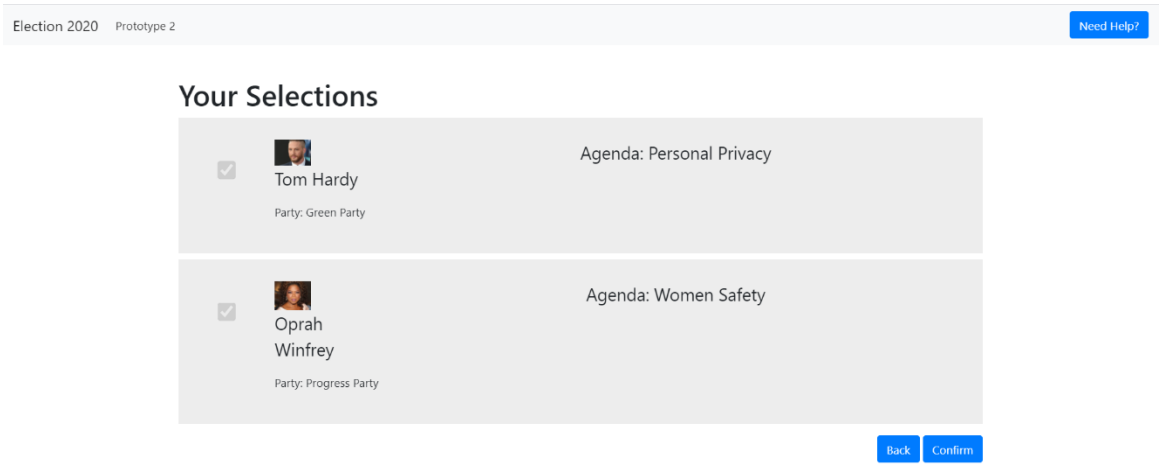

Figure 8: candidate selection page for prototype 2

This is the candidate selection page for prototype 2.

4.4.3 Prototype 3

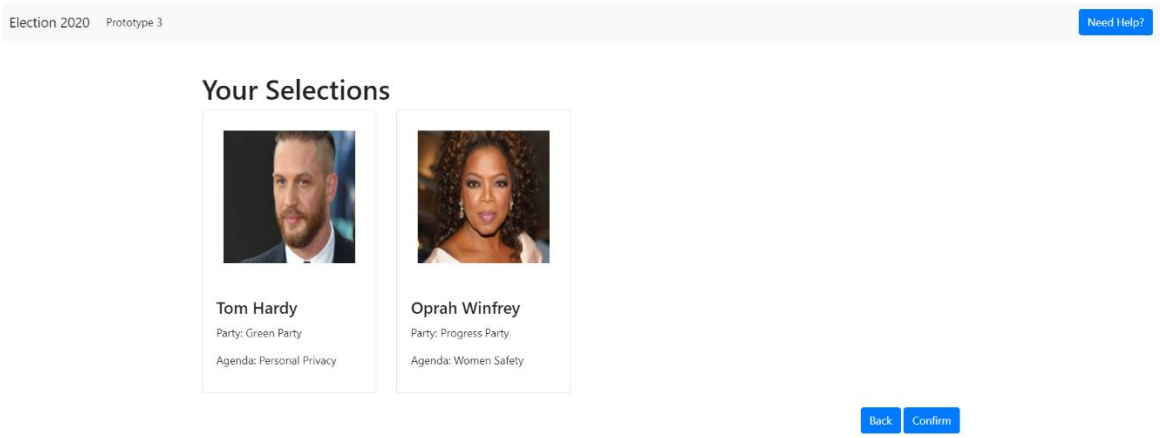

Figure 9: candidate selection page for prototype 3

This is the candidate selection page for prototype 3.

5. Data Collection Procedure

Data collection falls into two categories: primary sources and secondary sources, where primary sources are the original sources collected by the researcher that have not been collected previously and secondary sources are the data that has been collected previously by someone else for different purposes (i.e., both published and unpublished data). In this research, data were collected through a pre-session questionnaire, usability testing session and post-session interview.

5.1 Task Design

Task design is an important part of preparing the user testing. Whenever we are creating a task, we need to make sure that it is unambiguous and should have typically one clear solution (Lazar et al., 2017). Among different factors of designing the task, the important consideration to be made is making sure that the task is goal-oriented (Dumas & Fox, 2009). The task is designed based on the requirement of the user and research question so that it satisfies the requirements and contributes to providing the answer to the question. Since usability testing does not include any of the user's personal information such as health, finance, contact details etc. in this research, we need to make sure no such information shall be stored.

Since there are no fixed rules regarding whether interventions are allowed during the session, it is totally up to the moderators who decide if they can intervene or not (Lazar et al., 2017). While going through the interface, the participants might get stuck or confused and cannot proceed further, here comes the role of the moderator whether to step in and help them pass through or let the participants overcome the barrier by themselves (Dumas & Fox, 2009). But if the moderators decide to step in and help the participants, it might surely have some effect in the result, so any kind of intervention should be mentioned in the result section.

In the current study, there are two tasks in each task group, both are goal driven. Based on the guidelines from the Nielsen Norman Group, the task was designed to measure the usability testing of the interface (McCloskey, 2014). The guidelines included engaging participants by writing task scenarios that are

realistic, making tasks actionable and avoiding giving clues and describing the steps. Usability Heuristics of User Interface Design have been used in this research, covering visibility of system status, user control and feedback, error prevention, help users recognize, diagnose, and recover from errors and help section (Nielsen, 2020). There are three prototypes and all three have two pages and the task was limited within those two pages. Since one of the objectives of the test was to diagnose how intuitive the interface is, less intervention was planned except for some exceptions. In case of the exceptions, if people could not find the vote button which is at the bottom left, I planned to suggest them to check the help button in the top right corner instead of showing the vote button directly.

The table below contains the three task groups A, B, C designed for the test.

Task Group A

Table 1: Task Group A

No.	**Task Type**	**Task Details**
1	Goal-driven	Select one candidate of your preference and cast your vote for him/her
2	Goal-driven	Select Princess Diana and cast your vote for them

Task Group B

Table 2: Task Group B

No.	**Task Type**	**Task Details**
1	Goal-driven	Select two candidates of your preference and cast your vote for them.
2	Goal-driven	Select Queen Elizabeth and Michelle Obama and cast your vote for them

Task Group C

Table 3: Task Group C

No	Task Type	Task Details
1	Goal-driven	Select two candidates of your preference and cast your vote for him/her.
2	Goal-driven	Select Serena Williams, and Rebecca Ferguson and cast your vote for the candidate

5.2 System and Materials for User Testing

The resources and approach used for the collection of the data are:

• Lenovo laptop with Windows 10 OS Intel Core i5 processor, 8GB RAM and 14” screen

• Chrome Web Browser

• Pre-usability testing session Questionnaire

• Tasks document for session

• Post usability testing session Interview

5.3 Participants

For the purpose of this usability testing session, four participants were included. Those participants were elderly people aged over 65 of which three being female and one male. The selection of the gender was random based on their availability. The usability testing session location, date and time were managed according to the availability of the participants. All the sessions, i.e., user testing and interview were done in Oslo, Norway. The user testing session was divided into three parts and there was a 5-minute break after each part. The elderly people can be easily exhausted, and experience tiredness more often compared to young people (Azzolino, Arosio, Marzetti, Calvani, & Cesari, 2020). Hence to mitigate the exhaustion for the participants while conducting the user testing a few breaks between the sub-sessions(parts) was used. The user testing was conducted from November 2019 – January 2020 in Oslo. The user testing session lasted 25-60 minutes for each participant and the interview session lasted

for 15-20 minutes. Some users completed the user testing session in under 30 minutes while others really struggled and needed assistance to go through the tasks and took a longer time. A possible explanation for this time difference might be that some participants were more experienced and familiar with these kinds of digital applications while others were not.

Out of four participants, three participants chose to conduct all the sessions (user test and interview) in their own home. One participant decided to carry out all the sessions at his workplace office. The English language was a common language between us, so we decided to use the language in user testing and interviews. Initially, I contacted the participants through common friends. The invitation form (with consent) was sent to the participants to let them know about the project and communication with the participants was made through the help of text messages. I thanked all the participants at the end of the session for helping me with my research and for their participation.

5.4 Ethical Consideration

No information that could identify the participants was collected during the whole process. The consent of the participants was acquired through a consent form and no recordings of the sessions or the interviews were done. The information about all these things was explained to the participants prior to starting the process. Also, it was assured to all the participants that the collected information will be kept anonymous (regarding their response to the research). All the questions and tasks that were asked posed no risk and were able to take the decision for themselves. The main aim of ethics is to “improve the quality of life” through technology and it seems logical if the technology can act as the replacement of lost abilities for those vulnerable groups i.e. elderly people (Culén & Bratteteig, 2013). The challenges with the vulnerable group are that their abilities are different from person to person and change over time which means particular people have a particular way of touching the screen. Some people are used to touch for a longer time and some for a shorter time, so the design is implemented in such a way that whichever method the user chooses it reacts in

the same way i.e. performs click function without creating any error or confusion to the user.

5.5 Session Procedure

The usability testing session was conducted in three segments: pre-usability testing session, usability testing session and post-usability testing session.

Pre-Usability Testing Session: Once the participant was present, consent from the participant was taken. After consent from the participant for the session, the participant was handed a pre-session questionnaire to collect information regarding demographic information, prior experience with computing devices, websites, and polling system as well.

Usability Testing Session: Since user feedback is important it is normally standard in usability testing to inform the user that they are testing the interface because of which they can criticize the interface as if they are the experts (Lazar et al., 2017). After completing the pre-usability testing session questionnaire, all the participants were eligible to perform user-based testing.

- The 3 prototypes with different candidate lists were included.
- 3 different task group was designed and those 3 different task groups (i.e. A, B, C) were performed by each participant
- To overcome the learning effect randomization was used

Post-Usability Testing Session: After the completion of the Usability testing session, I conducted interviews. Though the usability testing session was based on ‘think aloud’ protocol, still the interview questions were designed to identify the pros and cons of the layout as well as to get some suggestions regarding the design flaws in case they were missed during ‘think aloud’ protocol.

After the session was finished, I did not forget to thank the participants with a big smile for their help.

6. Data Analysis and Results

The result of user-testing, observations, and interviews. The data was collected by taking notes and recordings were not done in any form. A Usability testing approach was used to explore the experience of the user regarding the voting process through an interface.

All the elderly participants went through the three prototypes. The participants expressed their views towards electronic voting and considered it easier compared to paper voting since they were used to paper voting in Norway. The participants considered the prototype to be intuitive and avoid the need to have assistance because of the availability of the help feature and error control.

6.1 Participants Demographic Information

Four participants were included in this research and among them three were female and one was male. Since the research is focused on elderly people, all the participants were above the 65 years age group. Among four participants, one male candidate had a doctorate degree, two female candidates had a high school degree, and one male candidate was a university graduate. It was found that all the participants had more than five years of computer use experience. And all the participants preferred small screen portable devices compared to bigger screen devices.

6.2 User Testing: Observation

Three out of four participants considered the use of big images of the candidate or party logos to be easier to identify the choice instead of just the names while one participant considered selection by the name to be easier instead of looking for pictures.

All the participants were positive about the implementation of electronic voting. There were some features about the system where the participants faced difficulties. All the identified issues based on the usability heuristics are listed below:

1.Visibility of the system Status:

All three prototypes have visual feedback to keep users updated about the ongoing process. When a user hovers around the list of candidates, the visual feedback is given by the change in color so that the users know that the candidate is being selected. In the first two prototypes the selected candidates are identified by the checkbox which is more visible. While in the third prototype the blue color mark which is comparatively thin that appears around the candidate box is less visible compared to the first two prototypes. Based on the responses, all four participants found the visibility status for the first two prototypes good enough while the third prototype needed to be worked since it was not clear enough to be visible.

Figure 10: marked candidates after selected by the user in prototype 1

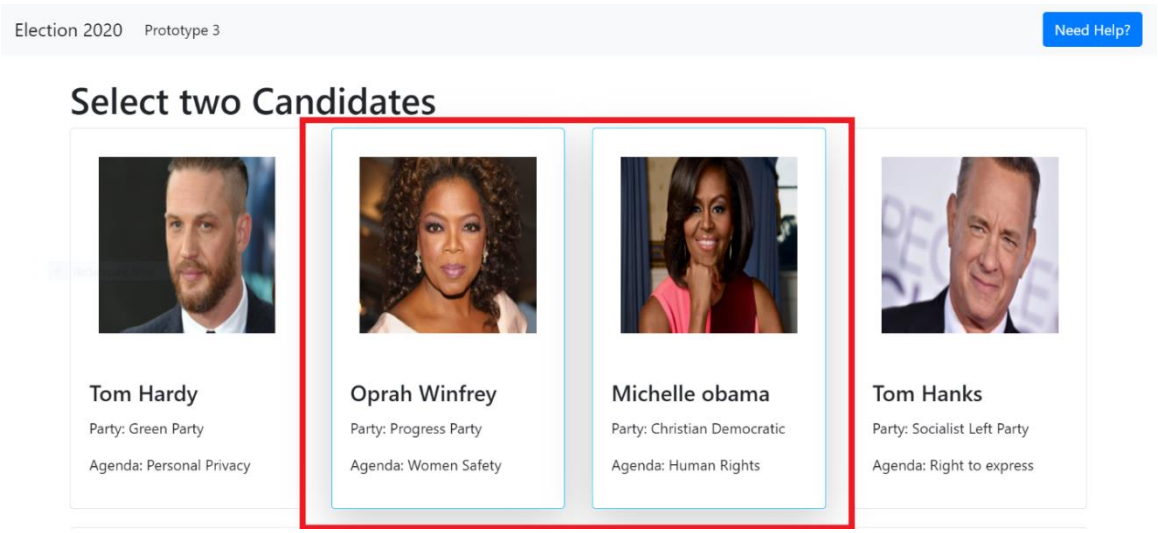

Figure 11: marked candidates after selected by the user in prototype 3

2.User control and freedom

All the participants were satisfied in this case where the system has flexibility to back out of the process as well as show a clear way for an exit (i.e. back button).

Figure 12: back button to go back and re-select the candidates again

3.Consistency, industry conventions and standard

Though the prototype followed the consistency and industry standard, still one participant struggled while selecting the candidate. Even after selecting the candidate that particular participant seemed lost and was unaware of the next

step. This might be because of the participant's lack of experience with electronic voting since the participant was used to paper voting which did not require navigation from one page to another. But the rest of the participants expressed a positive attitude towards the navigation and stated it to be intuitive and easier.

4.Error Prevention

All the participants felt that warning messages present in the third prototype were helpful enough to prevent them from making the mistake while going through the task which lacked in the first two prototypes. All participants had the mutual thought that the use of error messages was a must to control the mistakes.

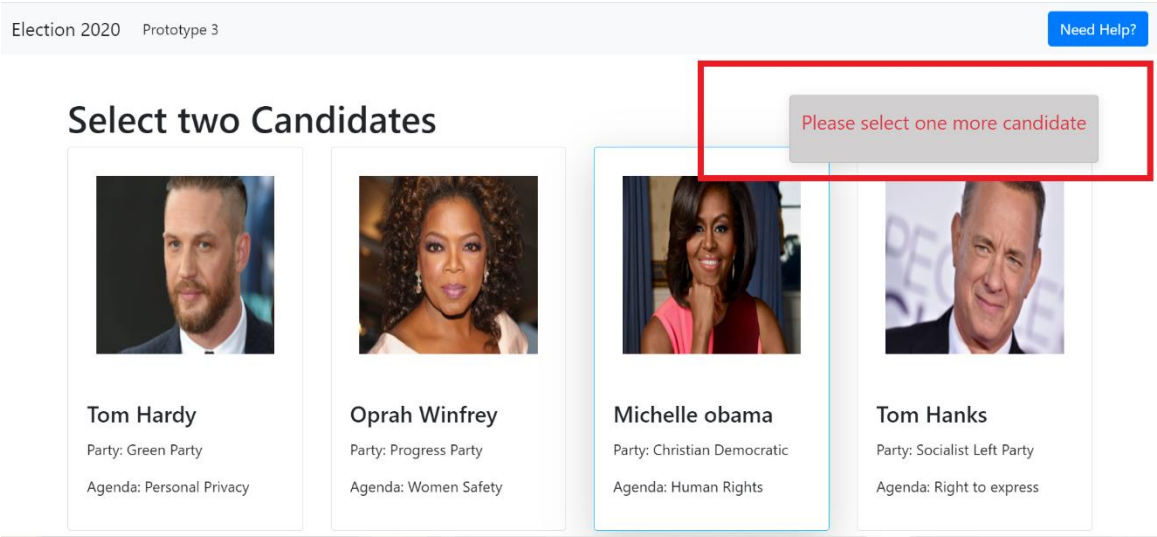

Figure 13: error message during the selection of candidates

5.Recognition rather than recall

The participants felt the overall elements, actions, and options visible except the VOTE button that was at the bottom right of the page. Three out of four participants had the common problem accessing the button because of its small size and being hidden all the time until the page is scrolled down. They recommend making the button bigger and made visible all the time without scrolling the page. Three out of four participants liked the pictures used in the P3

to represent the candidate while one participant disliked the use of pictures and felt that name was easier to find the candidate from the list.

6.Aesthetics and minimalist design

Three out of four participants did not like the scrolling function. Because of the list of candidates, the page needed to be scrolled down to see all the candidates which participants found difficult. The remaining participant has no problem with the scrolling.

7.Help users recognize, diagnose, and recover from errors

All the participants were satisfied with the plain language used in the error message which notified about the problem and suggested the solution of the problem in the P3. The P1 and P2 missed this feature, and all the participants felt the need since it led to mistakes while doing the task.

8.Help and documentation

Almost all the participants liked the placement of the help section. Three out of four participants liked the instructions given in the help and the rest participant did not need the instructions.

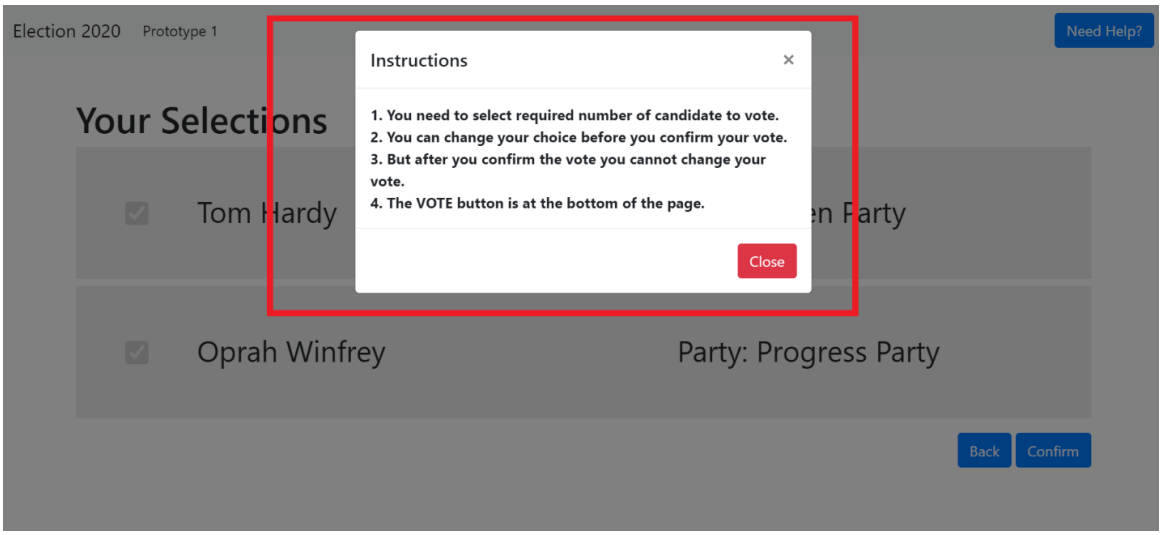

Figure 14: set of instructions after clicking ‘need help’ button

Based on the responses, most of the participants liked the minimalistic design of the prototype where every component and process are simple, easy to understand, minimal physical and mental effort. The most liked feature is the number of clicks required to complete the task. All the participants felt that P3 which contains the big pictures of the candidates is more visually appealing than the other two prototypes. The error message is very helpful to warn the users from making the mistake. Hence the voting platform can be made more usable if the usability guidelines are followed while designing the system. And some of the features the participants really liked are the minimalistic design, system visibility, visually appealing, less mental, and physical effort, less number of clicks, error control mechanism. And based on the responses, three out of four participants preferred P3 because of the availability of these features. The only drawback in P3 was the low system visibility while selecting the candidates. Another thing that I noticed was two out of four participants seemed nervous or cautious while going through the task as if they might have in mind that they were being judged or tested.

6.3 Interview

In terms of design, three out of four participants responded as the P3 being the best among the three prototypes. Two out of four participants felt that the design of P1 was similar to paper voting. All the participants responded that P1 was less visually appealing compared to P2 and P3. Regarding the VOTE button all the participants had similar thoughts i.e. the size being small and being placed at the bottom of the page which keeps it hidden all the time. Regarding P2, all the participants felt it to be an improvement of the P1, but the image size is too small to be recognized.

All the participants expressed a positive attitude towards electronic voting compared to paper voting because of easiness, effectiveness and requiring minimal physical and mental effort. All the participants liked the help section and error prevention feature which helped them to guide the process. Most of the participants liked the number of clicks needed to complete the voting process.

The participants responded that the number of clicks were perfect during the process. Even though the participants were struggling during the testing session, they were not confident to express that during the interview. While going through the user testing, one participant seemed confused in every next step, but the participant did not mention that in the interview. Sometimes the participants seem to struggle when going to the next page when navigating. All the participants seemed more confident in the interview session compared to the usability testing session.

7. Discussion

This section includes the findings compared to the literature and discusses their relevance with the findings. This chapter begins with a comparison to previous studies and is followed by recommendations and limitations of the research.

7.1 Comparison to previous studies

There had been lots of research in the past regarding the usability of electronic voting but limited one considering the elderly ones (Powell, Williams, Bock, Doellman, & Allen, 2012). With all those findings there is still room for improvements for the usability issues in the context of elderly people. The analysis of this research showed some mixed results but promising with some usability issues.

Based on the previous literatures It is agreed that positive attitudes of the participants are required towards the implementation of electronic voting for conducting further research on usability. Until unless people are willing to adopt the change, we cannot achieve anything only by trying hard to implement new technologies. And findings from this study suggests people are ready to leap towards the new change since they consider it easier compared to traditional methods. Based on people's opinions, digital service assists in various ways in their daily lives and they would love to have system where they can vote from their home without the need for going to polling station. Fuglerud and Røssvoll (2012) also had the same opinion where people were optimistic regarding the web based electronic voting.

It can be agreed to some extent with the previous study that usability heuristics like Match between the system and the real world, Consistency and industry convention of design, User control and freedom, Minimalistic design is necessary feature that contribute to usability of the system which was included in their study. Hsu and Bronson (2018) and Marky et al. (2020) had similar opinion regarding the user control, minimalism, consistency and industry standard of the design which is essential for making the design usable.

But the scrolling feature used in the prototype had the mixed response from the present study. Some of the participant felt that scrolling feature is good enough to keep list of all the candidates in single page so that people does not need to navigate to another page for checking the candidates' details. But some participant felt that scrolling feature caused them to scroll down to find all the candidates' details and which was not usable according to them. Also, the participants felt that the system providing visual feedbacks to keep them updated while going through the task was crucial to keep up the task which is similar to the previous study. (Fairweather & Rogerson, 2005) had also mixed opinion mentioning that scrolling features should be eliminated but also had the opinion of keeping it stating people are used to it.

Though the previous study focused on the size of the text, contrast, language, review screen, visibility of the system which is similar to this study but lacked some features required for usability of any system. Most of the previous studies focused on the WCAG and accessibility guidelines, hence it might be the reason they lacked some of the important usability features such as error prevention and recovery, recognition rather than recall. And all those missing features are included in this study. With the above consideration, the study somehow provides an important clue to future researchers and developers to design and implement a usable voting system.

7.2 Recommendations

Based on the user's feedback we had some mixed reviews, and some features and functionality required some modifications.

Some recommendations based on the results can be provided as:

- The buttons 'VOTE' placed at the bottom of the page can be made bigger enough to be seen all the time even without the need of scrolling down since it is not seen in the beginning without scrolling the page down.
- The visibility of the system can be increased to provide visual feedback to keep users updated about the process.

- The page required scrolling down to see all the lists of the candidates and to access the ‘VOTE’ button. Some of the participants did not like the scrolling feature, so some alternative can be provided in this case.

7.3 Limitations of the study

There were some limitations in this research that could have affected the results in some way. One of the limitations of this research is the limited number of participants used for the research purpose. If more participants could be included, then there would obviously be more responses for the study. The participants are limited to the Oslo region only, hence including more participants from different parts of the world would help in reducing the risk of having biased responses or people having similar experiences or opinions regarding the research area.

Another limitation is restricting the recruitment of participants to Oslo only. Instead of recruiting participants only from one region, if more participants could be recruited from different countries, then we could expect different diverse responses based on their experience and expertise. Greater diversity among the participants could contribute in many ways regarding the responses which in return could help find the drawbacks of the prototype usability issues.

In this study, usability testing was carried out using the laptop only. Since the study is about the usability of the interface, so the interface could be anything like mobile, iPad, kiosks, or any other form of the device but we tested using the laptop only so one particular design which is perfect in one device might have some problem in other types of devices. So, if all different devices were included in the study, then more accurate results could have been expected. Also, the inclusion of some more interview questions could have been helpful in identifying the usability issues.

8. Conclusion and Future Work

8.1 Conclusion

This research analyzed the usability issues of the voting user interface with the help of different prototypes. With the help of different literature, problems related to the usability of the voting interface were studied and three different prototypes were designed based on usability heuristics. All three prototypes were similar with some design changes. After that usability testing was carried out with 4 participants and a post usability interview session and the results were analyzed.

The purpose was to investigate the field of electronic voting usability so that all people can practice their democratic rights equally without being excluded. The research aims to contribute to the usability of the electronic voting user interface identifying the issues and providing and recommending the solutions regarding usability.

To answer the research question “How can an electronic voting system be more than just accessible, but also usable, so that it can facilitate digital inclusion in society for elderly people to practice their democratic rights?”, we need to consider usability Heuristics for User Interface Design as explained above. The interface should have flexibility to go back and undo feature. To keep the user updated about the ongoing process it should provide visual feedback. To help the user track their mistakes the design should have warning messages from to keep them in right track. The most important thing is the intuitive design that avoids the need to memorize. These features are already mentioned in usability heuristics as well. Moreover, based on the responses people do not like to spend a lot of time while going through a goal-oriented task. So, the interface should be designed in such a way that it requires minimal effort and tasks can be completed in minimum clicks. It was discussed earlier as well that a usable system helps users to complete the task independently without the help of another person. Hence if each individual can take part in a ballot and can choose the candidate of

their choice without being pressured by any other person then that is a proper exercise of democracy.

Though the prototype was not completely able to meet the people's needs in terms of usability. The research was carried out using three prototypes. Still, the result from usability testing and post usability interviews can be used to design the interface completely different from these and make it more usable. Since this prototype does not match any country's ballot design, designers can design the interface in their own terms and creativity considering the usability issues and requirements that we got from the result in this research.

8.2 Future Work

For the future work following points might be interesting. Some recommendations based on the results can be provided as:

- The number of the participants (sample size) was limited and if there were enough participants then the result might have been more accurate.
- All the participants were from Oslo, so the inclusion of diverse participants from all around the world would be beneficial.
- The testing device was limited to laptops only because of the time limit. The use of various devices could help in generating some diverse results may be.

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Appendices

A. Pre-test Questionnaire

Demographic Information

Before starting the experiment some basic information regarding the education of the user, past experience with similar types of the systems, understanding about the internet and web applications, is asked to get some overview of the user using the system. For the sake of privacy of the user, the information shall be kept confidential.

Please check the answer that suits you

Gender: ☐Male ☐Female ☐ Do not want to mention

Age (years): _____

Education: ☐ Basic School ☐ High School ☐ Graduate ☐ Doctorate

Profession: ☐ Student ☐ Professor ☐ Designer ☐ Other_____

Computer Use Experience: ☐ Less than 1 year ☐ 2-5 years ☐ more than 5 years

Prior Experience with online polling/voting: ☐ Less than a year ☐2-5 years ☐ 6-10 years ☐more than 10 years

Device Preferences to use web applications: ☐ Laptop Computer ☐Desktop Computer ☐Smartphone devices ☐Others_____

B. Post-test Interview

I would like to thank you for your time in this research. In the following section you will be asked questions based on your experience while carrying out the task. Here I developed 11 questions based on different conditions.

Questions:

1. What do you think about all the designs?
2. How did you find this voting compared to paper voting/previous ones that you used?
3. How is the user interface/layout/design of the system?
4. Do you think it is easier to vote using this system? How?
5. What do you think of the help section?
6. What do you think of the messages that appeared while you were doing the user testing?
7. What are you views about the images used in the prototype and do you think image size is important factor for recognition?
8. What are the features you liked?
9. What are the features you did not like?
10. What do you think about the available features? Is it enough?
11. Are there any future recommendations to improve any of the system?

C. Randomization of Participants

Participants	**Session 1**		**Session 2**		**Session 3**	
	Pro	**Task Group**	**Pro**	**Task Group**	**Pro**	**Task Group**
1.	2	C	0	A	1	B
2.	0	B	2	C	1	A
3.	1	A	2	B	0	C
4.	2	B	0	A	1	C

D. Invitation + Consent form

Are you interested in taking part in the research project: "Usable electronic voting for the elderly people"?

This is an invitation about participation in a research project where the main purpose is to provide a usable voting interface for the elderly people so that they can vote independently without the help of any other person in election or any other polls to present their own opinions. Participants will take part in testing different types of electronic voting interface and give their feedback. In this letter I will give you the information about the purpose of the project and what your participation will involve.

Purpose of the Project

The electoral system is the fundamental building block of democracy. But as much as democracy expects participation of all eligible voters, the question remains whether all citizens can participate in the poll. Paper ballot system inherently creates usability barriers which can be removed by the help of electronic voting. Electronic voting helps the eligible voter to cast their votes with the help of a digital media (i.e. computer, tablet, kiosks etc.) connected to the internet. The purpose of this research is to provide a better electronic voting interface. For this purpose, different interfaces are tested and get feedback regarding these interfaces.

This is a master's thesis research project. And no personal data regarding the participants will be collected during the process.

Who is responsible for the research project?

Oslo Metropolitan University

Why are you being asked to participate?

This project focuses on researching the usability and accessibility of electronic voting interfaces for the elderly people. You have been requested to take part in this project as you have identified people aged 65 and over.

What does participation involve for you?

First of all, you need to fill a questionnaire. After that you will be testing different types of electronic voting interfaces which is about choosing candidates like in an electoral system and cast a vote based on your preferences where you will be speaking about what factors you liked, which you felt confusing, less usable, etc. When you are testing the interfaces through them you can keep talking about the features, your likes, dislikes. I will take notes while you speak about the experiences while you go through the interfaces. After you cast your votes in different interfaces, there will be one post-test interview. In general, I will ask you about the problems, views you faced while testing the prototype and figure out the flaws and get the suggestions if you have any.

Participation is voluntary

Participation in the project is voluntary and you are free to withdraw if you want and you do not have to give any reasons. You will not be responsible for anything if you choose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

Since I do not need your personal data, I will not be taking any information that would recognize you.

The information will not be taped.

The participants will be identified as participant 1, participant 2, participant 3, participant 4 and participant 5 etc.

Yours sincerely,

Vishal Thapa
Student
Oslo Metropolitan University

Consent form

I have received and understood information about the “Usable electronic voting interface for elderly people” and have been given the opportunity to ask questions. I give consent:

☒ to participate in the user testing session

☐ not to participate in the user testing session